

Manhole Rehabilitation

PERFORMANCE SPECIFICATION GUIDELINE



NASSCO

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This Performance Specification Guideline is maintained and updated by NASSCO's:
Sewer Structure Rehabilitation Committee

Disclaimer

These Specifications were prepared by Committees comprised of representatives of NASSCO members and peer-reviewed by industry professionals. These Specifications are not specific to any one product, project, or job site, and should be considered a guideline only. Conditions for use may require additions, deletions, or amendments to these guidelines to conform to project-specific site conditions and to comply with applicable laws, regulations, and ordinances. NASSCO does not guarantee, certify or assure any result and assumes no liability as to content, use and application of these guidelines.

Foreword

This Performance Specification Guideline (PSG) presents a performance-based specification designed to guide the rehabilitation of manholes, which are defined as cylindrical, vertically buried structures. Manholes are also known as access points, utility holes, maintenance holes, inspection chambers, or access chambers. The PSG offers a variety of materials and technologies that may be considered for use in sanitary and storm sewer manhole rehabilitation projects. This PSG may also be applicable in other environments where similar structural geometry, material composition, and corrosive elements are present. Throughout the specification, guidance is provided to aid users in customizing and drafting a specification tailored to the specific needs of their project. These guidelines are clearly highlighted in bold print and enclosed within bold borders to ensure easy identification and clarity for the user.

NASSCO recognizes that, for the products and technologies included in this PSG to consistently deliver the performance required, those involved in the rehabilitation process - from assessment to inspection - need access to learning opportunities to understand these rehabilitation technologies. NASSCO has responded to these needs by providing instructional learning and objective technical resources, including the following:

Inspector Training Certification Program (ITCP™) for the Inspection of Manhole Rehabilitation is a training and certification program that provides field construction professionals (i.e., consulting and municipal engineers and contractors) with resources to understand and inspect manhole rehabilitation technologies.

Manhole Assessment Certification Program (MACP™) is a component of NASSCO's Pipeline Assessment Certification Program (PACP™), being the trusted source for proper and consistent assessment condition coding of pipelines and manholes. The goal of these programs is to help system owners develop preventative assessment and maintenance programs based on a science-based standard.

On NASSCO's website at [NASSCO.org](https://nassco.org), you can find educational opportunities, technical resources, and ways to stay informed or get involved in advocacy for the underground infrastructure industry. From published reports to specification guidelines, NASSCO's continually growing library of technical resources is the foundation for setting quality industry standards.

PART 1 GENERAL

1.1 SUMMARY

- A. This Performance Specification Guideline (PSG) includes recommended minimum requirements for the repair, replacement and/or rehabilitation, hereinafter collectively referred to as rehabilitation, of sanitary and storm sewer manholes by providing the work necessary to furnish and install manhole rehabilitation systems, either individually or together, as specified by the Owner or Owner's assigned representative, herein referred to as Owner.
- B. Rehabilitation of existing manholes can include the following rehabilitation systems, hereinafter collectively referred to as "SYSTEM(S)" to describe use of one or several rehabilitation systems.
 - 1. Cementitious Systems
 - 2. Polymeric Systems
 - 3. Cured-in-Place Manhole (CIPM)
 - 4. Poured-in-Place Concrete Liner
 - 5. Panel Liners
 - 6. Manhole Inserts
 - 7. Mechanical Chimney Seal
 - 8. Applied Polymer Chimney Seal
 - 9. Cured-in-Place Chimney Seal
 - 10. Replace Frame and Cover
 - 11. Manhole Frame Adjustment
 - 12. Manhole Steps
- C. This includes the minimum requirements for the rehabilitation of manholes defined herein and as shown on the plans included as part of these contract documents.
- D. Manholes may be specified for rehabilitation using one SYSTEM or the combination of several SYSTEMS. The Contractor is responsible for the accurate and complete installation and warranty of SYSTEMS installed.

1.2 DESCRIPTION OF WORK AND PRODUCT DELIVERY

The specifications must include a description of the work required including products or SYSTEMS that are to be included in the installation, and what is to be delivered by the Contractor.

- A. The Work covered by this PSG consists of all work necessary to furnish and install one or more SYSTEMS. The Contractor shall deliver a finished product(s) including all materials, labor, equipment, and services necessary for mobilization, traffic control,

bypass pumping and/or diversion of sewage flows, cleaning equipment, product installation, quality control and samples for performance of required material tests, final inspection and warranty work, as included in these specifications and at the quantities of each component contained in the Bid Proposal.

- B. Every manhole rehabilitated shall be integrated and compatible with the SYSTEMS, materials, equipment and installation procedures used to complete the work.

A performance statement should outline the objective(s) that the construction or rehabilitation is intended to achieve. The three primary goals for manhole rehabilitation are included in Section 1.2.C. below. However, when applying these to a particular project, the specifications should be modified in Section 1.2.C. to include one, all, or a combination of these objectives, depending on the project requirements.

- C. Installed SYSTEMS shall be inspected and tested to confirm the installation meets the performance criteria specified for each SYSTEM as required in these specifications, which may include the following:
1. Prevent infiltration or inflow from entering the manhole through rehabilitated components.
 2. Create a barrier covering rehabilitated components of the manhole that is impermeable to corrosive gases or liquids to prevent future corrosion of the rehabilitated components.
 3. Restore or replace deteriorated components of the manhole to re-establish the structural integrity of the manhole or rehabilitated components.
- D. Installed SYSTEMS shall be free of defects that will compromise the operation or performance of the rehabilitated manhole.

Materials or processes used by the Contractor shall not result in the distribution to, formation, or production of detrimental compounds or by-products at the wastewater treatment plant or receiving waters. The Contractor shall notify the Owner and identify by-products produced because of the installation operations, test and monitor the levels, and comply with local waste discharge requirements.

- E. The rehabilitation process and/or materials installed shall not cause adverse effects to the Owner's processes or facilities during construction.
- F. The Contractor will conduct installation operations and schedule cleanup in a manner to restore the site to existing conditions while minimizing disruption to traffic, pedestrians, businesses, property owners or tenants in accordance with local regulations.
- G. All materials furnished shall be marked with product information, stored in a manner as specified by the manufacturer and tested to the requirements of this contract.

- H. Samples from the project installation, marked with a chain of custody information, shall be collected at the request of the Owner.
- I. For each manhole rehabilitation, a complete and accurate record of materials installed/applied shall be prepared by the Contractor. The record shall include the date, identifying manhole number, location, and quantities of rehabilitation components installed based on Bid Item descriptions.
- J. Quality assurance documentation and test reports for SYSTEM installations shall be prepared and submitted post-rehabilitation by the Contractor as required herein.
- K. Testing and warranty inspections shall be executed by the Owner. Defects shall be repaired or replaced by the Contractor as required in the contract documents.

1.3 PRICES

- A. The Contractor shall deliver a finished product(s) including all materials, labor, equipment, and services necessary to complete the work including traffic control, bypass pumping and/or diversion of active flows, cleaning equipment, product installation, quality controls and samples for performance of required material tests, final inspection and warranty work, as specified in the Description of Work and at the quantities of each component contained in the Bid Items.

Measurement for payment typically varies depending upon the SYSTEMS. For example, full depth manhole coatings or linings may be measured by vertical foot, chimney seals may be measured by each manhole or by vertical foot, and manhole rim adjustments or inserts by each manhole.

Multi-year contracts should include/address consideration for price escalations from the Owner.

1.4 REFERENCE STANDARDS

Since there are several rehabilitation SYSTEMS within this PSG, the referenced standards are included in the individual Product sections for each SYSTEM. However, when drafting specifications for a particular project, the referenced standards should be listed in this Section 1.4.

- A. ASTM, ICRI, NACE, SSPC, and other applicable standard documents, which are listed in the specifications, are made a part of these specifications by reference to the extent stated herein and shall be the latest edition thereof. Where there are differences between codes, standards, and these specifications, these specifications shall govern.
- B. ASCE Manuals and Reports on Engineering Practice No. 92, Manhole Inspection and Rehabilitation, Third Edition, 2022.

- C. NASSCO's Pipeline Assessment Certification Program (PACP™) and Manhole Assessment Certification Program (MACP™)
- D. NASSCO's Inspector Training Certification Program (ITCP™) for Manhole Rehabilitation

1.5 PERFORMANCE WORK STATEMENT (PWS)

In place of the project specifications defining the specific method for SYSTEMS installation, the contractor defines the installation means and methods through a written plan called the Performance Work Statement (PWS). During construction, the PWS provides information to the inspector used to determine if the submitted means and methods are being followed by the contractor. The PWS also outlines recommended quality checks to be performed and documents the installation crew qualifications.

- A. The Contractor shall submit, to the Owner, a Performance Work Statement (PWS) which clearly defines the proposed SYSTEMS delivery in conformance with the requirements of these contract documents. Unless directed otherwise by the Owner, the PWS shall at a minimum contain the following:
 - 1. Documentation that the SYSTEMS will conform to the project requirements as outlined in these specifications.
 - 2. A SYSTEMS installation plan describing preparation work, cleaning operations, pre-inspections, bypass or flow maintenance, traffic control, installation procedure, method of curing, quality control, testing to be performed, final inspection, and other necessary and appropriate for a complete SYSTEMS application/installation.
 - 3. An installation schedule shall be prepared, submitted and conform to the requirements of this contract.
 - 4. The manufacturer's description of the SYSTEMS, or materials which comprise the SYSTEMS, to be furnished for the project. Material descriptions shall be sufficiently detailed in the submittals to verify conformance to these specifications and/or shall conform to the pre-approved SYSTEMS submission.
 - 5. A statement of the Contractor's experience for each SYSTEMS to be submitted within the Bid Proposal. The name and experience of each lead individual performing work on this contract, for each component, shall be submitted with the PWS. Personnel replaced by the Contractor, on this contract, shall have similar, verifiable experience as the personnel originally submitted for the project.
 - 6. Current documentation from the SYSTEMS manufacturer certifying that the Contractor possesses the required equipment and training to comply completely with the SYSTEMS manufacturer's Quality Assurance requirements for installation. Contractor's personnel possessing current required training shall be listed individually.

Specific qualification requirements can vary by project typically based upon scope and size of the project as well as the availability of contractors qualified to provide specialized services for the various SYSTEMS.

- B. To verify the competency of contractors for properly installing the specified SYSTEMS, the requirements outlined in the specifications may include certification of training completion from the manufacturer, documentation showing that the contractor has successfully completed a project of similar scope and size, evidence of installing a requisite volume of footage or having a certain number of years of experience installing the SYSTEM. For contractors with training but without the required experience, allowances may be considered by requiring a technical representative from the manufacturer to be present on-site. A minimum of [e.g., five (5)] references of the Contractor's work is required, indicating the successful application of the SYSTEMS, or that of the same material type, as specified herein or to be furnished by the Contractor and applied in a similar project environment as included in these contract documents.
- C. Structural design calculations shall include data that conforms to the requirements of these specifications or has been pre-approved by the Owner and shall be certified by a registered Professional Engineer.
- D. Manufacturer's technical data (e.g., technical data sheet(s) on SYSTEMS, safety data sheets (SDS), storage, handling, use and installation guidelines) shall be submitted for SYSTEMS and associated technology to be furnished.

Mixing, spray and spincast application equipment can be critical for the installation of coatings and lining SYSTEMS. This specialty equipment type is not readily available for rent from local equipment rental companies. Because of this, the availability of redundant equipment or a plan for managing delays and damage may be specified.

- E. Information on the SYSTEMS and tools and equipment required for a complete application/installation, shall be submitted. The PWS shall identify which tools and equipment will be redundant on the job site in the event of equipment breakdown. The Contractor shall outline the mitigation procedure to be implemented in the event of key equipment failure during the installation process.
- F. A description of the Contractor's proposed procedures for cleaning and preparing the manhole structure prior to applying/installing the SYSTEMS shall be submitted as part of the PWS, including testing that will be performed by the Contractor to verify acceptability of the prepared surfaces for application/installation of the SYSTEMS.
- G. A description of the Contractor's evaluation and remediation process to address common defects that may occur in the installed SYSTEM.
- H. Compensation for the work required for the submittal of the PWS shall be included in the corresponding pay item contained in the Bid Proposal.

1.6 PRODUCT SUBMITTALS

Product submittals require the contractor to submit the SYSTEMS (i.e., materials) intended for use in the installation. If allowed by the contract documents, the Contractor may propose alternative SYSTEMS that are equal to or better than those specified. The submitted information should be sufficient for the Owner to assess the alternative SYSTEMS' ability to meet the contract's specified requirements.

- A. Product data submittals for each SYSTEM proposed for installation under this contract, including materials that comprise the SYSTEMS or material used in the rehabilitation.
- B. Technical data sheet(s) including manufacturer, product material type, intended use, physical properties, and standards referenced for materials or design.
- C. Copies of third-party test results for mechanical properties and chemical resistance indicating that the product meets the requirements of these specifications and when required the submitted design.

Test results on formulated materials must be for the specific and current formulation to be furnished on the project. Formulations may change due to raw material availability or reformulation for performance and cost.

- D. Design approach and test data derived from the SYSTEMS being submitted that supports the ability of the product to meet the design and expected service life required in these specifications.
- E. Manufacturer's requirements for handling and storing materials. If applicable to the proposed SYSTEM materials, include a method for maintaining and monitoring the environment (i.e., temperature, humidity) at the storage location.
- F. Safety Data Sheets (SDS) for all materials to be furnished for the project.
- G. Manufacturer's installation or application requirements for the SYSTEMS proposed, including mixing, additives, set time, cure time, return to service, compatibility with other materials, requirements for multiple application layers of the same or different materials, and equipment required for delivery of a quality product.
- H. Manufacturer's quality assurance guidelines for inspection and testing throughout the installation process including acceptance protocol.

1.7 DESIGN

SYSTEMS may be designed to rehabilitate the existing manhole by providing corrosion protection, removing I&I, restoring structural integrity, or a combination thereof. The selection or omission of performance and submittal requirements should be based on the specific project needs and clearly delineated in Section 1.7.A. when drafting specifications for a particular project.

Designs are based upon the operating conditions, and the current and anticipated condition state of the manholes scheduled to be rehabilitated. The required wall thickness of a coating or liner is tied to the interactive performance properties of the SYSTEM with the manhole and the loads deemed likely to be acting on the manhole structure going forward. In certain cases, the preparation, certification, and submission of design by a registered Professional Engineer are required for manhole rehabilitation technologies. Design should be supported by third party testing and documentation for the specific product being submitted.

Chapter 7 of ASCE Manuals and Reports on Engineering Practice No. 92 provides guidance on SYSTEMS wall thickness design for full-depth manhole rehabilitation, addressing existing problems and ensuring the rehabilitated manhole meets expectations for an extended service life.

- A. SYSTEMS consisting of a coating or liner material application or wall thickness shall be in accordance with design as submitted and approved in the contract documents to:
 - 1. Sustain prescribed earth, hydrostatic and dynamic loading without support of the existing structure.
 - 2. Sustain prescribed hydrostatic loading by groundwater while maintaining a bond to the existing structure.
 - 3. Provide a monolithic protective barrier against corrosion.
- B. Certification and submission of design by a registered Professional Engineer is required for the following:
 - 1. Manholes specified to be structurally rehabilitated to sustain prescribed earth, hydrostatic and dynamic loading without support by the existing structure.
- C. Certification and submission of the required thickness (i.e., wall thickness) of the installed SYSTEM and/or additional design requirements by the SYSTEMS manufacturer are required for the following:
 - 1. Manholes specified for structural restoration or rehabilitated to sustain prescribed hydrostatic loading by groundwater.

- D. Certification and submission of third party chemical resistance testing, minimum application thickness, and installed SYSTEMS inspection procedures required by the SYSTEMS manufacturer is required for the following:
 - 1. Manholes specified for rehabilitation to prevent future corrosion for prescribed operational conditions.
- E. Submission of third party testing provided by the SYSTEMS manufacturer will be acceptable for application suitability for the following:
 - 1. Manholes specified to receive a coating to restore mortar or other deteriorated components of a manhole but has no specified longevity or corrosion resistance requirement.
 - 2. Manholes specified to receive repair materials for select portions of the manhole.

1.8 SAFETY

- A. The Contractor shall comply with applicable work safety requirements set forth by relevant regulatory agencies, including the Occupational Safety and Health Administration (OSHA), and shall ensure that the work site is secured and maintained in accordance with these standards. The Contractor shall erect signs and other devices as are necessary for the safety of the work site.
- B. The Contractor shall perform Work in accordance with compliance with relevant OSHA standards. Emphasis shall be placed upon the requirements for entering confined spaces, traffic control, trenching, and equipment being used.

It is notable that requirements for confined space entry are found in OSHA Construction Standard 29 CFR 1926 Subpart AA, while trenching and excavation requirements are specified in OSHA Trenching and Excavation Standard 29 CFR 1926.650, and for hazardous materials that may be encountered requirements are found in the OSHA Hazard Communication Standard 29 CFR 1910.1200. Guidance for traffic control can be found in the Manual on Uniform Traffic Control Devices.

- C. The Contractor shall submit a proposed Safety Plan to the Owner prior to beginning Work. The plan shall include a description of a daily safety program for the job site and emergency procedures to be implemented in the event of a safety incident. Work shall be conducted in accordance with the Contractor's submitted Safety Plan and relevant OSHA and regulatory guidelines.
- D. Mixing and handling chemical grout, which may be toxic under certain conditions, shall be done to minimize hazards to personnel and shall be in accordance with the manufacturer's recommendations and relevant OSHA standards, including Hazard Communication Standard 29 CFR 1910.1200. It is the responsibility of the Contractor to conduct a hazard risk assessment and provide appropriate protective measures to ensure that chemicals are handled only by trained and authorized personnel.

Equipment used to install the grout shall be as recommended by the manufacturer and only personnel trained by the employer with the grouting material and meeting the qualification requirements specified herein shall perform the actual grouting operation.

1.9 QUALITY CONTROL PLAN (QCP)

A Quality Control Plan (QCP) should be submitted by the Contractor. The QCP should include a discussion of the proposed quality controls to be implemented by the contractor, covering material protection and handling, equipment operation, and documentation requirements. The Contractor personnel, including names and cell phone numbers for those that are responsible for ensuring that quality requirements are met, should be identified and submitted. It is recommended that Contractor personnel performing and documenting inspections or testing be required to be NASSCO-Certified Professionals in ITCP for Manhole Rehabilitation, as applicable to the scope of work for the project.

- A. QCP shall be submitted to the Owner that conforms to the requirements of these specifications. At a minimum, the QCP shall include the following:
 - 1. A description of the proposed quality controls to be performed by the Contractor.
 - 2. Proposed procedures for quality control, product sampling and testing.
 - 3. Proposed methods for product performance controls, including method of and frequency of product sampling and testing both in raw material form and cured product form as applicable.
 - 4. Scheduled performance and product test result reviews between the Contractor and the Owner at regularly scheduled progress meetings.
 - 5. Proposed methods and procedures for SYSTEMS repair or replacement in the event of product defects or total failure.
 - 6. A description of the qualifications of individuals scheduled to perform inspection and/or testing, such as NASSCO-certified MACP™ or ITCP™ professionals.
- B. Inspection forms and guidelines for quality control inspections shall be prepared in accordance with the standards specified in the contract documents and submitted within the QCP.

Success of manhole rehabilitation leverages an industry standard of care, performance specification, and an inspector that understands manhole rehabilitation quality control procedures required on the project and for the SYSTEMS being furnished. The inspector should be trained and knowledgeable in where the SYSTEM is applicable, technology procedures, surface preparation, material mixing, application/installation, curing requirements, acceptability standards and required testing. It is recommended that Owner personnel or the Owner's representative performing and documenting inspections or testing be required to be NASSCO-Certified Professionals in MACP and/or ITCP for Manhole Rehabilitation, as applicable to the scope of work for the project.

1.10 DELIVERY, STORAGE AND HANDLING

- A. Rehabilitation component materials are to be kept dry, protected from weather and stored under cover and in accordance with manufacturer's recommendations.
- B. Materials are to be handled according to their safety data sheets (SDS) and manufacturer recommendations.

1.11 WARRANTY

The Contractor should warrant the SYSTEMS material and installation for a period as specified. Extended warranties may be considered on repaired defects or new technologies. After completion of the work but before the warranty period has expired, the Owner should inspect a portion of the rehabilitated SYSTEMS. The warranty inspection may be based on the recommendations documented by the project inspector during the execution of the project. Defects found should be remedied in accordance with the repair/replacement plan submitted in the PWS. Depending on the frequency of defects found, the Owner may inspect more installations, as necessary.

- A. The materials used for the project shall be certified by the manufacturer for the specified purpose. The manufacturer shall warrant the SYSTEMS to be free from defects in raw materials for [X period] after installation or from the date of acceptance by the Owner, whichever is later. The Contractor shall warrant the installation of the rehabilitation component for a period of [X]. During the warranty period if the rehabilitation component fails, delaminates, peels or presents a defect, which may materially affect the integrity, strength, function and/or operation of the manhole structure, it shall be immediately repaired at the Contractor's expense to the quality originally specified or approved in the contract documents.

The Owner should perform, at its own cost, warranty inspections with its own personnel or personnel independent of the installation Contractor.

Inspection of the manholes should be performed and documented by a qualified inspector knowledgeable of the SYSTEMS used for the repair, rehabilitation and/or replacement of the manhole and/or its selected components.

PART 2 PRODUCTS

2.1 GENERAL

- A. The SYSTEMS defined herein include those identified as commercially accepted methods for manhole rehabilitation. Methods or products not defined herein must be pre-approved by the Owner before use on this project under these specifications.
- B. Materials used to stop infiltration, repair and rehabilitate shall be chemically compatible and designed to work together without causing adverse reactions or degradation to ensure the durability and effectiveness of the installed SYSTEMS.

2.2 MATERIALS

Specific physical properties and minimum test values may be included within the specifications; alternatively, these should be provided in the PWS submitted by the Contractor, along with third party test results and/or other documentation supporting the compliance of the submitted SYSTEMS with the contract requirements.

A. Infiltration Control Materials

- 1. Hydraulic Water Plug - rapid setting cementitious materials shall be designed specifically for leak control with the following requirements:
 - a. References:
 - 1) *ASTM C109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)*
 - 2) *ASTM C1090 Standard Test Method for Measuring Changes in Height of Cylindrical Specimens of Hydraulic-Cement Grout*
 - b. [Optional] Initial Set Time at 70°F: 60 to 90 seconds with final set time 1 hour
 - c. [Optional] Compressive Strength, ASTM C109, minimum value of [XXX] psi in 1 hour, [XXX] psi at 24 hours.
 - d. [Optional] Shrinkage, ASTM C1090, minimum value at 28 days of 0%, tested at 90% relative humidity.
- 2. Chemical Grout Material - chemical grout specially formulated to stop active infiltration, seal cracks and around penetrations.
 - a. References:
 - 1) *ASTM F2414 Standard Practice for Sealing Sewer Manholes Using Chemical Grouting.*
 - b. The grout shall quickly react with water to form a waterproof membrane. Minimum set time shall be established to ensure grout travel is achieved to stop active infiltration. Reaction time and shrinkage shall be controllable with the use of chemicals supplied by the same manufacturer.
 - c. The grout shall be non-toxic in its cured form.

- d. Oakum Water Plugs shall include rapid setting, oil-free oakum and hydrophilic grout to seal active infiltration. Oil-free oakum meeting Federal Specification HH-P-117 saturated with a hydrophilic urethane resin specially formulated for leak control.

Injection grouting guidelines from NASSCO are available for use in addressing infiltration without the installation of additional rehabilitation products.

B. Repair Materials

1. Materials shall be designed to fill large voids in manhole walls and to repair or reconstruct benches, channels, and inverts.
2. Repair materials shall be specifically designed and/or formulated for compatibility with other materials to be used in contact with repair materials or resistant to direct exposure to the corrosive environment of the existing manhole.
 - a. Polymer materials shall include solvent-free polymer grout or mastic.
 - b. Cementitious materials shall include factory blended, rapid setting, high early strength, non-shrink repair mortar.

C. Cementitious Materials

1. References
 - a. ASTM F2551 Standard Practice for Installing a Protective Cementitious Liner System in Sanitary Sewer Manholes
 - b. ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
 - c. ASTM C78 Standard Test Method for Flexural Strength of Concrete; Using Simple Beam with Third Point Loading
 - d. ASTM C109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)
 - e. ASTM C267 Standard Test Methods for Chemical Resistance of Mortars, Grouts, and Monolithic Surfacing and Polymer Concretes
 - f. ASTM C469 Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
 - g. ASTM C496 Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
 - h. ASTM C666 Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
 - i. ASTM C882 Standard Test Method for Bond Strength of Bonding Systems Used With Concrete by Slant Shear

- j. ASTM C1090 Standard Test Method for Measuring Changes in Height of Cylindrical Specimens from Hydraulic-Cement Grout
- 2. Materials shall be factory blended, one-component (just add water) cementitious or geopolymer formulations specifically designed for the rehabilitation of manholes.
- 3. Suitable for hand troweled, spray or centrifugally cast (i.e., spincast) application.
- 4. Materials shall meet the requirements of these contract documents. When specified for corrosion resistance, test results shall include sulfide resistance in accordance with ASTM C267.

Depending upon the performance required, these products may have a variety of materials added to the cement-based mix such as corrosion resistant cements, fibers, and antimicrobial additives. Most cementitious materials are capable of being applied in a single coat to the design thickness required, typically ranging from 0.50 in. (12 mm) to 1 in. (25mm). The application method and design thickness should be submitted as part of the PWS.

Experience has shown that there may be variation between the design minimum wall thickness versus the practical or recommended minimum wall thickness to be applied for these materials. Manufacturer's application thickness and recommendation, as well as design thickness calculations submitted, should be based on the condition of the substrate and the material's ability to withstand operating conditions to provide the required performance specified in the contract documents. ASCE MOP 92 provides additional guidance in Chapter 7.

- 5. [Optional] Minimum acceptable test values shall be:
 - a. Compressive Strength, ASTM C39 or ASTM C109, >[XXX] psi at 1 day, >[XXX] psi at 28 days
 - b. Bond Strength, ASTM C882, >[XXX] psi at 28 days
 - c. Freeze/Thaw, ASTM C666, 300 cycles, no damage
 - d. Sulfide resistance, ASTM C267, pH 1 sulfuric acid with <3% loss after 90 days
 - e. Shrinkage, ASTM C1090, 0% 28 days at 90% RH

D. Polymeric Materials

- 1. References
 - a. ASTM D543 - Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
 - b. ASTM D638 - Standard Test Method for Tensile Properties of Plastics
 - c. ASTM D695 - Standard Test Method for Compressive Properties of Rigid Plastics

- d. ASTM D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 - e. ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages
 - f. ASTM D7234 - Standard Test Method for Pull-off Adhesion Strength of Coatings On Concrete Using a Portable Adhesion Tester
 - g. ASTM G210 - Standard Practice for Operating the Severe Wastewater Analysis Testing Apparatus
 - h. SSPC SP-10/NACE No. 2 - Near-White Metal Blast Cleaning
 - i. SSPC SP-13/NACE No. 6 – Surface Preparation of Concrete
 - j. ICRI Technical Guideline No. 310.2R - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair
 - k. NACE SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
- 2. Polymeric materials shall include epoxy, polyurethane, polyurea, and multi-layer polyurea with polyurethane foam SYSTEMS. These shall be solvent-free and specifically formulated and designed for the rehabilitation of manholes.
 - 3. Suitable for hand troweled, spray or centrifugally cast (i.e., spincast) application.
 - 4. Materials shall meet the performance requirements of these contract documents. Chemical resistance test results shall include reagents commonly found within sanitary sewer environment when tested in accordance with ASTM D543.

When polymeric materials are applied to form a monolithic coating of the fully exposed interior part of the structure, and the SYSTEM relies on bonding to the existing substrate, the minimum thickness of the materials is determined based on the condition of the substrate and the material's ability to withstand the operating conditions, as well as its capacity to provide the required performance specified in the contract documents. When polymeric materials do not rely on bonding to the existing substrate, these SYSTEMS may be designed as thin walled, vertically oriented cylindrical shells capable of resisting external hydrostatic pressure from the surrounding ground, as well as any earth or live load(s) acting on the manhole structure. ASCE MOP 92 provides additional guidance in Chapter 7.

Test values of the various types of polymeric materials will differ. When specifying more than one type of polymeric material consideration should be given to listing applicable ASTM test methods and acceptable test values for each material type.

5. [Optional] Minimum acceptable test values shall be:
 - a. Tensile Strength, ASTM [XXX], >[XXX] psi
 - b. Compressive Strength, ASTM [XXX], >[XXX] psi
 - c. Flexural Strength, ASTM [XXX], >[XXX] psi
 - d. Bond Strength, ASTM [XXX], substrate failure
- E. Hand Applied Reinforced Materials
 1. References
 - a. ASTM D543 - Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
 - b. ASTM D638 - Standard Test Method for Tensile Properties of Plastics
 - c. ASTM D695 - Standard Test Method for Compressive Properties of Rigid Plastics
 - d. ASTM D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 - e. ASTM D7234 - Standard Test Method for Pull-off Adhesion Strength of Coatings on Concrete Using a Portable Adhesion Tester
 - f. ASTM G210 - Standard Practice for Operating the Severe Wastewater Analysis Testing Apparatus
 - g. SSPC SP-10/NACE No. 2 - Near-White Metal Blast Cleaning
 - h. SSPC SP-13/NACE No. 6 – Surface Preparation of Concrete
 - i. ICRI Technical Guideline No. 310.2R - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair
 - j. NACE SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
 2. Materials shall consist of fiberglass fabric of Type E glass and solvent-free epoxy specifically formulated and designed for use in constructing a composite liner for the rehabilitation of manholes.
 3. [Optional] Minimum acceptable test values for the composite SYSTEMS shall be:
 - a. Tensile Strength, ASTM D638, >[XXX] psi
 - b. Compressive Strength, ASTM D695, >[XXX] psi
 - c. Flexural Strength, ASTM D790, >[XXX] psi
 - d. Bond Strength, ASTM D7234, substrate failure
 4. Materials shall meet the performance requirements of these contract documents. Chemical resistance test results shall include reagents commonly found within sanitary sewer environment when tested in accordance with ASTM D543.

F. Cured-In-Place Manhole (CIPM) Materials

1. References

- a. ASTM D543 - Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
- b. ASTM D638 Standard Test Method for Tensile Properties of Plastics
- c. ASTM D695 Standard Test Method for Compressive Properties of Rigid Plastics
- d. ASTM D790 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- e. ASTM F3033 Standard Practice for Installation of a Single-Sized Cured-In-Place Liner Utilizing an Inflatable Bladder for Resurfacing Manhole Walls of Various Shapes and Sizes.
- f. ASTM D3039 Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials
- g. ASTM D4787 Standard Practice of Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
- h. ASTM D7234 Standard Test Method for Pull-Off Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
- i. SSPC SP-10/NACE No. 2 - Near-White Metal Blast Cleaning
- j. SSPC SP-13/NACE No. 6 – Surface Preparation of Concrete

2. Materials shall consist of textile materials made of felt and/or fiberglass fabric, and a non-porous membrane layer designed for saturation with compatible thermosetting resins for use with polyvinyl chloride/polyester (PVCP) liner material to form a composite once cured specifically for partial or full-depth rehabilitation of a manhole or the structural sealing of the chimney component.

Refer to NASSCO's Guideline for the Safe Use and Handling of Styrene-Based Resins in Cured-In-Place Pipe when styrene-based polyester or vinyl ester resins are to be used.

3. [Optional]. Minimum acceptable test values shall be:

- a. Tensile Strength, ASTM D638 or ASTM D3039, >[XXX] psi
- b. Flexural Strength, D790, >[XXX] psi
- c. Compressive Strength, D695, >[XXX] psi
- d. Bond Strength, ASTM D7234, substrate failure

4. Materials shall meet the performance requirements of these contract documents. Chemical resistance test results shall include reagents commonly found within sanitary sewer environment when tested in accordance with ASTM D543.

G. Poured-In-Place Manhole Materials

1. References

- a. ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
 - b. ASTM C94 Standard Test Method for Ready-Mix Concrete
 - c. ASTM C1244 Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
2. Materials shall consist of Type I/II Portland cement concrete in accordance with ASTM C94, with maximum aggregate size of 5/8 inch, fiber reinforcement, and plasticizers producing an 8 to 10 in. slump specifically designed for poured-in-place construction of manholes.
3. Concrete walls shall have a cross-sectional dimension of sufficient thickness to be structurally independent and allow for the maximum new finished inside diameter.
4. [Optional] Minimum acceptable Compressive Strength, ASTM C39, [XXX] psi at 28 days.

H. Panel Liners

1. References

- a. ASTM C1244 Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
 - b. ASTM D412 Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
 - c. ASTM D543 - Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
 - d. ASTM D638 - Standard Test Method for Tensile Properties of Plastics
 - e. ASTM D4787 Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates
2. Panel materials shall consist of:
- a. High density polyethylene (HDPE) integrally extruded complete with anchoring studs, minimum [XX] studs per square foot. The minimum thickness of panel sheet with anchoring studs shall be [X] mm (X.XX inch). The minimum thickness of flat liner sheet at joint overlaps shall be [X] mm (X.XX inch). Joint materials shall be of the same material type and capable of being sealed using thermal welding as recommended by the manufacturer.
 - b. Polyvinyl chloride (PVC) is integrally extruded complete with anchoring studs at maximum [X] inch center and minimum [X.XX] inch deep. The minimum thickness of liner sheet with anchoring studs and the joint overlaps shall be [X] mm (X.XX inch). Joint materials shall be of the same material type and

capable of being sealed using thermal welding as recommended by the manufacturer.

3. Grout materials shall consist of flowable concrete or polymer mastic specifically designed for use with the panel materials in the rehabilitation of manholes.
4. [Optional] Minimum acceptable test values of the panel material shall be:
 - a. Tensile Elongation at Break, ASTM D412 or ASTM D638, HDPE >400%, PVC >200%
 - b. Minimum pull-out strength (from grout material): 100 pounds per linear inch
5. Materials shall meet the performance requirements of these contract documents. Chemical resistance test results shall include reagents commonly found within sanitary sewer environment when tested in accordance with ASTM D543.

I. Manhole Inserts

1. References
 - a. ASTM C1244 Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill
 - b. ASTM D3753 Standard Specification for Glass-Fiber Reinforced Polyester Manholes and Wet Wells
2. Inserts shall comply with ASTM D3753 and the following:
 - a. Inserts shall be single piece barrel and [concentric] [eccentric] reducer construction without seams, joints, or sections, comprised of chopped strand and continuous fiber glass reinforcement within isophthalic polyester resin containing finely graded sand. Materials shall be resistant to corrosive attack from sanitary sewage and sewer gases including sulfuric acid and shall satisfy the 100,000-hour criterion in ASTM D3753.
 - b. Interior and exterior surfaces shall be smooth and free of sharp projections and protruding glass fibers. No blisters or delamination shall be visible.
 - c. Inserts shall be sized to fit inside existing manholes and allow grade rings and frame between the top and finish grade. Wall thickness shall provide an AASHTO H-20 load rating and wall stiffness of 36 psi minimum.
3. Sealants
 - a. A sealant, as recommended by the manufacturer shall be inserted between the fiberglass reinforced polymer reducer and frame.
 - b. Sealant between fiberglass reinforced polymer insert and the surfaces of the manhole base shall be a quick-setting grout as recommended by the manufacturer.
 - c. Grout shall meet the specifications required by the manufacturer.

J. Mechanical Chimney Seal Materials

1. References

- a. ASTM C923 Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
2. The flexible sleeve portion of the seal shall be extruded or molded from a high-quality rubber compound, which conforms to the resilient material properties prescribed in ASTM C923 Table 1.
 - a. The sleeve shall have an unexpanded vertical height sufficient to seal the entire grade adjustment area and be corrugated or pleated to allow for vertical and horizontal movement.
 - b. The expansion bands used for compressing the sleeve and extensions against the manhole shall be fabricated stainless steel, conforming to the applicable section 4.2 of ASTM C923. The manufacturers mechanism used to expand the bands shall have the capacity to develop sufficient pressure to create a watertight seal. The bands shall be permanently held in the expanded position with a positive locking mechanism that conforms to the applicable section 4.2 of ASTM C923.

K. Applied Polymer Chimney Seals

1. References

- a. ASTM D543 - Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
- b. ASTM D638 - Standard Test Method for Tensile Properties of Plastics
- c. ASTM D695 - Standard Test Method for Compressive Properties of Rigid Plastics
- d. ASTM D790 - Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
- e. ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages
- f. ASTM D7234 - Standard Test Method for Pull-off Adhesion Strength of Coatings on Concrete Using a Portable Adhesion Tester
- g. SSPC SP-10/NACE No. 2 - Near-White Metal Blast Cleaning
- h. SSPC SP-13/NACE No. 6 – Surface Preparation of Concrete
- i. ICRI Technical Guideline No. 310.2R - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair
- j. NACE SP0188 - Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates

2. Polymer chimney seal materials shall include epoxy, polyurethane, and polyurea SYSTEMS. These shall be solvent-free and specifically formulated and designed for rehabilitation and sealing of a manhole chimney.
 3. Suitable for hand troweled or spray application.
 4. [Optional] Minimum acceptable test values shall be:
 - a. Tensile Elongation at Break, ASTM D638, >[XXX]%
 - b. Tensile Strength, D638, >[XXX] psi
 - c. Bond Strength, ASTM D7234, substrate failure
 5. Materials shall meet the performance requirements of these contract documents. Chemical resistance test results shall include reagents commonly found within sanitary sewer environment when tested in accordance with ASTM D543.
- L. Cured-In-Place Manhole Chimney Seals
1. References
 - a. ASTM D543 - Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents
 - b. ASTM D638 Standard Test Method for Tensile Properties of Plastics
 - c. ASTM D695 Standard Test Method for Compressive Properties of Rigid Plastics
 - d. ASTM D790 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 - e. ASTM F3033 Standard Practice for Installation of a Single-Sized Cured-In-Place Liner Utilizing an Inflatable Bladder for Resurfacing Manhole Walls of Various Shapes and Sizes.
 - f. ASTM D3039 Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials
 - g. ASTM D4787 Standard Practice of Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates.
 - h. ASTM D7234 Standard Test Method for Pull-Off Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.
 - i. SSPC SP-10/NACE No. 2 - Near-White Metal Blast Cleaning
 - j. SSPC SP-13/NACE No. 6 – Surface Preparation of Concrete
 2. The cured-in-place manhole chimney seal consists of a resin impregnated textile tube that is inserted into the manhole chimney and cured under pressure.

3. [Optional] Minimum acceptable test values shall be:
 - a. Tensile Strength, ASTM D638 or ASTM D3039, >[XXX] psi
 - b. Flexural Strength, D790, >[XXX] psi
 - c. Compressive Strength, D695, >[XXX] psi
 - d. Bond Strength, ASTM D7234, substrate failure

M. Manhole Frame and Cover

1. References
 - a. AASHTO M306 Standard Specifications for Drainage, Sewer, Utility, and Related Castings
 - b. ASTM A48 Standard Specification for Gray Iron Castings
 - c. ASTM A536 Standard Specification for Ductile Iron Castings
2. Gray iron castings shall conform to the requirements of ASTM A48 Class 35B.
3. Ductile iron castings shall conform to the requirements of ASTM A536 Grade 80-55-06, unless otherwise specified by the Owner.
4. Castings shall be manufactured true to pattern and component parts shall fit together in a satisfactory manner. Circular manhole frames, covers, and grates shall be furnished with machined horizontal bearing surfaces unless otherwise specified. Square and rectangular units shall be furnished with an as-cast bearing surface unless otherwise specified
5. All frame and cover materials shall meet the load rating requirements of AASHTO M306.

N. Manhole Frame Adjustment Materials

1. References
 - a. AASHTO M306 Standard Specifications for Drainage, Sewer, Utility, and Related Castings
 - b. ASTM C478 Standard Specification for Precast Reinforced Concrete Manhole Sections
 - c. ASTM D3575 Standard Test Methods for Flexible Cellular Materials Made from Olefin Polymers
 - d. ASTM D4819 Standard Specification for Flexible Cellular Materials Made From Polyolefin Plastics
 - e. ASTM D4976 Standard Specification for Polyethylene Plastics Molding and Extrusion Materials
2. Manhole frame adjustment materials shall be HDPE, PVC, expanded polypropylene (EPP), rubber, brick, block, cement or poured concrete meeting the requirements of applicable material type standards as shown in detail in these specifications.

Approved products and standard specifications of the Owner should be incorporated in the specifications when frame adjustment materials may be required during the rehabilitation of manholes.

3. All manhole adjustment materials shall meet the load rating requirements of AASHTO M306, HS-20 and HS-25.

O. Manhole Steps

1. References
 - a. ASTM C478 Standard Specification for Pre-cast Reinforced Concrete Manhole Sections
 - b. ASTM A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
 - c. AASHTO M199 Standard Specification for Precast Reinforced Concrete Manhole Sections
2. Reinforcing bar manhole steps shall conform to the minimum requirements of ASTM C478, Para, 11. The reinforcing bar shall be grade 60, deformed 0.50-inch (12 mm) reinforcing bar conforming to the requirements of ASTM A615.
3. Manhole steps or step bolts shall meet the requirements of CFR 1910.24 Subpart D.

PART 3 EXECUTION

3.1 GENERAL

- A. Maintain or bypass flow in the manhole throughout duration of project to prevent backups or overflows.
- B. Provide 48-hour notice to the Owner prior to the start of work for the Inspector to review and document materials and equipment to be used, for Quality Assurance and testing requirements.
- C. Contractors qualified in accordance with these specifications shall perform the installation or application of the SYSTEM.
- D. SYSTEM installation or application shall be made in accordance with these specifications, by the Contractor, using equipment and methods as recommended and approved by the specific SYSTEM manufacturer, including surface preparation, material installation or application, cure, sampling and testing.
- E. Confirm that SYSTEMS and materials to be used for the rehabilitation of the manhole are compatible. Do not use materials that have not been verified for compatibility.

- F. Method for SYSTEM termination in a manhole shall be in accordance with the requirements of the SYSTEM manufacturer, or as submitted and approved in the PWS.

Verify with asset owner as to whether manhole steps are to be replaced after removal when necessary for proper SYSTEM installation.

Many municipalities or asset owners require step removal to discourage entry without following confined space entry regulations.

3.2 PRE-REHABILITATION PREPARATION

Preparation of the manhole structure should be considered a critical project requirement when rehabilitating a manhole. If the manhole is not properly cleaned and prepared, the effective life of the rehabilitated manhole may be reduced significantly. Surface preparation for materials that rely on adhesion, must produce a sound surface including a roughness profile and porosity that will promote a strong mechanical bond between the manhole surface and the applied material.

When the channel is rehabilitated, flow control can be as simple as plugging the incoming pipes and monitoring the flow back-up in each pipe, placing a flow through jumper plug from the incoming pipe to the outgoing pipe of the manhole and allowing the flow to continue through the jumper pipe. Conditions such as incoming force mains, large diameter sewers, or high flow levels may require bypassing the existing flow around the manhole being rehabilitated. To achieve a monolithic installation, flow must be diverted from those areas of the manhole that are planned for rehabilitation.

- A. Flow control shall be conducted as required by the SYSTEM manufacturer.
- B. Prior to the application or installation of a coating or lining system, the manhole surfaces shall be cleaned and prepared to produce a uniform, sound, clean and neutralized surface suitable for installation or application of the specified system, and to promote adhesion to the manhole surfaces when required.
- C. Before starting cleaning or preparation work, install a perforated device, catch bucket, or other straining device to prevent construction debris from entering downstream pipes.
- D. Standard Portland cement - concrete (not quick setting high strength cement) must cure a minimum of 28 days prior to application of the coating product(s), unless otherwise approved by the Owner.
- E. Clean interior surfaces of manhole to produce a uniform, sound, clean and neutralized surface suitable for installation or application of the specified SYSTEMS, and to promote adhesion to the manhole surfaces when required for performance of the SYSTEMS being installed.

Thoroughly clean, removing unsound or loose material, grease, dirt, and existing coatings and prepare existing surfaces to promote a mechanical bond with the coating or lining.

Cleaning equipment and methods are submitted by the Contractor in the PWS based upon the existing materials (i.e., brick, concrete, block, cast iron, steel) and condition of the surfaces being rehabilitated, contaminants present, access to perform the work, and the requirements of the SYSTEMS to be applied or installed. A minimum capability of 3,500 psi (508 kPa) to 5,000 psi (725 kPa) at 4 gpm (0.25 l/sec) using a rotating nozzle, should be used when pressure washing manhole walls to remove loose mortar, concrete and debris. Pressure washing levels, used for cleaning, shall be as recommended by the SYSTEMS manufacturer. Other methods include abrasive blasting and hand tool cleaning.

Use of biodegradable detergents and/or hot water may be required to remove fats, oils and grease.

When coating or lining, adhesion to the existing substrate is required, and surface preparation must produce a sound surface including a roughness profile or Concrete Surface Profile (CSP) that will promote a strong mechanical bond between the manhole surface and the coating or lining being applied or installed. Coating and lining materials used in manhole rehabilitation do not create a chemical bond with the substrate.

Moisture content in the substrate can inhibit adhesion of coatings and linings. Moisture content in manhole substrates may be described as including five states: 1) wet - substrate is saturated with visible water present on the surface; 2) damp - moisture is present in the substrate, feels damp to the touch with possible visible signs of moisture on the surface; 3) saturated surface dry (SSD) - where the substrate is saturated with water, but there is no standing water on the surface, and although the surface may appear damp, it neither glistens nor feels wet to the touch; 4) air dry - where the substrate is not fully dry but has been exposed to air where it no longer feels wet to the touch; and 5) oven dry - where the moisture is removed by using a heat source leaving the substrate completely dry. The requirements for surface preparation including acceptable moisture content of the substrate should be provided by the coating or lining manufacturer.

F. Sealing Active Infiltration

1. The work consists of hand applying a hydraulic water plug or chemical grout designed to instantly stop running water or seepage in concrete and masonry structures. The applicator shall apply material in accordance with manufacturer's recommendations in accordance with the following minimum specifications:
 - a. The area to be repaired must be clean and free of debris per the requirements set forth elsewhere in these specifications.

- b. Once cleaned, prepare crack or hole by chipping out loose material to a minimum depth recommended.
- c. As recommended by the manufacturer, place a generous amount of the hydraulic water plug material to the active leak, with a smooth fast motion, maintaining external pressure as recommended by the manufacturer, repeat until leak is stopped.
- d. Proper application should not require special mixing of product or special curing requirements after application.
- e. Oil-free oakum water plugs are made by saturating oakum with chemical grouts following approved submittals and using additives as required. Place and cure following manufacturer's recommendations.
- f. Injection grouting shall consist of the injection of chemical grouts following approved submittals to stop active infiltration installed in accordance with ASTM F2414.

INJECTION GROUTING - refer to NASSCO Grouting Unified Safe Operating Practices Program and Specification Guideline for Pipeline Packer Injection Pre-Rehabilitation Grouting for guidance when using chemical grouts in pre-rehabilitation preparation of manholes. Injection grouting should only be performed on a structurally sound manhole unless the grout is used to prevent water from entering the manhole during application of a lining or coating system. Structural repairs, adjustments to the frame and cover or installation of grade adjustment rings shall be completed prior to beginning the grouting operation. Normal grouting operations shall be performed at the temperatures as recommended by the manufacturer.

G. Repair and Resurfacing

- 1. Repair irregularities in manhole using materials compatible with proposed SYSTEM materials and as recommended by the manufacturer.
- 2. Repair products shall be used to fill voids, bug holes, and/or smooth transitions between components prior to the installation of the SYSTEMS. Repair materials must be properly cured and must be compatible with the SYSTEMS and shall be used and applied in accordance with the manufacturer's recommended requirements.
- 3. Large voids shall be filled using products consistent with the original construction.
- 4. All repair and resurfacing materials should be properly cured and prepared for SYSTEM top coated application. When the repair or resurfacing material is to be top coated, the cure required shall be as recommended by the topcoat SYSTEM manufacturer.
- 5. Trim and grout incoming laterals and pipes as required to install the specified SYSTEMS.

- H. Remove debris from manhole and incoming sewer connections.
 - 1. Handle cleaning water to prevent water and residue from causing damage.
 - 2. Do not discharge debris downstream through the sewer system.
 - 3. Filter solids-laden water through a de-silting device.
 - 4. Properly dispose of debris and residue from cleaning and other construction operations in accordance with regulations of the Owner and authority having jurisdiction over area where work site is located.
- I. Invert Repair and Rebuild
 - 1. Use approved repair materials to fill large voids and repair manhole channels prior to installation of SYSTEMS. For invert repairs, flow must be temporarily removed or diverted prior to cleaning.
 - a. The area to be repaired must be cleaned and free of debris.
 - b. Mix water used with cementitious patching materials shall be clean potable water.
 - c. Cementitious material shall be mixed per manufacturer's specifications.
 - d. Once mixed to proper consistency, the materials shall be applied to the invert or void areas by hand or trowel. For in invert applications, care should be taken to not apply excessive material in the channel, which could restrict flow. Once applied, materials should be smoothed either by hand or trowel to facilitate flow, minimize turbulence, and avoid the collection of debris.
 - e. Flow shall be released when material has set or cured in accordance with manufacturer's requirements.

3.3 REHABILITATION

- A. Provide all materials, labor, and equipment required to perform the work as recommended by the SYSTEMS manufacturer and as required by these specifications.
- B. Inspect each manhole to determine active infiltration has been stopped and repairs performed in accordance with the requirements of the rehabilitation SYSTEMS to be installed or applied.

Promptly inform Owner of errors or discrepancies between these specifications and the field conditions found, in order that changed conditions can be evaluated and revised directives issued in a timely manner.

If an internal chimney seal is required in conjunction with a rehabilitation SYSTEM, specifications should clearly define the sequence of rehabilitation and requirements to prepare rehabilitated surfaces for the installation of the chimney seal after the SYSTEM has been installed.

This PSG includes various inspection and testing options for each SYSTEM. Depending on the specific conditions, the rehabilitation product being installed, and the size and scope of the project, appropriate test methods should be selected and incorporated into the project specifications. These tests should include measurable criteria and acceptable results, with consideration given to value and cost-effectiveness.

3.4 CEMENTITIOUS SYSTEMS

- A. The work consists of troweling, spray applying and/or spincasting cementitious materials to the inside of the existing manhole.
- B. Flow shall be controlled or removed from application surfaces until the cementitious SYSTEM is set and cured in accordance with the requirements of the material manufacturer.
- C. Surfaces shall be prepared in accordance with the requirements of the SYSTEM manufacturer. Material shall be applied only when manhole is in a damp to wet or saturated surface dry (SSD) state, or in accordance with the requirements by the SYSTEM manufacturer.
- D. Active infiltration shall be stopped prior to application of the cementitious SYSTEMS.
- E. Cementitious material shall not be applied during freezing weather conditions where the ambient temperature is 37°F (3°C) and falling, or when the temperature is anticipated to fall below 32°F (0°C) within the ensuing 24 hours.
- F. Cementitious material shall be mixed with potable water in accordance with the requirements of the SYSTEM manufacturer. Once mixed to proper consistency, the cementitious mortar shall be pumped to the nozzle or rotating applicator head.
- G. Application of cementitious SYSTEMS shall be in accordance with the requirements of the SYSTEM manufacturer and ASTM F2551.
- H. Manhole steps shall be removed flush to the manhole surface prior to installation of the cementitious SYSTEM unless otherwise specified in the contract documents.
- I. Application
 - 1. Spray or spincast application methods shall be executed in accordance with the requirements of the SYSTEM manufacturer.
 - 2. Spraying shall be performed by starting at the manhole invert and progressing up the wall to the chimney.
 - 3. The spincast device used for application is raised and lowered at a controlled retrieval speed conducive to centrifugally casting the mortar to produce a uniform application to the interior surfaces of the manhole.

4. Cementitious material shall be applied at a uniform minimum thickness as approved in the design submitted in accordance with the contract documents.
 5. Cementitious material shall be applied to the bench area in such a manner as to provide for proper drainage.
 6. Cementitious material thickness may be verified using a depth gauge. If additional material is required, the rotating applicator head shall be placed at that level and application shall recommence until that area is thickened.
 7. Spray and spincast application methods may be used in conjunction to facilitate application of the mortar material to irregularities in the contour of the manhole walls and bench areas.
- J. Once spray application has completed, the cementitious material shall be troweled to densify and smooth out the surfaces while compacting the material into voids. A brush or broom finish may be conducted as required by the SYSTEM manufacturer specified for top coating.
- K. For the proper cure, the manhole cover shall be replaced no more than 10-20 minutes after troweling is completed to avoid moisture loss in the material due to sunlight and wind.
- L. Testing and Acceptance
1. Perform a visual inspection to verify that there is no infiltration and that the surface appears uniform, free of cracks or loose material.
 2. Perform a vacuum test to verify the integrity of fully rehabilitated manholes in accordance with ASTM C1244.
 3. Obtain cube or cylinder samples of the cementitious material for each manhole or batch of material, as required by the Owner. The samples shall be prepared by the Contractor and sent to the Owner, through a chain of custody, to an independent laboratory for testing of compressive strength at 28 days in accordance with ASTM C39 or ASTM C109.

3.5 POLYMERIC SYSTEMS

- A. The work consists of troweling, spray applying and/or spincasting polymeric materials to the inside of the existing manhole.
1. Contractors qualified in accordance with these specifications shall perform the application or installation of the polymeric SYSTEMS.
- B. Flow shall be controlled or removed from application surfaces until the polymeric material is applied and cured in accordance with the requirements of the material manufacturer.

Choice of surface preparation method(s) should be based upon the condition of the structure and concrete or masonry surface, potential contaminants present, access to perform work, and required cleanliness and profile of the prepared surface to receive the specified polymer coating product, as recommended by the manufacturer.

Surface preparation methods or combination of methods that may be used include high pressure water cleaning, high pressure water jetting, abrasive blasting, grinding, scarifying, detergent water cleaning, hot water blasting, and others as described in NACE No. 6/SSPC SP-13 to achieve the surface profile as described in ICRI Technical Guideline No. 310.2R as recommended by the polymeric manufacturer. Whichever method(s) are used, they shall be performed in a manner that provides a uniform, sound clean neutralized surface with sufficient profile to promote an acceptable bond with the specified polymer coating.

- C. Surfaces shall be cleaned and prepared as required by the polymeric material manufacturer and defined in SSPC SP-13/NACE No. 6 to acceptable moisture levels within the substrate and with a uniform, sound clean neutralized surface having sufficient profile to promote a mechanical bond with the polymeric coating. Oils, grease, incompatible existing coatings, waxes, form release, curing compounds, efflorescence, sealers, salts, or other contaminants which may affect the performance and adhesion of the coating to the substrate shall be removed. Concrete and/or mortar damaged by corrosion, chemical attack or other means of degradation shall be removed so that only sound substrate remains.
 - 1. Epoxy polymeric SYSTEMS shall be applied only when manhole surfaces are in a saturated surface dry (SSD) state, with no visible water dripping or running over the manhole walls, or as required by the SYSTEMS manufacturer. The prepared surface profile shall meet ICRI 310.2R CSP 3-5, or as required by the SYSTEMS manufacturer.
 - 2. Polyurethane, polyurea, and hybrid polymeric SYSTEMS shall be applied only when manhole surfaces are in an oven-dry or air-dry state, with the surface feeling dry to the touch, or as required by the SYSTEMS manufacturer. The prepared surface profile shall be to ICRI 310.2R CSP 3-5, or as required by the SYSTEMS manufacturer.
- D. Active infiltration shall be stopped prior to application of polymeric SYSTEMS.

- E. Repair materials compatible with the polymeric SYSTEMS shall be used to fill voids, bugholes, and other surface defects which may affect the performance or adhesion of the polymeric SYSTEMS and to repair, smooth or rebuild surfaces providing a concrete or masonry substrate suitable for application of the polymeric SYSTEMS. These materials shall be designed and installed to minimum thickness as recommended within the polymeric SYSTEMS manufacturer's published guidelines. Should resurfacing or rebuilding be necessary, these products shall be installed to a thickness as specified in these specifications, submitted and approved in accordance with the contract documents.
 - 1. Areas where corroded rebar is observed shall be cleaned and prepared in accordance with ICRI 310.1R and coated with the specified or approved polymeric material as recommended by the polymeric SYSTEMS manufacturer.
 - 2. Repaired or resurfaced surfaces shall be inspected for cleanliness and suitability prior to application of the polymeric SYSTEMS. Additional surface preparation may be required prior to application.
- F. Specified surfaces shall be shielded to avoid exposure to direct sunlight or other intense heat source throughout the application process. Where varying surface temperatures exist, coating application shall be scheduled when the temperature is falling and not rising as recommended by the polymeric material manufacturer.
- G. Manhole steps shall be removed flush to the manhole surface prior to application of a polymeric SYSTEM unless otherwise specified in the contract documents as required by the Owner.
- H. Portland cement-based precast or poured-in-place structures shall have cured a minimum of 28 days since manufacture or installation date prior to commencing with application of a polymeric SYSTEM, or as recommended by the manufacturer.
- I. The polymeric SYSTEMS shall be terminated at the joint between the manhole chimney and frame, or as recommended by the SYSTEMS manufacturer and submitted as a part of the PWS.
- J. Spray Application
 - 1. Spray or spincast application methods shall be executed in accordance with the requirements of the SYSTEMS manufacturer.
 - 2. The spincast device used for application is raised and lowered at a controlled retrieval speed conducive to centrifugally casting the polymeric material to produce a uniform application to the interior surfaces of the manhole.
 - 3. Polymeric material shall be applied to the uniform minimum thickness as approved in the design submitted in accordance with the contract documents.

Application thickness recommendations are available through the polymeric SYSTEMS manufacturers based upon project assessment. Contact the SYSTEMS manufacturer for project specific recommendations.

4. Subsequent top coating or additional coats of a polymeric material shall occur within the material's recoat time. Additional surface preparation procedures will be required if this recoat time is exceeded. Requirements from the polymeric SYSTEMS manufacturer for the specific application, in consideration of temperature and project conditions, shall be followed by the Contractor.
5. When the polymeric materials rely on a mechanical bond with adjoining construction materials throughout the manhole structure to effectively seal and protect concrete or masonry substrates from infiltration and attack by corrosive elements, requirements by the polymer SYSTEMS manufacturer shall be followed.

K. Hand Applied Reinforced Application

1. The components of the epoxy resin system are measured and mixed according to the material manufacturer's requirements. The mixed epoxy resin is hand applied uniformly using a roller or trowel forcing the epoxy into the prepared surface filling gaps or voids to attain a smooth surface. The fiberglass fabric is then laid up into the epoxy base coat by hand and the use of rollers to push the fabric into the epoxy. Each fabric sheet should overlap the adjacent one slightly to ensure continuous and uniform reinforcement. Once the fabric is in place, additional epoxy resin is applied on top of it to fully saturate the fabric with resin. Rollers are then used to remove air bubbles and ensure contact between the wet composite and the substrate. The finished surface shall not have fiberglass fibers exposed.

L. Testing and Acceptance

1. Perform a visual inspection to verify that there is no infiltration, the installed SYSTEM uniformly covers specified surfaces, and is free of pinholes, or defects that could reduce its intended performance.
2. Measure the installed thickness of the SYSTEM to confirm it meets the minimum value required in these specifications. Wet film thickness shall be measured in accordance with ASTM D4414.
3. Inspect surfaces of the installed SYSTEM using holiday detection or spark testing equipment in accordance with NACE SP0188 to identify holidays and pinholes. Repair the identified defects and re-test.
4. Conduct adhesion testing in accordance with ASTM D7234 to verify that the SYSTEM is bonded to the manhole substrate, as evidenced by substrate failure during testing. Repair damage from testing, following the SYSTEM manufacturer's recommendations.

3.6 CURED-IN-PLACE MANHOLE (CIPM) SYSTEMS

- A. The work consists of installation of a reinforced fabric tube saturated with a polymer resin into a manhole that is expanded to conform to the existing manhole using air pressure and cured in place using controlled steam. Installation shall be performed in accordance with the requirements of the SYSTEM manufacturer or ASTM F3033.
 - 1. Contractors qualified in accordance with these specifications shall perform the installation of the CIPM SYSTEM.
- B. Flow shall be controlled or removed from installation surfaces until the CIPM is installed and cured in accordance with the requirements of the CIPM SYSTEMS manufacturer.
 - 1. When the CIPM is not extended within the channel, a bridge or flow through tube shall be installed within the channel. After installation, the bottom of the CIPM shall be cut near the flow line in the channel and the pipe connections opened to restore flow.
 - 2. When the CIPM is extended within the channel, the pipe openings shall be plugged prior to CIPM installation. Plug the pipes entering the manhole and line the flow channel to the edge of the pipe. Trim pipe openings and restore the flow in the channel.

Rehabilitation may include night work. The cost of night work required should be included in the contract price of the applicable item. The Contractor should not perform work to manholes until plans for bypass pumping or flow restriction have been submitted to the Owner and accepted. No plugging of existing utility system gravity mains should be made without submitting a plan to the Owner for review and acceptance.

- C. Surfaces shall be cleaned and prepared as required by the CIPM SYSTEMS manufacturer to acceptable moisture levels within the substrate and with a sound clean neutralized surface having sufficient profile to promote a mechanical bond with the liner when specified. Fats, oils, and grease shall be removed using hot water and an environmentally safe detergent when pressure washing the surfaces. The existing casting shall be prepared using a grinder or abrasive blasting.
- D. SYSTEMS shall be installed only when manhole surfaces are in a saturated surface dry (SSD) state, with no visible water dripping or running over the manhole walls. The prepared surface profile shall be to ICRI 310.2R CSP 3-5, or as required by the CIPM SYSTEMS manufacturer.
- E. Manhole steps shall be removed flush to the manhole surface prior to installation of a CIPM SYSTEM unless otherwise specified in the contract documents.
- F. Active infiltration shall be stopped prior to installation of the CIPM SYSTEMS.

- G. Repair materials compatible with CIPM SYSTEMS shall be used to fill holes, missing bricks, and voids larger than a baseball as recommended by the CIPM SYSTEMS manufacturer.

Specifications should consider including a separate bid item for Channel Rebuild when required. Specifiers may also include drawings or additional requirements on shaping of channels to accommodate maintenance needs.

- H. Remove loose grout and rubble of existing channel. Rebuild the channel by shaping and repairing slope of shelves or benches. Work shall include alignment of incoming and outgoing pipe flow in such manner to prevent the deposition of solids at the transition point(s). Structure invert shall follow the grades of the pipe entering the manhole.
- I. CIPM Premade-Liner Installation
1. The Contractor shall furnish materials, equipment, tools, and labor as required for the rehabilitation of the manholes specified, including the installation of the Premade-Liner.
 2. Line bench area with CIPM material placed in the bottom of the manhole and extending a minimum of 6 inches (150 mm) up the manhole wall.
 3. Saturate the Premade-Liner with resin. Insert it into the manhole, pressurize using air and cure with steam or hot air, or pressurize using water and cure with hot water following the requirements of the CIPM SYSTEMS manufacturer.
- J. CIPM Tube Installation
1. The Contractor shall measure the manhole depth and cut the Tube from a bulk roll to match the depth of the manhole.
 2. Using a controlled vacuum impregnation process, the resin is manually measured and mixed and introduced into the Tube following the requirements of the CIPM SYSTEMS manufacturer.
 3. The resin impregnated Tube is inverted through the center of the retaining ring until the liner is fully turned inside out and positioned within the manhole.
 4. An inflation bladder inserted within the Tube is pressurized to expand the Tube against the interior surfaces of the manhole and maintained until cured.

CIPM Tube installations commonly use ambient cure resins which typically cure within two hours of mixing. Cure can be accelerated with steam which can allow for winter or cold weather installations.

5. After cure is complete, the inflation bladder is removed and the CIPM Tube is trimmed at the top of the manhole frame flush with the manhole cover seat.

K. Testing and Acceptance

1. Perform a visual inspection to verify that there is no infiltration through the installed SYSTEM, and that it is free from severe wrinkles, areas deficient from uncured resin, delamination of the fabric layers, hollow areas behind the liner, or other defects that could reduce the intended performance of the SYSTEM.
2. Inspect surfaces of the installed SYSTEM using holiday detection or spark testing equipment in accordance with NACE SP0188 or ASTM D4787 to identify holidays and pinholes. Repair the identified defects and re-test. Conduct adhesion testing in accordance with ASTM D7234 to verify that the SYSTEM is bonded to the manhole substrate, as evidenced by substrate failure during testing. Repair damage from testing, following the SYSTEM manufacturer's recommendations.
3. Remove a core sample or measure the SYSTEM thickness from the adhesion test dolly, if scored and removed, to verify the wall thickness and confirm it meets the minimum value required in these specifications.

3.7 POURED-IN-PLACE CONCRETE LINER

- A. The existing manhole shall be cleaned to remove loose material and debris. Existing steps which interfere with the erection of the forms shall be removed. Precautions shall be taken to prevent foreign material from entering the active lines. Active infiltration shall be stopped or reduced as required by the SYSTEMS manufacturer.

B. Installation

1. Segmented, stackable steel forms shall be bolted together in cylindrical and conical sections with either eccentric or concentric cones or flat top ceilings and conform to the interior shape of the existing manhole.
2. Pipe extensions shall be placed through the new concrete wall at the base and at higher points of entry, such as drop inlets, to maintain flows during the procedure.
3. The form shall be sized and erected to conform to the existing interior dimensions and shape. The space between the forms and the existing wall shall be of sufficient thickness, as specified. The finished opening shall have a minimum diameter of 20 inches (500 mm).
4. The form shall be positioned, sealed and finished at the manhole base to ensure concrete does not enter the sewer.
5. The concrete shall be placed from the bottom up in such a manner as to prevent segregation of the cement and aggregate. The concrete shall be consolidated to fill pockets, seams and cracks within the existing wall.
6. When the concrete has sufficiently cured to preclude slump or damage, the form shall be disassembled and removed.
7. The bench shall receive an overlay of concrete as proposed by the Contractor at a minimum thickness as specified.

8. Prior to installation of the new concrete wall, a water stop shall be placed around the circumference of the bench where it meets the vertical wall (bench/wall joint) and around pipe penetrations to form a water stop.
9. The resultant concrete interior wall shall be smooth and free of honeycomb and areas of segregated aggregate.

C. Testing and Acceptance

1. Perform a visual inspection to verify there is no active infiltration and that the surfaces are smooth and free of honeycombs or areas of segregated aggregate.
2. Perform a vacuum test to verify the integrity of the SYSTEM, when it includes the rehabilitation or rebuild of the entire manhole, including the bench and channel, in accordance with ASTM C1244.
3. Obtain cube or cylinder samples of the concrete material for each manhole or batch of material, as required by the Owner. The samples shall be prepared by the Contractor and sent to the Owner, through a chain of custody, to an independent laboratory for testing of compressive strength at 28 days in accordance with ASTM C39.

3.8 PANEL LINERS

A. Surfaces shall be prepared in accordance with the manufacturer's requirements.

B. High-Density Polyethylene (HDPE)

1. Manhole steps shall be removed flush to the manhole surface prior to installation of the SYSTEM unless otherwise specified in the contract documents.
2. A bonding agent compatible with grout or concrete shall be applied to manhole wall before placing liner sheets.
3. Adequate annular space between the liner sheet and manhole wall shall be provided to allow placement of concrete or grout.
4. The liner sheet supports shall be secured to the manhole walls.
5. The liner sheets shall be inserted into the manhole and supported as per the manufacturer's recommendations.
6. Secure the liner sheets to the installed supports.
7. Form liner sheet seams in accordance with the manufacturer's recommendations.
8. Place the concrete or grout, as recommended by the material manufacturer, with no wrinkling of the liner. Vibrate, as required, to prevent voids.
9. After the concrete or grout has cured, remove the internal forms or supports and finish all seams as recommended by the PANEL LINER SYSTEMS manufacturer.

C. Polyvinyl Chloride (PVC)

1. Apply mastic primer to manhole wall and cure following the material manufacturer's requirements.
2. Apply mastic to primed manhole wall.
3. Apply liner to mastic.
4. Embed anchoring extensions in mastic.
5. Wrinkling of liner not permitted.
6. Finish liner seams following PVC SYSTEMS manufacturer's requirements.

D. Testing and Acceptance

1. Perform a visual inspection to verify that there is no infiltration, and there are no cuts, tears, loose panels, or other areas that could reduce its intended performance.
2. Inspect seams and welds of the installed SYSTEM using holiday detection or spark testing equipment in accordance with NACE SP0188 or ASTM D4787. Repair the identified defects and re-test.
3. Perform a vacuum test to verify the integrity of the SYSTEM, when it includes the rehabilitation or rebuild of the entire manhole, including the bench and channel, in accordance with ASTM C1244.

3.9 MANHOLE INSERTS

- A. Bypassing system flows without backup, overflow, or spillage when the bench and channel are being rehabilitated.
- B. Surfaces shall be prepared in accordance with the manufacturer's requirements.
- C. Remove dirt, grease, and debris from floor and interior walls of manhole using high pressure water and cleaners and cleaning methods as recommended by the manufacturer.
- D. Deteriorated invert and bench surfaces shall be abrasive blasted to profile the surface. Compressed air shall be supplied from compressors fitted with oil/moisture separators. Surfaces shall be cleaned of dust and grit particles by dry air blast cleaning, vacuum cleaning, or wiping with a tack cloth. Used abrasives shall be collected and removed preventing them from entering the system flows in the manhole.
- E. Active leaks, if present, shall be sealed by application of leak repair material in accordance with the manufacturer's requirements.
- F. Repair and reshape manhole inverts and benches. Inverts shall be U-shaped and have a minimum depth of 1/2 pipe diameter. Benches shall have smooth surfaces without defects that allow debris to accumulate.

G. Installation

1. Remove pavement if present. Excavate around the manhole as necessary to prevent soil and debris from falling into manhole while frame and grade rings are removed. Set aside frame and cover for reuse in rehabilitated manhole.
2. Cut the insert or chip the concrete benches so that the insert will be evenly supported when lowered into place. Accurately locate incoming and outgoing sewer lines and cut the insert for a close fit within 1 inch (25 mm) of both. Seal the cut edges with resin as recommended by the manufacturer.
3. Lower the insert into a 4-inch-deep (100 mm) layer of quick-setting grout mixture, making sure that the sewer lines and insert openings align.
4. Place a 6-inch-deep (150 mm) layer of quick-setting grout at the bottom of the annular space between the insert and the wall.
5. Seal the sewer openings with Oakum soaked in sealing gel.
6. Fill the remaining annular space with grout. Consolidate the grout without damage to the insert.
7. Install the grade rings, frame, and cover, sealing the surfaces between the reducer, the grade rings, and the frame.
8. Replace pavement.

H. Protective Coating Application

1. Oil and grease shall be removed from the application surface area by detergent cleaning with solvent, vapor, alkali, emulsion, or steam.
2. Follow detergent cleaning with abrasive blast cleaning to remove laitance and deteriorated concrete and to roughen the surface to manufacturer specifications.
3. The application surface area shall be clean and dry before applying the protective coating.
4. Apply a quick set grout to the chimney, bench and invert and seal the bottom edge of the insert. Apply two coats of filler/sealer with a squeegee as necessary and as recommended by the manufacturer, to achieve a smooth void free surface. Apply additional coats of filler/sealer to achieve a total applied thickness as recommended by the manufacturer.

I. Testing and Acceptance

1. Perform a visual inspection to verify that there is no infiltration, the assembly and joint connections have been properly installed, and no damage is observed to the SYSTEM that could reduce its intended performance.
2. Perform a vacuum test to verify the integrity of the SYSTEM, when it includes the rehabilitation or rebuild of the entire manhole, including the bench and channel, in accordance with ASTM C1244.

3.10 MECHANICAL CHIMNEY SEAL

- A. Loose and protruding mortar, brick or other material that could interfere with the installation of the seal shall be removed. The contact surfaces for the sleeve and/or extensions shall be clean and smooth, circular and free from excessive voids or defects. If the masonry surface is rough or irregular and will not provide an effective sealing surface, it shall be smoothed with a single component non-shrink quick set repair mortar designed for vertical and overhead use. The manhole frame and cover must be realigned if the offset is greater than 3 inches (75 mm) between the frame and top of the manhole structure.
- B. After surface preparation is completed and the rubber sleeve has been placed in the proper position, the lower band is positioned in the band recess and expanded as required to provide a watertight seal. If an extension or extensions are being used, place the extension in the proper position, insert the band into the lower band recess and expand as required to provide a watertight seal.
- C. Extension flap shall be placed into or behind the expansion band recess to allow for the compression of both the extension flap and sleeve against the manhole surface by the expansion band. Continue by placing the upper band or bands in the recess, ensuring the seal is properly placed on the manhole cone, chimney and frame and expand as required to provide an effective seal.
- D. Installation procedures shall be in accordance with the manufacturer's requirements and ASTM C923.
- E. Testing and Acceptance
 - 1. Perform a visual inspection to verify that there is no infiltration, the SYSTEM has been properly installed, and no damage is observed to the SYSTEM that could reduce its intended performance.
 - 2. Perform a leakage test following the expansion of the lower band in accordance with ASTM C923 to verify effective sealing following manufacturer's recommendations. The sealing shall be considered effective if no water leaks from behind the seal at the lower sealing area.

3.11 APPLIED POLYMER CHIMNEY SEAL

- A. Manhole castings and chimney surfaces shall be cleaned and prepared in accordance with SSPC-SP 10 / NACE No. 2 and SSPC-SP 13 / NACE No. 6 to ICRI 310.2R CSP 3-5. SYSTEMS shall be applied only when the prepared surfaces are in an air dry and saturated surface dry (SSD) state, with the surface feeling dry to the touch and no visible water dripping or running over the surfaces, or as required by the SYSTEMS manufacturer.

- B. Loose and protruding mortar and brick shall be removed. Lips for gravel pan supports shall be cut off flush with the manhole casting. Missing mortar, loose bricks, and large voids shall be repaired using compatible repair materials, as recommended by the SYSTEMS manufacturer.
- C. Active leaks shall be stopped prior to installing the polymer chimney seal SYSTEMS.
- D. Polymer chimney seal SYSTEMS may be applied in multiple layers or coats using spray, trowel, or brush application methods. The SYSTEM manufacturer's instructions for application, recoat window, and curing shall be submitted as a part of the PWS and followed during application. The polymer chimney seal SYSTEMS shall be applied uniformly over the entire chimney area, including the frame joint or casting above the manhole cone, as well as extensions to the chimney area.
- E. Testing and Acceptance
 - 1. Perform a visual inspection to verify that there is no infiltration, the installed SYSTEM uniformly covers specified surfaces, and is free of pinholes, or defects that could reduce its intended performance.
 - 2. Measure the installed thickness of the SYSTEM to confirm it meets the minimum value required in these specifications. Wet film thickness shall be measured in accordance with ASTM D4414.
 - 3. Inspect surfaces of the installed SYSTEM using holiday detection or spark testing equipment in accordance with NACE SP0188 to identify holidays and pinholes. Repair the identified defects and re-test.
 - 4. Conduct adhesion testing in accordance with ASTM D7234 to verify that the SYSTEM is bonded to the manhole substrate, as evidenced by substrate failure during testing. Repair damage from testing, following the SYSTEM manufacturer's recommendations.

3.12 HAND APPLIED REINFORCED POLYMER CHIMNEY SEAL

- A. Manhole castings and chimney surfaces shall be cleaned and prepared in accordance with SSPC-SP 10 / NACE No. 2 and SSPC-SP 13 / NACE No. 6 to ICRI 310.2R CSP 3-5. SYSTEMS shall be applied only when the prepared surfaces are in an air dry and saturated surface dry (SSD) state, with the surface feeling dry to the touch and no visible water dripping or running over the surfaces, or as required by the SYSTEMS manufacturer.
- B. Loose and protruding mortar and brick shall be removed. Lips for gravel pan supports shall be cut off flush with the manhole casting. Missing mortar, loose bricks, and large voids shall be repaired using compatible repair materials, as recommended by the SYSTEMS manufacturer.
- C. Active leaks shall be stopped prior to installing the reinforced polymer chimney seal SYSTEMS.

- D. Reinforced polymer chimney seal SYSTEMS are to be installed in multiple layers using trowel, roller, and hand lay-up application methods. The SYSTEMS manufacturer's instructions for application, recoat window, and curing shall be submitted as a part of the PWS and followed during application. The reinforced polymer chimney seal SYSTEMS shall be applied uniformly over the entire chimney area, including the frame joint or casting above the manhole cone, as well as extensions to the chimney area.
- E. Testing and Acceptance
 - 1. Perform a visual inspection to verify that there is no infiltration, the installed SYSTEM uniformly covers specified surfaces, and is free of pinholes, or defects that could reduce its intended performance.
 - 2. Measure the installed thickness of the SYSTEM to confirm it meets the minimum value required in these specifications. Wet film thickness shall be measured in accordance with ASTM D4414.
 - 3. Inspect surfaces of the installed SYSTEM using holiday detection or spark testing equipment in accordance with NACE SP0188 to identify holidays and pinholes. Repair the identified defects and re-test.
 - 4. Conduct adhesion testing in accordance with ASTM D7234 to verify that the SYSTEM is bonded to the manhole substrate, as evidenced by substrate failure during testing. Repair damage from testing, following the SYSTEM manufacturer's recommendations.

3.13 CURED-IN-PLACE CHIMNEY SEAL

- A. The work consists of constructing a CIPM Chimney that is constructed to fit the inside diameter of the manhole from the bottom of the frame to a point on the cone just below the chimney.
 - 1. Contractors qualified in accordance with these specifications shall perform the SYSTEM installation.
- B. Manhole steps shall be removed flush to the manhole surface prior to application of the SYSTEM unless otherwise specified in the contract documents as required by the Owner.
- C. Active infiltration shall be stopped prior to installation of CIPM Chimney SYSTEMS.
- D. Repair materials compatible with CIPM Chimney SYSTEMS shall be used to fill holes, missing bricks, and voids larger than a baseball as recommended by the CIPM Chimney SYSTEMS manufacturer.
- E. The coated non-woven textile fabric shall be vacuum impregnated (saturated) on-site under controlled conditions. The resin shall be pre-measured at the manufacturing plant prior to shipment. The volume of resin used shall be sufficient to fill voids in the fabric material at nominal thickness and diameter. No dry or unsaturated areas in the resin impregnated fabric (i.e., liner) shall be acceptable upon visual inspection.

F. Installation

1. The liner is placed with the saturated resin side facing the substrate. Once the liner is placed in the manhole and rested on the spacing rings, the installation device is inserted inside of the liner. The spacing rings located on top of the manhole allow the installation device to rest at the correct depth. Once the installation device has been inserted, the bladder is pressurized. The installation device stays in place and is pressurized until the liner is cured.
2. The liner is cured at ambient temperatures as it is pressed firmly against the structure. The curing time must take into consideration the resin system, ground conditions (temperature and moisture level), and weather conditions.

Typically, one hour is needed to cure the liner. A curing log shall document the pressure used to hold the liner in place, the time that the pressure is held, and the volume of resin used to saturate the fabric.

3. Once cure has been completed, the installation device is removed and the CIPM Chimney is trimmed at the manhole cover seat.

G. Testing and Acceptance

1. Perform a visual inspection to verify that there is no infiltration, the installed SYSTEM is free from areas of deficient or uncured resin, delamination of the fabric layers, and hollow areas behind the liner, has a smooth surface free from cracks, and is tightly adhered to the manhole surface at terminations.
2. Conduct adhesion testing in accordance with ASTM D7234 to verify that the SYSTEM is bonded to the manhole substrate, as evidenced by substrate failure during testing. Repair damage from testing, following the SYSTEM manufacturer's recommendations.

3.14 REPLACE FRAME AND COVER

- A. The manhole frame and cover shall be manufactured and installed to the dimensions provided in the contract documents.
- B. The cover shall not rock when rotated in the frame and shall sit down into the frame so that the top surface of the cover (rim) is flush with the top surface of the frame.

3.15 MANHOLE FRAME ADJUSTMENT

- A. The Contractor shall furnish all materials, equipment, tools and labor required for the adjustment of frames and covers to grade using adjustment rings.
- B. The frame and cover to be adjusted shall be located and clearly marked.
- C. Installation shall be in accordance with the manufacturer's instructions and these specifications.

- D. The existing road or ground surface shall be cut around the frame and cover, either by triangular, square or round cut to an adequate depth that will allow the specified adjustments to be accomplished.
- E. Pavement or ground inside of the cut shall be removed to allow safe working conditions during the adjustment and restoration.
- F. The frame shall be positioned, either by suspension or by placement on the correct amount of adjustment rings.
- G. Once the frame and adjustment rings are properly positioned and secured, the open area shall be filled and properly compacted with the materials prescribed in the bid documents and finished off in a manner to meet the requirements of the specifications.
- H. If the area has been filled (in whole or in part) with poured concrete and/or asphalt, it shall be adequately protected by control devices for a period that will allow the fill to properly cure before allowing traffic to resume.

3.16 MANHOLE STEPS

- A. Manhole steps shall be driven into pre-cast or drilled holes. Steps shall be installed no more than 16 inches (400 mm) apart vertically on the interior of the manhole wall at a point 4-inches (100 mm) below the base flange of the manhole casting.

PART 4 INSPECTION

Due to mechanical damage or defects in application, SYSTEMS will occasionally need to be repaired, or a portion of the installed product replaced. The manufacturer shall outline specific repair or replacement procedures for potential issues that may arise during the application of the SYSTEMS. Repair/replacement procedures shall be as recommended by the SYSTEMS manufacturer and shall be submitted as part of the PWS.

4.1 DEFECT REMEDIATION

- A. Issues that may not affect the operation and long-term life of the product shall be identified and defined by the manufacturer.
- B. Repairable issues that may occur in the SYSTEMS shall be specifically based on manufacturer's recommendations, including repair procedure, resulting in a finished product meeting the estimated life cycle of the component and requirements of these contract documents.
- C. Unrepairable issues that may occur in the SYSTEMS shall be clearly defined based on the manufacturer's recommendations. The Contractor together with the manufacturer shall define the best recommended procedure for the total removal and replacement of the SYSTEMS.

- D. The Contractor shall receive no additional compensation for the repair or replacement of SYSTEMS deemed non-conforming to the requirements of these contract documents and unacceptable by the Owner.

PART 5 MEASUREMENT AND PAYMENT

5.1 BID ITEMS

The bid item(s) for the rehabilitation process of the manholes may include items such as traffic control, flow bypass, mobilization, application or installation of the product, and testing. These items may be listed individually or combined with other work to be performed. Units of measurement should be relevant to the item(s) included and may be listed as Lump Sum, Per Each, Per Vertical Foot (meter), Per Joint, or another measurement.

The following examples (5.1.A. - E.) of bid items are for informational purposes only and may or may not be applicable to a specific project.

- A. Mobilization – Lump Sum – Includes PWS info, submittals, safety plan, as built drawings, test samples and mobilization/demobilization of labor, equipment and materials to the project site.
- B. Full depth Manhole Lining, [X] in. ([X] mm) diameter – per vertical foot (meter) - including all labor, materials and equipment required to install the SYSTEM as specified, complete.
- C. Replace Manhole Frame and Cover –per each, manhole - including all labor, materials and equipment required to remove and dispose of the existing manhole frame and cover, furnish and install a new manhole frame and cover, and restoration of pavement or disturbed surfaces, complete.
- D. Bench/Channel Rebuild – per each, manhole - includes all labor, materials and equipment required to rebuild the bench and channel as specified, complete.
- E. Manhole Steps – per each – includes all labor, equipment and materials required, by the Contractor, to install each manhole step as required by the Owner, complete.

5.2 MEASUREMENT AND PAYMENT

- A. Measurements for each item furnished and installed to the satisfaction of the Owner shall be at the units of measure contained in the Bid Proposal.
- B. Payment for each SYSTEM furnished and installed, in accordance with the contract documents and to the satisfaction of the Owner, will be at the unit prices in the Bid Proposal.

END OF SECTION

APPENDIX A: SURFACE PREPARATION OF BRICK MASONRY MANHOLES

1. Foreword

Brick masonry manholes constructed with clay or shale brick and laid with portland-cement mortar remain operational in our collection systems throughout North America. Although typically historical in nature, brick manholes remain a common encounter in manhole rehabilitation.

Manhole brick are ceramic products manufactured primarily from clay, shale, or similar naturally occurring earthy substances and subjected to a heat treatment (firing) at elevated temperatures. Manhole brick is relatively corrosion resistant while the masonry portland-cement mortar is susceptible to biogenic sulfide corrosion. In a sewer headspace exposure, the portland-cement mortar is typically corroded, oftentimes considerably, while leaving the bricks “etched” but mostly intact and candidate for rehabilitation.

2. Scope

This guideline defines the surface preparation and resulting condition of brick masonry manholes to render suitable for top-coating with bonded cementitious and polymer linings. Surface preparation procedures included in this guideline include pressurized water blasting and pressurized detergent water blasting. If brick glaze is present, additional surface preparation methods such as acid etch cleaning, mechanical grinding, or abrasive blasting are required to remove the brick glazing.

This standard is not meant to exclude solid precast segmental concrete masonry (CMU) from its use, however, due to the vast amounts of masonry materials available and the differing surface conditions that may result from surface preparation, it was not included in this standard. With a properly worded specification, this standard may be used successfully for abrasive blast cleaning of concrete masonry substrates.

Brick manholes require surface preparation to remove any surface contaminants prior to the application of bonded cementitious and polymer materials. This includes manhole brick as well as the portland mortar joints. The surface preparation includes surface cleaning of the brick masonry to remove surface contaminants such as fats, oils and grease (FOG), dirt, loose material, residue, existing coatings, etc., and to expose the existing surface brick texture in preparation for the application of protective linings without damaging or altering the surface profile of the manhole brick. Consult with cementitious or polymer linings manufacturer for additional surface preparation requirements.

Other surface preparation or remedial repairs, such as replacing missing manhole brick, repointing portland joints, elimination of water infiltration using fast-setting hydraulic cements or polyurethane injection grout or cutting existing manhole steps may be necessary and must be completed by the contractor prior to top-coating with a bonded cementitious and polymer linings.

3. Definitions

brick, *n*—a solid or hollow masonry unit of clay or shale, usually formed into a rectangular prism, then burned or fired in a kiln; brick is a ceramic product.

glaze, *n*—an impervious finish composed of ceramic materials, fused during firing with the body of brick or tile, which is a semivitreous or vitreous surface and may be clear, white, or colored.

infiltration, *n*—the ingress of groundwater through a defect or faulty joint or porous area of manhole wall.

brick mortar, *n*—a mixture of sand, portland cement, and water mixed to create a workable paste which hardens to bind the brick, the irregular gaps between them, and spread the weight of the brick evenly.

repair mortar, *n*—Repair mortars are specifically designed for restoring or replacing the original profile and function of the damaged concrete substrate. They help to repair concrete defects, improve appearance, restore structural integrity, increase durability and extend the structure's longevity.

4. Procedures Prior to Surface Preparation

Prior to conducting surface preparation, the contractor shall inspect the brick manhole to determine the method or methods required to meet the requirements of this guideline.

Examine the brick manhole and reference NASSCO PACP Manual for appropriate codes regarding signs of infiltration, loose, protruding, fractured, or missing brick, deteriorated or missing brick mortar, and other contaminants such as efflorescence or FOG, that may require specific attention. Existing manhole steps whether constructed from iron, plastic, fiberglass, or brick are recommended to be removed.

Visually inspect the brick manhole for fractured, broken or missing brick. For areas of concern, a sounding test may be performed by tapping the brick with a hammer or rod and noting whether the generated sound is solid or dull. A dull sound can be an indication of unsound brick and needs to be replaced. Identify areas of missing or displaced brick and missing brick mortar. Brick or a cementitious repair mortar may be used to repair missing brick masonry if less than three contiguous bricks are missing. Consult the asset owner or the asset owner's representative if more than three contiguous bricks are missing or displaced as this may require alternate structural rehabilitation.

The brick shall also be examined to determine the presence of glaze. A water drop (water-break) test may be used to determine whether the water droplet beads or absorbs. When a drop of water is placed or sprayed onto the brick face brick with glaze, the water will bead. Brick free of glaze will allow the water droplet to form a thin, continuous, uniform film of water that absorbs into the brick.



Figure 1 - Example of White Glaze on Brick Face

5. Surface Preparation Methods and Operation

Surface preparation is intended to provide a clean, dry, contamination-free, and sound surface without damaging the brick masonry surfaces as a minimum. The intent of this standard is to remove from the manhole wall and bench sections all FOG, loose or unsound brick and brick mortar, efflorescence, and similar dry, firmly adhering foreign material, existing cementitious and polymer linings, and to achieve a sound, contaminate-free brick masonry surface and bench section. Remove all loose and protruding bricks, unsound brick mortar, and unsound concrete. This guideline is not intended to profile the brick unless a glaze is detected. The removal of metal, plastic, fiberglass or brick stairs is recommended.

The contractor is responsible to dam, plug, or divert flow from piping entering the structure and ensure that the brick manhole is properly cleaned and prepared in accordance with this standard. Place wooden or plastic covers over the sewer manhole invert while cleaning the manhole wall and bench to collect debris. Wire mesh and fabric filters allowing water to pass are also acceptable.

High Pressure Cleaning—Use a high-pressure washer delivering a minimum of 5,000 psi (34 MPa). A minimum of four gallons per minute (15 liters per minute) should be delivered through the spray tip. The spray tip should be kept between 6 and 12 in. (15 and 30 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 meters per second). Cleaning should begin with the frame surface and progress down to and include the bench. The cleaning is intended to remove material but not damage the brick. Specifier note: A rotating spray nozzle or fan nozzle may be used for cleaning as long as it meets the pressure and flow requirements.

If the surface is especially dirty or has buildup of FOG, bio-degradable cleaning agents should 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).

Glaze removal— Dry abrasive blasting, wet abrasive blasting, power tool grinders, or acid etching may be used to remove glazing from brick surface. The method should produce a uniformly prepared, glaze-free brick surface.

Captured debris, including FOG, from all cleaning methods should be disposed of in accordance with local regulations.

6. Procedures Following Surface Preparation and Immediately Prior to Application

Visually examine prepared surface to confirm the removal of all contaminants and the surface is free of stains. Acceptable surfaces shall be free of debris, dust, dirt, FOG, and other contaminants. The prepared brick surface shall be clean and free of surface contamination and existing coatings, sound, and exhibit a natural textured surface .

Any evidence of remaining contamination or unsound substrate shall be removed by additional surface preparation. Soundness of the prepared surface may be verified using a flathead screwdriver and lightly pushing the flat edge across the surface of the concrete, maintaining an angle of approximately 30 degrees. If the edge of the screwdriver rides over the surface without loosening any portland mortar particles and leaves no more than a shiny mark, the surface is sound. If this process gouges the surface or removes loose material, the surface is not sound. Impact tools such as chipping hammers or other devices may be required to remove unsound mortar.

Surface pH testing of the brick and brick mortar can also be used to confirm the substrate has been properly prepared to an acceptable minimum pH (typically 8 pH or greater) in accordance with the cementitious or polymer lining manufacturer's recommendations.

Active water infiltration shall be arrested using chemical injection grout or hydraulic cement water stop materials. Remove any unreacted chemical injection grout or hydraulic cement water stop materials. Refer to ICGC Grouting Manual.

Reinstall any missing or displaced brick and missing mortar and tuckpoint mortar joints using an approved material compatible with the cementitious or polymer lining. Alternately, a cementitious or polymeric repair mortar can be used to fill the void space of missing brick.

7. Prior to Application

Immediately prior to application, the entire surface to be coated shall comply with the degree of cleanliness defined by this guideline. The surfaces should be re-cleaned to remove potential contaminants if the brick manhole is exposed to or was placed into sewer service after completion of surface preparation.

Prepared brick masonry should be tested in accordance with manufacturer's guidelines for residual moisture after cleaning and drying but prior to the application of the cementitious or polymer lining. If a specific measured moisture percentage content is required for proper performance of the coating system to be applied, the contractor shall dry the manhole surface until the moisture content of the brick masonry is within acceptable limits as required by the manufacturer.

8. Safety and Environmental Requirements

This guideline provides information for surface preparation of brick masonry manholes to render suitable for top coating with bonded cementitious and polymer linings, including pressurized water blasting and pressurized detergent water blasting. Additionally, if brick glaze is present, surface preparation methods such as acid etch cleaning, mechanical grinding, or abrasive blasting may be required to remove the brick glazing.

When performing any of the afore mentioned tasks, it is essential to wear appropriate personal protective equipment (PPE) to safeguard employees against various hazards such as flying debris, respirable dust, noise, acid burns etc. The PPE that should be considered for these tasks may include eye/face protection (safety glasses, goggles, or face shield), respiratory protection, hearing protection (earmuffs or goggles), gloves, proper footwear, hard hat, and Tyvek-type coveralls, as well as confined space entry. Assure proper ventilation for any grinding operations and inspect tools and PPE prior to use according to manufacturer's guidelines. **NOTE: The employer should conduct a written risk assessment of each task being performed and determine the appropriate PPE for that specific task.**