

MANHOLE REHABILITATION

PERFORMANCE SPECIFICATION GUIDELINE

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GENERAL DISCUSSION OF PRODUCTS AND TECHNOLOGIES

- A. The rehabilitation of manholes can be complicated and the selection of the correct product or technology can, at times, be confusing. There are many methods available for the rehabilitation of manholes. Each method must be evaluated to determine its applicability to provide the correct solution for the best available price. The following steps can be taken to develop the best approach towards rehabilitation and what family of products best meet specific project requirements.
1. Thoroughly evaluate the condition of the manhole to be rehabilitated using the Manhole Assessment Certification Program (MACP) as developed by NASSCO for providing a uniform coding for the defects typically found in a manhole structure.
 2. Define the type of defects as structural defects, operational & maintenance defects, construction features and other.
 3. Based on the defined defects classify each manhole into the general rehabilitation technology or technologies to be considered. Technologies can be classified into general rehabilitation needs including grouting, cementitious reconstruction, polymer coatings/linings, cured-in-place lining, panel liners, mechanical seals and bench and channel inserts.
 4. Select the correct solution based on the problems identified.
 5. What are the problems being addressed?
 6. Does the selected technology provide the desired long-term solution to the problem?
 7. Does the selected technology go beyond solving the immediate need and if so, is there a reasonable cost for the added benefit?
 8. Does the selected technology ensure compatibility of all materials being used to complete the repair?
 9. Is the selected technology Contractor friendly? Is it relatively well suited for the project site conditions?
 10. Select products and/or technologies that have viable, proven installation techniques.
 11. Can the Contractor capabilities and experience be quantifiable during the bid process?
 12. Can the qualifications of the personnel, working for the Contractor and applying the product be verified?
- B. There are many products technologies and variations available. Only generic categories of technologies are included in these sample specifications. Technology and product applicability, to each project, should be verified by contacting the manufacturer of each product, and discussing the proposed application to verify product compatibilities. Supporting documentation and third party testing should always be reviewed prior to selection. In some cases multiple technologies will be required to totally rehabilitate the manhole structure. Products and Technologies are generally referred to herein as Rehabilitation Component Systems (SYSTEM's) and include the following:

1. Chemical Grouting – Generally used when the existing manhole is structurally sound but has leakage or I&I problems. Grout types and longevity in different soil conditions must be verified through the grout manufacturer.
2. Cementitious Manhole Restoration – Cementitious materials can be Portland Cement, Microsilica enhanced, Calcium Aluminate, or Geopolymer based. The Geopolymer, Calcium Aluminates and Microsilica cements typically have a higher resistance to corrosion and typically attain high structural strength after curing which facilitates top-coating in a relatively short period of time. Standard Portland cements typically require a 28 day cure before top coating. Cementitious materials can be trowelled, sprayed, spun cast or poured in place. This type of technology is generally used for structural reconstruction, elimination of I&I and prevention against low levels of corrosion. In some cases, cementitious materials are used as a base coating to level or smooth out the existing structure surface before applying a polymer top coat.
3. Polymers (Epoxy, Polyurethane, Polyurea Coatings) – Generally used for corrosion protection and to eliminate I&I. Epoxies and urethanes can have structural benefit when applied sufficiently thick. When applying multiple components to rehabilitate a manhole it is extremely important that all components are compatible with each other and each is properly cured and prepared before the application of the next product. Application of polymers on new manhole and concrete structures requires specific attention to off-gassing of the concrete causing unwanted pin-holing in the material during and immediately after application. As a general rule, cured concrete will off-gas air when the structure temperature is rising and will inhale when the concrete temperature drops. New or green concrete typically off-gasses almost continually and often requires penetrating primers to densify the surface prior to coating application. The Manufacturer of each system should be contacted to determine what the effect off-gassing has on the product and the best procedures for the application of polymers directly onto new concrete structures. The Contractor should be experienced in coating both new and old concrete structures.
4. Cured-In-Place Liners – Generally used for structural reconstruction of a manhole, I&I removal and corrosion protection. The process includes the installation of a specifically designed fabric liner, saturated with a thermosetting resin, that is heat cured under pressure and molded tightly to fit the inside shape of the existing manhole.
5. Panel Liners – Generally non-structural liners used for corrosion protection and elimination of I&I. Usually installed in the form of panels, thermally welded at the seams and mechanically anchored or glued to the manhole wall using a special adhesive.
6. Chimney Seals – Used for defects in the adjustable portion of the manhole. Seals can be used as a stand-alone product or in conjunction with a cementitious or polymer product. Seals can be applied both internally and externally to the manhole structure and can be comprised of polymer applied, cured-in-place or rubber mechanical composition.

7. Barrel Joint Seals – Includes joints between pre-cast manhole sections where leaking joints are contributing groundwater infiltration and no structural deficiencies are present.
8. Bench and Channel Inserts - Preformed corrosion resistant inserts installed in the bench and channel of the manhole.
9. Dish Inserts – Manhole opening cover. Prevents water from entering through the manhole cover holes.

References:

NASSCO Manhole Assessment Certification Program (MACP) - A certification program administered by NASSCO to train manhole inspection personnel on the standard coding of defects found in the manhole structure.

PART 1 - GENERAL

- A. These Specifications include the minimum requirements for the rehabilitation of manholes as shown on the plans included as part of these [contract documents].
- B. The rehabilitation of manholes shall be accomplished by the application or installation of rehabilitation components either individually or together. These may include grouts, protective coatings, a variety of linings, inserts, seals and mechanical devices that, when installed, shall protect the manhole structure, seal it from I & I, rebuild it structurally (if needed) and provide chemical resistance for the length of time specified. Several manhole components such as frames, covers and steps will typically be replaced rather than rehabilitated. The Contractor is responsible for the accurate and complete installation, and warranty of each manhole Rehabilitation Component System (SYSTEM) specified by the Owner.
- C. The manhole SYSTEM's installed shall cause no adverse effects to any of the Owner's processes or facilities either during or after application. The use of the product, by the Contractor, shall not result in the formation or production of any detrimental compounds or by-products at the wastewater treatment plant. The Contractor shall notify the Owner and identify any by-products produced as a result of the installation operations, test and monitor the levels, and comply with any and all local waste discharge requirements. The Contractor shall cleanup, restore existing surface conditions and structures, and repair any of the manhole SYSTEM's installed and determined to be defective. The Contractor shall conduct installation operations and schedule cleanup in a manner to cause the least possible obstruction and inconvenience to traffic, pedestrians, businesses, and property owners or tenants.
- D. The prices submitted by the Contractor, shall include all costs of permits, labor, equipment and materials for the various bid items necessary for furnishing and applying, complete in place, manhole SYSTEM's, in accordance with these specifications. All items of work not specifically mentioned herein which are required

to make the product perform as intended and deliver the final product as specified herein shall be included in the respective lump sum and unit prices bid in the Proposal. These Specifications include the minimum requirements for the rehabilitation of manholes defined herein and as shown on the plans included as part of these contract documents.

1.1 DESCRIPTION OF WORK AND PRODUCT DELIVERY

- A. These Specifications cover all work necessary to furnish and install, a variety of protective manhole SYSTEM's. The Contractor shall deliver a finished product(s) including all materials, labor, equipment, and services necessary for traffic control, bypass pumping and/or diversion of sewage flows, cleaning equipment, product installation, all quality controls and samples for performance of required material tests, final inspection and warranty work, all as specified in these contract documents and at the quantities of each component contained in the Bid Proposal.
- B. The SYSTEM's furnished shall be complete integrated and compatible systems including all materials, manufacturer's recommended equipment and manufacturer's installation procedures. The SYSTEM manufacturer may submit to the Owner, a minimum of 14 calendar days in advance of a bid date, all required product information to obtain pre-approval SYSTEM status. Those SYSTEM's that have been pre-approved will not need to be re-submitted as required in the submittal section of these specifications unless any of the system components have changed from those pre-approved by the Owner. All other component products will be required to meet the submittal requirements as contained herein.
- C. The SYSTEM's installed shall be free of all defects that will affect the design and service life and operation of the manhole.
- D. The SYSTEM installed shall eliminate water leakage into the manhole and prevent water or vapors to leak out of the manhole through pin-holes or other defects. If leakage occurs either in or out of the manhole the Contractor shall seal these areas to stop all leakage using a material compatible with the SYSTEM applied and as specified by the manufacturer. If leakage occurs through any SYSTEM applied to the manhole, the SYSTEM shall be repaired or removed as recommended by the manufacturer. All repair materials shall have the same estimated life expectancy than the SYSTEM installed. Final approval of the SYSTEM installation will be based on meeting the acceptance test requirements for each SYSTEM applied/installed.
- E. The SYSTEM (applied to the intended structure) shall be designed against corrosion and typical chemicals found in domestic sewage, unless otherwise specified in the detailed section of the contract documents. The manufacturer of the SYSTEM shall provide testing data that supports their SYSTEM's design and service life.

- F. SYSTEM'S may be designed to rehabilitate the existing manhole against corrosion, I&I structural build-back, or a combination of the three. In certain cases the preparation, certification and submission of design calculations by a registered professional engineer is required for manhole replacement and rehabilitation technologies. All design must be supported by third party testing and documentation for the exact product that is being submitted.
1. A manhole is specified to be structurally replaced, being able to sustain all earth, hydrostatic and dynamic loading without support by the existing structure. Certification and submission of design calculations by a registered professional engineer is required
 2. A manhole is specified to be structurally rebuilt, with build-back materials, or rehabilitated to sustain hydrostatic loading by groundwater. Certification and submission of design calculations by a registered professional engineer is required
 3. A manhole is specified to receive a corrosion protective coating sufficiently thick to totally protect the existing host structure from further corrosion, deterioration and water vapor transmission. Certification and submission of design calculations by a registered engineer may be required
 4. A manhole is specified to receive a coating to renew mortar or other deteriorated components of a manhole but has no specified longevity or corrosion resistance requirement. The manufacture's third party testing will be acceptable for application suitability.
 5. A manhole is specified to receive patch repair materials for portions of the manhole. The manufacture's third party testing will be acceptable for application suitability.
- G. All manhole steps shall be removed prior to a coating or lining application.
- H. Flow from existing active service connections entering the manhole shall be maintained or bypassed if the flow will affect proper SYSTEM application/installation.
- I. All component materials furnished, as part of this contract shall be marked with detailed product information, stored in a manner specified by the manufacturer and tested to the requirements of this contract.
- J. Testing shall be executed by the owner or by the contractor in the presence of the owner. Warranty inspections shall be executed by the Owner or its representative. Any defects found shall be repaired or replaced by the Contractor.
- K. The Contractor shall furnish all samples for product testing as required in the contract documents. The Owner shall take possession of the samples for testing and shall maintain a chain of custody, deliver the samples and pay an approved laboratory for all material and product testing performed under this contract.

- L. Compensation for all work required for providing test samples shall be included in the various SYSTEM items contained in the Bid Proposal.

1.2 SCOPE OF WORK INCLUDED

- A. A detailed description of each SYSTEM included in the contract, complete with estimated quantities.

1.3 PERFORMANCE WORK STATEMENT (PWS) SUBMITTAL

- A. The Contractor shall submit, to the Owner, a Performance Work Statement (PWS) at the pre-construction meeting, which clearly defines the proposed manhole SYSTEM 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:
 - B. Clearly indicate that the SYSTEM will conform to the project requirements as outlined in the Description of Work, Scope of Work Included and as further delineated in these contract documents.
 - C. Certify at the time of the bid, that the designated manholes, included in the contract documents, were visited, inspected and evaluated by the Contractor or Contractor's Representative, prior to submitting a bid.
 - D. Where the scope of work is specifically delineated in the contract documents, a detailed installation plan describing all preparation work, cleaning operations, pre-inspections, sewage flow maintenance, traffic control, installation procedure, method of curing, quality control, testing to be performed, final inspection, warranties furnished and all else necessary and appropriate for a complete SYSTEM application/installation, shall be submitted.
 - E. A detailed installation schedule shall be prepared, submitted and conform to the requirements of these contract documents.
 - F. The manufacturer's description of the SYSTEM materials are 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 SYSTEM submission.
 - G. The Contractor's experience for each type of rehabilitation component shall be as more specifically delineated in the detailed specifications. The name and experience of each lead individual performing work on this contract, for each component, shall be submitted with the PWS. If personnel are substituted after submittal of the PWS, the name and experience of the individual shall be submitted to the Owner for approval before starting any work.

- H. Engineering design calculations may be requested for verification of structural design submittals. These calculations shall be in accordance with the applicable ASTM or industry standard for each structural design component/system to be installed. These calculations shall be performed and certified by a registered Engineer.
- I. Information on the SYSTEM and all 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.
- J. A detailed description of the Contractor's proposed procedures for cleaning and preparing the manhole structure, prior to applying/installing the SYSTEM shall be submitted as part of the PWS. The Contractor will describe in detail what substrate testing will be performed by the contractor to verify acceptability of the SYSTEM material to be applied.
- K. Compensation for all work required for the SYSTEM submittal of the PWS shall be included in the Mobilization Item contained in the Bid Proposal.

1.4 SUBMITTALS

- A. Product data submittals required for all rehabilitation SYSTEM's proposed for installation under this contract shall include:
 - 1. SYSTEM material type and manufacturer to be used including: catalog data sheets, ASTM references, material composition, manufacturers recommended specifications, component physical properties and chemical resistance. (PWS)
 - 2. Manufacturer's detailed description of the recommended procedures for handling and storing materials including a proposed method for monitoring temperatures of the storage location, if applicable to the specific SYSTEM material. (PWS)
 - 3. Manufacturers detailed description of the recommended material installation/application process including mixing, additives, set time, cure time (return to service) and all equipment required for quality product delivery. (PWS)
 - 4. Technical data sheet describing each rehabilitation component to be applied/installed, stating the expected longevity of the component in a wastewater environment. Data shall be based on independent third party tests. (PWS)
 - 5. Manufacturer's detailed description of all required field testing processes and procedures. (PWS)
 - 6. Copies of independent testing performed on the rehabilitation component, indicating that the product meets the requirements as specified in these contract documents and the manufacturers design. (PWS)

7. Technical data sheet and project specific data for manhole repair materials to be used in conjunction with each rehabilitation component(s) including application cure time and surface preparation procedures. (PWS)
8. Certification that backup installation equipment is available on the job site or can be delivered to the job site by the morning of the next business day. (PWS)
9. Shipping information including: (Jobsite)
 - a. Shipped item, including manufacturer, stock and lot number
 - b. Date shipped including origination and delivery locations
 - c. Shipping method and carrier
 - d. All shipping, storage and safety requirements including MSDS documents.
 - e. Date delivered to project site including name and signature of receiver
10. By-Pass Pumping Plan if applicable to the SYSTEM's being installed. (PWS)
11. Traffic Control plan, if applicable for the SYSTEM's being installed.
12. Certified statement, from the manufacturer, that the contractor/installer is an approved installer of the SYSTEM with certificates of completed training for each crew member involved in each rehabilitation component. This requirement shall comply with the specific SYSTEM requirements specified in the contract documents. (PWS)
13. For each manhole rehabilitation, a complete and accurate record of all SYSTEM's installed/applied shall be prepared by the Contractor. The record shall include identifying manhole number, location, quantities of rehabilitation components installed.
14. Submittal of all quality assurance documentation and test reports for SYSTEM's installed. (After Rehabilitation Completion)
15. Compensation for all work required for product submittals and the submittal of a By-Pass Pumping Plan and a Traffic Control Plan shall be included in the Mobilization Item contained in the Bid Proposal.
16. Refer to section 1.1.F for design requirements.

1.5 QUALITY CONTROL PLAN (QCP)

- A. A detailed quality assurance plan (QCP) shall be submitted to the Owner that fully represents and conforms to the quality control requirements of these specifications. At a minimum the QCP shall include the following:
 - B. A detailed description of the proposed quality controls to be performed by the Contractor.
 - C. Defined responsibilities, of each of the Contractor's personnel, for assuring that all quality control requirements, for this contract, are met. These shall be assigned, by the Contractor, to his specific personnel.
 - D. Proposed procedures for quality control, product sampling and testing shall be defined.

- E. 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.
- F. A scheduled performance and product test result reviews between the Contractor and the Owner at a scheduled job meeting.
- G. Inspection forms and guidelines for quality control inspections shall be prepared in accordance with the standards specified in this contract and submitted with the QCP.
- H. Inspector training, by a qualified trainer, for the Owner's inspectors shall be provided as further defined in Section 1.9. This training shall be prior to SYSTEM installation, include both technical and field training and include all key aspects of visual inspection and sampling procedures for testing requirements. On smaller projects having an estimated duration of less than two (2) weeks of rehabilitation work, the system manufacturer shall furnish a check list containing key elements of the SYSTEM criteria, represented in the QCP, for the Owner's representative to ensure that quality control and testing requirements are performed in accordance with the contract documents.
- I. Proposed methods and procedures for SYSTEM repair or replacement, (as defined in Section 1.6) in the event of product defects or total failure.

1.6 SYSTEM REPAIR/REPLACEMENT

- A. Due to mechanical damage or defects in application, SYSTEM's will occasionally need to be repaired or replace a portion of the installed product. The Manufacturer shall outline specific repair or replacement procedures for potential issues that may occur during the application of the SYSTEM. Repair/replacement procedures shall be as recommended by the SYSTEM Manufacturer and shall be submitted as part of the PWS.
- B. Issues, that may not affect the operation and long term life of the product, shall be identified and defined by the Manufacturer.
- C. Repairable issues that may occur in the SYSTEM shall be specifically based on Manufacturer's recommendations, including a detailed step-by-step repair procedure, resulting in a finished product meeting the estimated life cycle of the component and requirements of these contract specifications.
- D. Un-repairable issues that may occur in the SYSTEM 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 SYSTEM.

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

1.7 REFERENCES

- A. ASTM and other applicable standard documents, that are listed in the detailed 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.

1.8 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. Polymer and Cementitious protective coating materials are to be stored at temperatures as recommended by the manufacturer and handled according to their material safety data sheets. Do not store near flame, heat or strong oxidants.

1.9 INSPECTOR TRAINING

- A. The Contractor shall provide training by a manufacturer's approved trainer for the Owner's representatives/inspectors on the specific product being installed.
- B. The inspector training shall include sufficient amount of classroom time to instruct the inspector's on the basic concepts of the technology and what aspects are important to review and inspect in the field while the SYSTEM is being installed by the Contractor. The inspector training shall also include a sufficient amount of time to instruct the inspectors on what needs to be inspected in the field, what needs to be inspected for each SYSTEM and what documentation is needed to verify that the SYSTEM has been installed in accordance with the contract documents.
- C. Compensation for inspector training shall be at the number of days specified and the unit price Bid in the Proposal.

1.10 SAFETY

- A. The Contractor shall conform to all work safety requirements of pertinent regulatory agencies, and shall secure the site for working conditions in compliance with the same. The Contractor shall erect such signs and other devices as are necessary for the safety of the work site.

- B. The Contractor shall perform all of the Work in accordance with applicable OSHA safety standards. Emphasis shall be placed upon the requirements for entering confined spaces and with the equipment being utilized for manhole rehabilitation components. Confined space, defined as any space having one or more of the following characteristics:
 - 1. Limited openings for entry and exit.
 - 2. Unfavorable natural ventilation.
 - 3. Not designed for continuous worker occupancy.

- C. The Contractor shall have on the job site at all times at a minimum the following safety equipment:
 - 1. Gas monitor capable of testing and detecting for combustible gas, oxygen deficiency and hydrogen sulfide.
 - 2. Confined space access and retrieval winch system.
 - 3. Ventilating fans with large diameter ventilating hose.
 - 4. Supplied air respirator, MSHA/NIOSH approved type.
 - 5. Safety harness and life lines.
 - 6. Other equipment as may be required for a specific project
 - 7. All equipment to be available for use, in sufficient quantity, by the Contractor, Engineer and Owner for the duration of the project.

- D. All entries into or work within confined spaces shall be conducted in accordance with the U.S. Department of Health and Human Services/National Institute for Occupational Safety and Health [DHHS (NIOSH)] Publication No. 87-113, A Guide to Safety in Confined Spaces.

- E. The Contractor shall submit a proposed Safety Plan to the Owner, as part of the PWS and prior to beginning any work, identifying all competent persons, equipment and operating procedures. The plan shall include a description of a daily safety program and daily safety meeting for the job site and all emergency procedures to be implemented in the event of a safety incident. All work shall be conducted in accordance with the Contractor's submitted Safety Plan.

- F. Compensation for all work required for the submittal of the Safety Plan shall be included in the Lump Sum item for Mobilization contained in the Bid Proposal.

1.11 WARRANTY

- A. The materials used for the project shall be certified by the manufacturer for the specified purpose. The manufacturer shall warrant the SYSTEM to be free from defects in raw materials for one (1) year 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 one (1) year. During the one (1) year warranty period if the rehabilitation component, fails, delaminates, peels or

shows any 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 in accordance with procedures included in Section 1.6 Rehabilitation Component Repair/Replacement.

- B. After a manhole has been renewed and for a period of time up to one (1) year following completion and final acceptance of the project, the Owner may inspect all or portions of the renewed manholes. The specific locations will be selected at random by the Owner and will include all types of structures from this project.
- C. If any of the rehabilitation components have developed defects since the time of "Quality Assurance And Testing," the defects shall be repaired and/or the component shall be replaced as defined in Section 1.6 Rehabilitation Component System (SYSTEM) Repair/Replacement. Owner may inspect all manholes where SYSTEM's have been applied/installed under this contract.
- D. All verified defects shall be repaired and/or replaced by the Contractor and shall be performed in accordance with Section 1.6 Rehabilitation Component System Repair/Replacement and per the original specifications, all at no additional cost to the Owner.

1.12 WARRANTY INSPECTIONS

- A. Visual inspection to determine integrity of SYSTEM materials and water-tightness will be conducted within 3 months before the expiration of the guarantee period.
- B. If possible, inspection should be performed in the spring during high groundwater and frequent rainfall events.
- C. The Owner shall perform, at its own cost, warranty inspections with its own personnel or personnel independent of the installation contractor.
- D. Ten (10) percent of manholes rehabilitated shall be inspected, at locations randomly selected, by the Owner.
 - 1. No infiltration or inflow shall be visible in the renewed manhole.
 - 2. If any SYSTEM fails the warranty inspection, the Owner shall inspect all SYSTEM's installed in the contract, together with Contractor.

1.13 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. Manhole coatings and linings will be measured over the entire installed length. Coating and/or lining of the channel shall be at the Lump Sum price per each bid therefore in the 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 or lump sum prices bid therefore in the Bid Proposal.

PART 2 - REHABILITATION COMPONENT SYSTEM PRODUCTS

- A. The SYSTEM'S 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.

2.1 CHEMICAL GROUTS

A. REFERENCES

ASTM F2414-03 Standard Practice for Sealing Sewer Manholes Using Chemical Grouting

B. CHEMICALGROUT TYPES

1. The Contractor shall specifically define the type of chemical grout that will be furnished for the project. Depending on the specific application either Acrylic or Acrylate Based Grout or Urethane Based Grout shall be furnished. The type of grout to be used shall be in accordance with the manufacturer's recommendation for the specific application area of the project.
2. Contractor shall deliver materials to job site in undamaged, unopened containers bearing manufacturer's original labels. Materials used as chemical grout shall be transported, stored, mixed and applied in manner prescribed by the manufacturer of the specified materials, as detailed in published data provided by manufacturer.

C. MATERIALS

1. Contractor shall provide a chemical sealant solution containing principal chemical sealant constituent, initiator (trigger) and catalyst specifically recommended for the purpose of sealing leaks in manholes. Chemical sealant constituent, initiator (trigger) and catalyst shall be compatible when mixed. Solution shall have ability to tolerate dilution and react in moving water. After final reaction, it shall be a stiff, impermeable, yet flexible gel. The grout proportions shall be such that dilute aqueous solutions, when properly catalyzed will form stiff gels. Materials provided shall gel in a predetermined time period when exposed to normal groundwater pH ranges, and be capable of formula adjustments to compensate for changing conditions. Final reaction shall produce a continuous, irreversible, impermeable stiff Gel and shall not be rigid or brittle.
2. The grout shall exhibit the following properties:

- a. Controllable reaction times and shrinkage through the use of chemicals supplied by the same manufacturer. The minimum set time shall be established so that adequate grout travel is achieved.
 - b. Resistance to chemicals, to most organic solvents, mild acids and alkali.
 - c. The grout shall be non-toxic in its cured form.
 - d. Sealing material shall not become rigid or brittle when subjected to a dry environment. The material shall be able to withstand freeze/thaw and moving load conditions as verified by third party testing.
3. The Contractor shall identify the type of grout and additives used on the contract and furnish references of successful use in similar applications. The Contractor shall select the choice of materials based on chemical and physical properties and expected performance for the requirements of the contract documents.
 4. Grout conditions may be adjusted for catalyzing the reaction, inhibiting the reaction, lowering the freezing temperature the grout solution, adding fillers, providing strength or for inhibiting root growth according to the instructions of the grout manufacturer and in the specified quantities as recommended by the grout manufacturer.

D. MIXING & HANDLING

1. Mixing and handling of chemical grout, which may be toxic under certain conditions, shall be done in such a manner as to minimize any hazard to personnel and shall be in accordance with the manufacturer's recommendations. It is the responsibility of the Contractor to provide appropriate protective measures to ensure that chemicals are handled only by trained and authorized personnel. All equipment used to install the grout shall be as recommended by the manufacturer and only personnel thoroughly familiar with all aspects of the grouting material and meeting the qualification requirements specified herein, shall perform the actual grouting operation.

2.2 CEMENTITIOUS MANHOLE RESTORATION

A. REFERENCES

ASTM F2551 Standard Practice for Installing a Protective Cementitious Liner System in Sanitary Sewer Manholes

ASTM C150 Standard Specification for Portland Cement Type I

ASTM C33-86 Standard Specification for Concrete Aggregates

ASTM C78 Standard Test Method for Flexural Strength of Concrete; Using Simple Beam with Third Point Loading

ASTM C109/C109M-05 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)

ASTM C157/C157M-06 Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

ASTM C267 Test Methods for Chemical Resistance of Mortars, Grouts and Monolithic Surfacing and Polymer Concretes

ASTM C293-02 Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)

ASTM C309 Specification for Liquid Membrane-Forming Compounds for Curing Concrete

ASTM C321-00(2005) Standard Test Method for Bond Strength of Chemical-Resistant Mortars

ASTM C348-02 Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars

ASTM C494-86 Standard Specification for Chemical Admixtures for Concrete

ASTM C496/C496M-04e1 Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens

ASTM C666/C666M-03 Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing

ASTM C882-05 Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete by Slant Shear

B. GENERAL

1. The Contractor shall provide a cementitious restoration material designed for structural build-back, I&I abatement, corrosion resistance, and repairing inverts to design requirements. All materials applied to a structure shall be compatible, as specified by the manufacturer.

C. MANHOLE REPAIR MATERIALS

1. Infiltration Control – Cementitious Material
 - a. All fast setting materials furnished shall be designed specifically for leak control, to be applied in dry powder form, with no prior mixing of water, directly to active leaks under hydrostatic pressure in manholes or related structures, in accordance with the manufacturer's recommendations.
2. Infiltration Control - Oakum Water Plugs
 - a. Rapid setting, oil free oakum and hydrophilic grout to seal active water leaks prior to applying other SYSTEM's
 - b. Oil-free oakum meeting Federal Specification HH-P-117
 - c. Two-part urethane resin.
3. Invert Repair and Patching
 - a. All material furnished, by the Contractor, shall be designed to fill large voids in manhole walls and to repair or reconstruct inverts where no hydrostatic

pressure exists. Material shall consist of rapid setting cements, monocrystalline quartz aggregates, and various accelerating agents. Material shall not contain chlorides or metallic particles and shall be applied in accordance with the manufacturer's recommendations.

- b. Repair and Patching Materials shall have its bond strength tested to substrate failure according to ASTM C952 and be compatible with all other material components applied to the manhole.
4. Grouting mix:
 - a. For stopping severe infiltration, the Contractor shall provide a polymer solution that reacts freely with water to form a strong film, gel, or foam of polyurethane. See specification section 2.1 Grouts.
5. Cementitious Coating Restoration Materials for manhole walls, channels, corbels, chimneys and benches. The Contractor shall install cementitious restoration materials that shall be specifically designed for the rehabilitation of manholes and other related wastewater structures. Liner materials shall be cement based, poly-fiber reinforced, shrinkage compensated, and enhanced with chemical admixtures and siliceous aggregates. Liner materials shall be mixed with water per manufacturer's written specifications and applied using equipment specifically designed for, troweling, low-pressure spray or centrifugal spin casting application. All cementitious liners shall be troweled to densify and smooth out the surfaces.
6. Refer to section 1.1.F for design requirements.

2.3 CAST-IN-PLACE CONCRETE RESTORATION

A. GENERAL

1. This method includes a formed in place seamless concrete manhole within the existing manhole extending from the manhole bench to the frame, utilizing an internal forming system for forming a new and structurally independent wall within the existing structure conforming generally to the existing inside and shape of the manhole.
2. The new interior wall shall have a cross-sectional dimension of sufficient thickness to be structurally independent and allow for the maximum new finished inside diameter. It shall be constructed of high strength ready mix concrete and specifically designed to be applicable for municipal and industrial sewer collection systems.

B. REFERENCES

ASTM C-39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C-94 Standard Test Method for Ready-Mix Concrete
ASTM C-143 Standard Test Method for Slump of Hydraulic Cement Concrete

C. MATERIALS

1. Concrete - The concrete shall be Type I&II Portland cement concrete with 5/8 inch minus coarse aggregate with fiber reinforcement and plasticizers. Other

formulations and filler materials may be selected to meet specific needs as recommended by the manufacturer.

D. FORMWORK

1. Segmented forms in cylindrical and conical sections
2. Provide adequate annular space for concrete.
3. Finished manhole opening shall not be less than 20 inches
4. The liner shall be sealed at the existing bench and pipe openings to form a long term water-tight connection.
5. Removable from within new cast concrete manhole wall.

E. PLASTIC INTERIOR WALL SURFACE

1. Provide PVC or Polyethylene liner on new manhole interior wall surface.
 - a. Refer to section 1.1.F for design requirements.
 - b. Ribbed or studded for embedment into the concrete liner.
 - c. Fit securely to exterior of concrete forms.
 - d. Heat fuse or extrusion weld seams

2.4 POLYMER SYSTEMS

A. REFERENCES

ASTM D543 - Resistance of Plastics to Chemical Reagents.
ASTM D638 - Tensile Properties of Plastics.
ASTM D695 - Compressive Properties of Rigid Plastics.
ASTM D790 - Flexural Properties of Unreinforced and Reinforced Plastics.
ASTM D2240 - Standard Test Method for Rubber Property—Durometer Hardness
ASTM D4060 - Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abrader
ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages
ASTM D7234 - Pull-off Strength of Coatings Using a Portable Adhesion Tester.
SSPC SP-13/NACE No. 6 – Surface Preparation of Concrete
NACE SP0188 - For performing holiday detection
CIGMAT - Evaluation of Liner System for Wastewater Concrete and Clay Brick Facilities
ASTM G210 - Severe Wastewater Analysis Test

B. EXISTING SUBSTRATE PREPARATION

1. Standard Portland cement or new concrete (not quick setting high strength cement) must cure a minimum of 28 days prior to application of the coating product(s).
2. Remove existing coatings prior to application of the SYSTEM which may affect the performance and adhesion of the SYSTEM.

3. Thoroughly clean, removing all laitance and prepare existing products to effect a mechanical bond with the SYSTEM.
4. Manufacturer shall recommend specific methods for surface preparation.

C. REPAIR AND RESURFACING PRODUCTS

1. Repair products shall be used to fill voids, bug holes, and/or smooth transitions between components prior to the installation of the SYSTEM. Repair materials must be properly cured and must be compatible with the SYSTEM and shall be used and applied in accordance with the manufacturer's recommended requirements.
2. Resurfacing products shall be used to fill large voids, lost mortar in masonry structures, smooth deteriorated surfaces and to rebuild severely deteriorated structures.
3. The following products may be accepted and approved as compatible repair and resurfacing products for use within the specifications:
 - a. 100% solids, solvent-free polymer grout specifically formulated for epoxy polymer top coating compatibility.
 - b. Factory blended, rapid setting, high early strength, fiber reinforced, non-shrink repair mortar that can be trowelled or pneumatically spray applied maybe approved if specifically formulated to be suitable for polymer top coating with the specified polymer product. The length of resurfacing material cure required before polymer top-coating, shall be as recommended by the manufacturer.
 - c. All repair and resurfacing materials should be properly cured and prepared for surface top-coat application.

D. COATING PRODUCTS

1. Refer to section 1.1.F for design requirements.

E. SYSTEM APPLICATION

1. Polymer System manufacturer shall provide System application procedures and requirements.
2. Manufacturer recommended and approved application equipment.
3. Hard to reach areas, primer application and touch-up may be performed using hand tools.

2.5 CURED-IN-PLACE MANHOLE LINERS

A. REFERENCES

ASTM D-638-03 Standard Test Method for Tensile Properties of Plastics

ASTM D695-02a Standard Test Method for Compressive Properties of Rigid Plastics

ASTM D790-07 Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

ASTM D2344/D2344M-00(2006) Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates

ASTM: D-3039 ASTM D3039/D3039M-00(2006) Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials

B. PRE-MADE LINERS

1. Pre-Made liners can be custom fabricated and can accommodate a variety of manhole shapes and sizes.
2. The liner is designed and fabricated for each specific manhole and must be installed in that manhole.

C. TUBE LINERS

1. The tube liner system includes a constant diameter tube design that is stretched to fit a range of manhole sizes and lengths.
2. The tube typically consists of stretchable resin absorbing textile material

D. MATERIALS

1. Manhole interior walls and benches shall be patched with compatible patching/plugging compounds as specified elsewhere herein. Manhole interior surfaces shall have all defects such as leaks, holes, mortar joints, bug holes, etc. patched with compatible cementitious patching/plugging compounds as specified elsewhere herein.
2. Channel reconstruction cement shall be as specified elsewhere herein.
3. As a minimum the manhole liner systems shall be composed of a multiple layered composite consisting of felt, an impervious membrane, and fiberglass as required.
4. The fibrous layer will be impregnated with a polymer resin. Add fiberglass and resin, for additional liner thickness.
5. Refer to section 1.1.F for design requirements.

2.6 COMPOSITE LINER
(Fiberglass Reinforced Epoxy Composite)

- A. The protective liner shall be a multi layered composite comprised of layers of epoxy and fiberglass/carbon fiber cloth, hand crafted, constructed in place and cured at ambient temperature.
- B. Manhole interior surfaces shall have all defects such as leaks, holes, mortar joints, bug holes, etc. patched with cementitious patching/plugging compounds as specified elsewhere herein.
- C. Manhole invert channels shall be reconstructed with cements as required and specified elsewhere herein.

- D. Manhole corbel and joints shall be surface prepped and resurfaced to an even and nearly smooth profile with cements as required and specified elsewhere herein.

2.7 CONCRETE PROTECTIVE LINERS

A. REFERENCES

ASTM C579 - Compressive Strength of Chemically Setting Silicate and of Shotcrete
ASTM C109/C109M-05 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars(Using 2-in. or [50-mm] Cube Specimens)
ASTM C307 - Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacing
ASTM D412-06a Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension
ASTM D638 - Standard Test Method for Tensile Properties of Plastics
ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D4833-00e1 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
ASTM D4787 Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates
ACI 506.2-77 - Specifications for Materials, Proportioning, and Application Silica Chemical Resistant Mortars.

B. HIGH DENSITY POLYETHYLENE (HDPE)

1. Protective liners shall be integrally extruded complete with anchoring studs. The minimum thickness of liner sheet with anchoring studs and the joint overlaps shall be recommended by the manufacturer. All joints shall be sealed using thermal welding as recommended by the manufacturer.
2. HDPE Material Properties. Manufacturer shall submit design for minimum density, elongation, and abrasion resistance.
 - a. Minimum annular space clearance when filling with flow-able concrete or grout shall be as required by manufacturer.
 - b. Anchor bolt penetration of concrete in manhole wall shall be to manufacturer specifications.
 - c. Countersink screws to mount liner to profiles
3. Manufacturer shall submit Cement and Grout material requirements to fill annular space between the liner and the manhole wall.

C. POLYVINYL CHLORIDE (PVC) PROTECTIVE SHEET LINERS

1. The minimum liner thickness shall be determined by the manufacturer.
2. All joints and seams to be thermally sealed as recommended by the manufacturer.
3. Manufacturer Refer to section 1.1.F for design requirements.
4. Apply primer and two part mastic to seal liner to manhole wall.

2.8 FRP MANHOLE INSERTS

A. REFERENCES

ASTM D3753-05e1 Standard Specification for Glass-Fiber Reinforced Polyester Manholes and Wet Wells

B. WALL CLEANING

1. Wall Cleaning as recommended by manufacturer

C. BENCH-FORMING AND REPAIR MATERIALS

1. Concrete shall be Type V, in accordance with the manufacturers recommendations.
2. Leak repair material as recommended by the manufacturer

D. FRP INSERT MATERIAL

1. 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 D 3753.
 - b. Interior and exterior surfaces shall be relatively smooth and be free of sharp projections and protruding glass fibers. No blisters or de-laminations 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 for an AASHTO H-20 load rating and wall stiffness of 36psi minimum.
2. Sealants
 - a. A sealant, as recommended by the manufacturer shall be inserted between the FRP reducer and frame
 - b. Sealant between FRP insert and the surfaces of the manhole base shall be a quick-setting grout as recommended by the manufacturer.
3. Grout
 - a. Grout shall meet the specifications as required by the manufacturer.

2.9 MANHOLE CHIMNEY SEALS

A. REFERENCES

ASTM C923-07 Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals

ASTM D412-06a Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers -Tension

ASTM D638-03 Standard Test Method for Tensile Properties of Plastics

ASTM D395-03 Standard Test Methods for Rubber Property - Compression Set
ASTM - D790 Standard Test Methods for Flexural Properties of Un-reinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D695-02a Standard Test Method for Compressive Properties of Rigid Plastics
ASTM D2240-05 Standard Test Method for Rubber Property - Durometer Hardness
ASTM D-638-03 Standard Test Method for Tensile Properties of Plastics
ASTM D790-07 Standard Test Methods for Flexural Properties of Un-reinforced and Reinforced Plastics and Electrical Insulating Materials
ASTM D2344/D2344M-00(2006) Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates
ASTM: D-3039 ASTM D3039/D3039M-00(2006) Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials

B. GENERAL

1. Manhole frame sealing includes the sealing of the frame joint area and the chimney above the cone of the manhole with either a manufactured or applied internal flexible seal.
2. The seal shall be designed to prevent leakage of water into the manhole.

C. MECHANICAL FRAME SEAL MATERIAL

1. 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 C 923 Table 1.
2. 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.
3. The upper and lower sections of the sleeve that compress against the frame casting, and manhole chimney or cone shall have an expansion band recess capable of restraining the band during expansion and after installation.
4. Any extension used in conjunction with the sleeve to increase chimney coverage shall be manufactured of the same material in conformance with ASTM C923, Table 1 and be designed with an extension flap which fits into or behind the expansion band recess allowing for joining the components with an expansion band.
5. 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 C 923. 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 C 923.
6. The installed internal seal or its appurtenances shall not extend far enough into the manhole opening to prevent or unduly restrict manhole entry. If the seal is constructed of another flexible material, it shall have both tensile and tear strength

equal to or greater than that of the natural or synthetic rubber when tested in accordance with the applicable ASTM procedures.

7. Physical Properties
 - a. Extruded or molded from a high grade rubber compound as per ASTM C923.
8. The installed seal shall remain flexible, to allow for repeated vertical movements of the frame due to frost lift, ground movement, or other causes and/or repeated horizontal movement of the frame due to thermal movement of pavement or other causes.

D. POLYMER CHIMNEY SEAL

1. Polymer manhole chimney seals shall be designed to prevent leakage of water into the manhole through the frame joint area and the area above the manhole cone including all extensions to the chimney area. Extensions shall include but are not limited to lifting rings, brick and/or block material that may have been used to achieve grade.
2. The polymer chimney seal material shall be corrosion resistant.
3. Mil thickness shall be determined by the manufacturer. Refer to section 1.1.F for design requirements.
4. The polymer chimney seal may require a primer resin applied to the entire surface before application. The sealing system shall line the interior of the adjustment area from the cone/top of the manhole and onto the inside of the casting. If the manhole has been relined prior to the seal installation the seal shall cover a minimum of 6 vertical inches to cover casting cone interface.

E. CURED-IN-PLACE CHIMNEY SEAL

1. The liner shall be continuous in length and consist of one or more layers of a stretchable absorbent textile material and resin. The liner is designed to prevent I&I, withstand hydrostatic pressures, bridge missing mortar or brick segments, withstand multiple freeze/thaw cycles, and conform to the contours of the existing structure. The saturated liner shall have uniform thickness and have excess resin distribution that when compressed at installation pressures will meet or exceed the design thickness after cure.
2. The exposed layer of the stretchable liner shall be coated with an impermeable, translucent, flexible membrane. The liner shall be marked correlating to the address or manhole identification number, and date of installation.
3. The liner shall be a one-piece assembly sewn in the shape of a tube at a predetermined length to seal the casting and to overlap onto the cone/corbel. The sewn seams shall be sealed using a tape compatible with the liner coating. The liner wall thickness shall be uniform throughout. The liner will be capable of conforming to offset bricks and grade rings, missing mortar gaps, and disfigured and deteriorated chimneys.
4. The resin system shall be a corrosion resistant silicate resin containing 100% solids and no VOC's. The resin system contained within the stretchable liner, when

properly cured, shall form a tenacious mechanical bond with properly prepared surfaces and withstands multiple freeze/thaw cycles without cracking

5. Refer to section 1.1.F for design requirements.

F. COMPOSITE CHIMNEY SEAL

1. The protective liner shall be a multi layered composite comprised of layers of epoxy and fiberglass cloth, hand crafted, constructed in place and cured at ambient temperature to mitigate curing stresses. The liner, when cured, shall prevent I & I by withstanding hydrostatic pressure as well as conforming to the shape and bonding tightly to the chimney substrate.
2. The chimney interior surfaces shall have all defects such as leaks, holes, mortar joints, bug holes, etc. patched with compatible patching/plugging compounds as specified elsewhere herein for use in manholes and compatible with the epoxy contained in the fiberglass or carbon fiber cloth.
3. The chimney seal shall, when cured, create a monolithic liner which ties the casting and the length of the chimney together with the first 3 inches of the corbel.

2.10 REPLACE MANHOLE FRAME AND COVER

A. REFERENCE

ASTM A48/A48M-03 Standard Specification for Gray Iron Castings Class 35B
AASHTO Standard Specifications for Highways and Bridges

B. CONDITION

1. The manhole casting shall be free from sand or blow holes and other defects. The machine bearing surfaces of the frame and cover shall have even bearing

2.11 MANHOLE ADJUSTMENT MATERIALS

A. REFERENCE

ASTM D4976-06 Standard Specification for Polyethylene Plastics Molding and Extrusion Materials
AASHTO Standard Specifications for Highways and Bridges

B. MATERIALS

1. Manhole frame adjustments shall be HDPE, PVC, EPP, rubber, brick, block, cement or poured concrete as shown in detail on the contract documents.
2. Measurement shall be by vertical linear inch of adjustment materials provided and/or installed.
3. Payment shall be at the price per vertical linear inch or as a lump sum as stated in the bid documents.

2.12 MANHOLE STEPS

A. REFERENCES

ASTM C478-07 Standard Specification for Pre-cast Reinforced Concrete Manhole Sections

ASTM A615/A615M-07 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

AASHTO M199

B. MATERIAL

1. Reinforcing bar manhole steps shall conform to the minimum requirements of ASTM C478, Para, 11. The reinforcing bar shall be grade 60, deformed 1/2inch reinforcing bar conforming to the requirements of ASTM A615

PART 3 - EXECUTION

A. GENERAL

1. Maintain all flow in the manhole throughout duration of project.
2. Provide 48 hour notice to the Owner prior to start of work for Inspector to review and document materials and equipment to be used, for Quality Assurance and testing requirements.

B. CONTRACTOR EXPERIENCE

1. Current documentation, from the SYSTEM product manufacturer, certifying that the Contractor's training, the Contractor's personnel and equipment comply completely with their product Quality Assurance requirements.
2. For a manhole coating or lining product to be considered for this project, a minimum of 1000 vertical feet of documented manhole rehabilitation must have been completed by the Contractor in the previous three (3) year period.
3. For all SYSTEM products, to be considered for this project, a minimum of a three (3) year successful installation history must be documented.
4. In all cases a minimum of five (5) recent verifiable references of the Contractor's work is required, indicating the successful application of the SYSTEM products 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 specifications.

C. MANHOLE PREPARATION

1. Bypass Pump sewage, in the manhole, as required
2. Clean interior surfaces of manhole of debris, dirt, oil, grease, remains of old coating materials, and any other extraneous materials.
3. Pressure wash manhole walls to remove loose mortar, concrete and debris. Pressure washing levels, used for cleaning, shall be as recommended by the manufacturer.
4. Repair irregularities in manhole using materials, compatible with proposed resurfacing material, as recommended by the manufacturer.

5. Repair leakage in manhole using materials, compatible with proposed resurfacing material, specified in these contract specifications.
6. Trim and grout incoming laterals and pipes as required and/or specified.
7. Remove debris from manhole and incoming sewer connections.
 - a. Handle cleaning water to prevent water and residue from causing damage.
 - b. Do not discharge debris downstream through the sanitary sewer system.
 - c. Filter solids-laden water through a de-silting device.
 - d. Properly dispose of debris and residue from cleaning and other construction operations in a manner satisfactory to Owner and authority having jurisdiction over area where work site is located.

3.1 CHEMICAL GROUT

A. GENERAL

1. 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. All structural repairs, adjustments to the frame and cover and installation of grade rings shall be completed prior to beginning the grouting operation. Normal grouting operations shall be performed at the temperatures as recommended by the manufacturer.

B. CHEMICAL GROUTING APPLICATION

1. Grouting applications may include sealing a manhole from infiltration/Inflow prior to application of a coating or lining or other structural rehabilitation component or using the grout for sealing the entire manhole structure. If the entire manhole is to be sealed, grouting shall include corbel, wall, pipe seals, bench and invert as recommended by the manufacturer of the grouting material.

C. DRILLING AND GROUT INJECTION

1. Drilling grout injection holes in the manhole in strategic locations to re-direct flow coming through cracks and other defects in the wall, or to seal the entire exterior surface of the manhole, shall be in accordance with the recommendations of the grout manufacturer.
2. Grout shall be injected through the drilled holes using the recommended probe and applying pressures that will effectively inject the grout but, not cause damage to the manhole structure or the surrounding area.
3. Grout typically, shall be injected through the lowest holes first, working the grout higher until the manhole is externally sealed with grout. Additional holes may be required to verify that the grout has encompassed the entire outside of the manhole.
4. The injection holes shall be cleaned and patched as recommended by the manufacture.

D. TESTING AND ACCEPTANCE

1. Visual inspection – all leakage into the manhole must be eliminated.

3.2 CEMENTITIOUS RESTORATION

A. GENERAL

1. Before starting any patch work or liner application install a perforated device, catch bucket, or other straining device to prevent construction debris from entering downstream pipes.
2. Provide all materials, labor, equipment, etc. required to perform the work as recommended by the manufacturer and as required by the contract documents.
3. Inspect each manhole to determine methods of stopping leaks and applying patch repairs.
4. Promptly inform Owner of errors or discrepancies between the contract documents and the field conditions found, in order that changed conditions can be evaluated and revised directives issued in a timely manner.
5. Install all products in accordance with manufacturer's instructions regarding surface preparation, product application and curing.
6. Confirm that all material to be used, for the rehabilitation of the manhole are compatible with each other. Do not use any materials that have not been verified for compatibility.

B. SEALING ACTIVE LEAKS

1. The work consists of hand applying a dry quick-setting cementitious mix designed to instantly stop running water or seepage in all types of 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 all debris per the guidelines 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 dry quick-setting cementitious material to the active leak, with a smooth fast motion, maintaining external pressure for 30 seconds, repeat until leak is stopped.
 - d. Proper application should not require any special mixing of product or special curing requirements after application.
 - e. Use of Oil-free Oakum Water Plugs.
 - 1) Saturate oakum with resin following approved submittals.
 - 2) Use additives as required.
 - 3) Place and cure following manufacturer's recommendations.

C. INVERT REPAIR

1. The work consists of hand mixing and applying a rapid setting, high early strength, non-shrink patching material to fill all large voids and repair manhole channels prior to spray lining of the manhole. For invert repairs, flow must be temporarily restricted by inflatable or mechanical plugs prior to cleaning.
 - a. The area to be repaired must be cleaned and free of all debris per the guidelines set forth in Section A, 1 Manhole Cleaning and Preparation.
 - b. Mix water shall be clean potable water and require no additives or admixtures for use with cementitious patching materials.
 - c. Cementitious material shall be mixed in a mortar tub or 5 gallon pail with water per manufacturer's specifications. Material should be mixed in small quantities, to avoid setting prior to placement in voids or channels.
 - d. Once mixed to proper consistency, the materials shall be applied to the invert or void areas by hand or trowel. 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 in order to facilitate flow.
 - e. Flows in channels shall be re-established when material has cured enough to withstand the flow as determined by the manufacturer.

D. APPLICATION OF CEMENTITIOUS MANHOLE LINER

1. The work consists of troweling, spray applying and/or centrifugally spin-casting a cementitious based liner to the inside of the existing manhole. The necessary equipment and application methods to apply the cementitious based liner materials shall be only as recommended and approved by the material manufacturer.
2. Material shall be mixed with water in accordance with manufacturer's specifications. Once mixed to proper consistency, the materials shall be pumped via a rotor-stator style progressive cavity pump through a material plaster hose for delivery to the appropriate and / or selected application device. The equipment shall be as recommended by the manufacturer, matched for the material being applied.
3. If a chimney seal is required in conjunction with the lining technology, the Contractor should contact the chimney seal manufacturer to determine the proper preparation required for effectively installing the chimney seal after the coating has been applied and cured.

E. SPRAY APPLICATION OF THE CEMENTITIOUS MATERIAL.

1. All material shall be applied and finished, by the Contractor, using equipment specified by the manufacturer.
 - a. Material hose shall be coupled to a low-velocity spray application nozzle. Pumping of the material shall commence and the mortar shall be atomized by the introduction of air at the nozzle, creating a low-velocity spray pattern for material application.
 - b. Spraying shall be performed by starting at the manhole invert and progressing up the wall to the corbel and chimney areas.

- c. Material shall be applied to a specified uniform minimum thickness as required by the manufacturer and as necessary for proper curing and application. Material shall be applied to the bench area in such a manner as to provide for proper drainage.
- d. Material shall be troweled smooth to compact material into voids. A brush or broom finish may be applied when a top coating is desired.

F. SPIN CASTING APPLICATION OF THE CEMENTITIOUS MATERIAL

1. All material shall be applied and finished by the Contractor using equipment specified by the manufacturer.
 - a. Material hose shall be coupled to a high speed rotating applicator device. The rotating casting applicator shall then be positioned within the center of the manhole at either the top of the manhole chimney or the lowest point elevation corresponding to the junction of the manhole bench and walls.
 - b. The high speed rotating applicator shall then be initialized and pumping of the material shall commence. As the mortar begins to be centrifugally cast evenly around the interior of the manhole, the rotating applicator head shall be raised and / or lowered at a controlled retrieval speed conducive to providing a uniform material thickness on the manhole walls.
 - c. Controlled multiple passes are then made until the specified minimum finished thickness is attained. If the procedure is interrupted for any reason, simply stop the retrieval of the applicator head until flows are recommenced.
 - d. Material thickness may be verified at any point with a depth gauge and shall be no less than a uniform ½-inch. If additional material is required at any level, the rotating applicator head shall be placed at that level and application shall recommence until that area is thickened.
 - e. Material shall be applied only when manhole is in a saturated surface dry (SSD) state, with no visible water dripping or running over the manhole walls.
 - f. The low-velocity spray nozzle and the centrifugal spin casting head may be used in conjunction to facilitate uniform application of the mortar material to irregularities in the contour of the manhole walls and bench areas.
 - g. Troweling of materials shall begin immediately following the spray application. Initial troweling shall be in an upward motion, to compress the material into voids and solidify manhole wall. A brush or broom finish may be applied if top coating is desired.
 - h. Curing will take place once the manhole cover has been replaced. It is important that the manhole cover is replaced no more than 10-20 minutes after troweling is complete to avoid moisture loss in the material due to sunlight and winds.
 - i. Material shall not be applied during freezing weather conditions. Material shall not be placed when the ambient temperature is 37 degrees Fahrenheit and falling or when the temperature is anticipated to fall below 32 degrees Fahrenheit during 24 hours.

G. TESTING AND ACCEPTANCE

1. Visual inspection – verify no infiltration, cracks, or loose material.
2. Vacuum Testing, as required in the contract documents
3. Cementitious Material Physical Property Testing

3.3 CAST-IN-PLACE CONCRETE LINER

A. PREPARATION

1. The Contractor shall employ adequate cleaning to remove loose material and debris from the manhole. Existing steps which might interfere with the erection of the forms shall be removed. Precautions shall be taken to prevent foreign material from entering the active lines. Infiltration which may adversely affect placement of the concrete shall be eliminated or reduced to an acceptable level.
2. If a chimney seal is required in conjunction with the lining technology, the Contractor should contact the chimney seal manufacturer to determine the proper preparation required for effectively installing the chimney seal after the liner has been installed and cured.

B. EQUIPMENT

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 generally to the interior shape of the existing manhole.

C. INSTALLATION PROCEDURE

1. 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.
2. 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 a sufficient thickness, as specified. The finished opening shall have a minimum diameter of 20 inches.
3. The form shall be positioned, sealed and finished at the manhole base to ensure concrete does not enter the sewer.
4. The concrete shall be carefully 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 all pockets, seams and cracks within the existing wall.
5. When the concrete has sufficiently cured to preclude slump or damage, the form shall be disassembled and removed.
6. The bench shall receive an overlay of concrete as proposed by the Contractor at a minimum thickness as specified.
7. 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 and around all pipe penetrations to form a water stop.

D. FINISH

1. The resultant concrete interior wall shall be smooth and free of honeycomb and areas of segregated aggregate.

E. CLEANUP

1. Upon completion, the Contractor shall clean up the work site and properly dispose of any excess material or debris.

F. SAFETY

1. The assembled internal manhole forms shall be bolted together to prevent shifting and shall have sufficient stiffness and strength to prevent collapse. All work shall be performed in strict accordance with the city and OSHA safety standards for confined space entry procedures.

G. TESTING AND ACCEPTANCE

1. Visual Inspection
2. Vacuum Testing, as specified in the contract documents
3. Material Physical Property Testing during and after installation

3.4 POLYMER LINERS

A. GENERAL

1. Contractor shall comply with local, state and federal regulatory and other applicable agencies with regard to environment, health and safety during work.
2. New Portland cement concrete structures shall have cured a minimum of 28 days since manufacture prior to commencing coating installation or as recommended by the manufacturer.
3. Any active flows shall be dammed, plugged or diverted as required to ensure all liquids are maintained below or away from the surfaces to be coated.
4. Temperature of the surface to be coated should be maintained between 40 deg F and 120 deg F or as recommended manufacturer.
5. Specified surfaces should be shielded to avoid exposure of direct sunlight or other intense heat source. Where varying surface temperatures do exist, coating application shall be scheduled when the temperature is falling and not rising or as recommended by the manufacturer.
6. Prior to commencing surface preparation, Contractor shall inspect all surfaces specified to receive the coating and notify Owner, in writing, of any noticeable disparity in the site, structure or surfaces which may interfere with the work, use of materials or procedures as specified herein.

B. SURFACE PREPARATION

1. 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 entirely removed.

2. Concrete and/or mortar damaged by corrosion, chemical attack or other means of degradation shall be removed so that only sound substrate remains.
3. 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.
4. Surface preparation methods or combination of methods that may be used include high pressure water cleaning, high pressure water jetting, abrasive blasting, shot blasting, grinding, scarifying, detergent water cleaning, hot water blasting and others as described in NACE No. 6/SSPC SP-13. 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.
5. Infiltration shall be stopped by using a material which is compatible with the repair products and is suitable for top-coating with the epoxy coating product. The manufacturer shall verify the product compatibility, in writing, to the Owner.
6. Manhole Chimney Joint and Casting: The area between the manhole and the manhole ring and the manhole casting shall be a termination point of the specified epoxy coating product.

C. APPLICATION OF REPAIR AND RESURFACING PRODUCTS

1. Areas where reinforcing bars have been exposed shall be repaired in accordance with the manufacturer's recommendations.
2. Areas where rebar has been exposed and is corroded shall be first prepared as required elsewhere in these specifications. The exposed rebar shall then be abrasive blasted and coated with the polymer coating product specified as recommended by the manufacturer.
3. Repair products shall be used to fill voids, bugholes, and other surface defects which may affect the performance or adhesion of the epoxy coating product.
4. Resurfacing products shall be used to repair, smooth or rebuild surfaces with rough profiles to provide a concrete or masonry substrate suitable for the polymer coating product to be applied. These products shall be installed to minimum thickness as recommended within the manufacturer's published guidelines. Should structural rebuild be necessary, these products shall be installed to a thickness as specified in the contract documents. Structural rebuild should be specified in advance of bid whenever feasible, and paid for at a separate unit price in the Bid Proposal.
 - a. Repair and resurfacing products shall be handled, mixed, installed and cured in accordance with manufacturer recommendations.
 - b. All repaired or resurfaced surfaces shall be inspected for cleanliness and suitability to receive the coating product(s). Additional surface preparation may be required prior to coating application.

5. If a chimney seal is required in conjunction with the lining technology, the Contractor should contact the chimney seal manufacturer to determine the proper preparation required for effectively installing the chimney seal after the coating has been applied and cured.

D. APPLICATION OF POLYMER COATING PRODUCT

1. Application procedures shall conform to the recommendations of the epoxy coating product manufacturer, including environmental controls, product handling, mixing, application equipment and methods.
2. Spray equipment shall be specifically designed to accurately ratio, apply the polymer coating product, shall be in proper working order and shall be as recommended by the product manufacturer.
3. Contractors qualified in accordance with these specifications shall perform all aspects of polymer coating product installation.
4. Prepared surfaces shall be coated by spray application of the coating product(s) described herein to a minimum as recommended by the manufacturer to meet the requirements of these contract documents.
NOTE: Coating thickness recommendations are available through the polymer coating product manufacturer based upon project assessment. Contact the manufacturer of the polymer coating for project specific recommendations.
5. Subsequent top coating or additional coats of the polymer coating product shall occur within the product's recoat time. Additional surface preparation procedures will be required if this recoat time is exceeded. The polymer manufacturer's re-coat time for the specific application, based on temperature and project conditions, shall be strictly followed by the applicator.
6. The polymer coating product shall mechanically 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. Procedures and materials necessary to effect this bond shall be as recommended by the polymer coating product manufacturer. No hollow spots will be accepted.
7. Contractor must submit manufacturers recommended method for terminating a coating or lining in a manhole
8. If required sewage flow shall be stopped, bypassed or diverted for application of the polymer coating product to the invert and interface with pipe materials.

E. TESTING AND ACCEPTANCE

1. Visual Inspection - Installed liner system shall be completely free of pinholes and hollow spots/voids and other defects that will reduce the life expectancy of the applied system.
2. Film thickness Measurements – (either wet or dry) Liner thickness shall be the minimum value as specified in the contract documents.
3. Holiday Detection Test (Spark Testing), to identify pinholes, thin material and any defects that will affect the life of the installed system.

4. Adhesion Testing – To verify that the system has consistently mechanically bonded to the host structure.
5. Dye Testing – For non-bonded systems to verify no leakage from an annular space
6. Vacuum Testing as specified in the contract documents

3.5 CURED-IN-PLACE MANHOLE LINERS (CIPM)

A. MAINTAINING WASTEWATER FLOWS

1. The Contractor shall be fully responsible for maintaining the normal sewage flow through the manhole where the specified rehabilitation work demands such flow control. The Contractor shall plan his work in order to maintain flows and to not interrupt sewer service. This may include night work. The cost of any night work required will be included in the contract price of the applicable item. The Contractor shall 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 will be made without submitting a plan to the Owner for review.
2. Unlined flow channel. Install a bridge or flow through tube and cut the liner bottom near the flow line in the channel to expose the flow channel and give access to the pipes. Plug the pipes entering the manhole through the wall and trim the pipe opening to restore flow.
3. Lined flow channel. Plug the pipes entering the manhole and line the flow channel to the edge of the pipe. Trim all pipe openings and restore the flow.

B. PRE-INSPECTION

1. Prior to beginning work, the manhole shall be visually inspected and any areas of apparent structural damage that will affect the installation of the liner shall be reported to the Owner for proceeding with the work.
2. All manhole steps shall be removed before the CIPM liner is installed.

C. INFILTRATION CONTROL

1. The stopping of active hydrostatic infiltration shall be accomplished by using a quick set cementitious material compatible to the liner material being installed or using compatible expansion type grouts

D. CHANNEL RECONSTRUCTION

1. Specifications should include a separate line item for Channel Rebuild which is sometimes required.
2. Remove all loose grout and rubble of existing channel. Rebuild channel by shaping and repairing slope of shelves or benches. Work shall include alignment of inflow and out flow ports in such manner to prevent the deposition of solids at the transition point(s). All inverts shall follow the grades of the pipe entering the manhole. Changes in direction of the sewer and entering branch or branches shall have a true curve of as large a radius as the size of the manhole will permit.

Channels shall be shaped to allow entrance of maintenance equipment into pipes including buckets, TV camera, etc.

3. Channels shall only be lined where indicated on the plans "lined channels".

E. CIPM PREMADE LINER INSTALLATION

1. The Contractor shall furnish all materials, equipment, tools, and labor as required for the rehabilitation of the manholes specified, including the installation of the CIPM liner.
2. The installation of the selected liner system shall be in strict accordance with the manufacturer's instructions. This shall include the preparation, installation, inflation, curing, and finishing, required for the complete installation of the CIPM liner. Custom fabricate liner to individual manhole dimensions.
3. Line bench area with material placed in the bottom of the manhole and extending a minimum of 6 inches up the manhole wall,
4. Saturate liner with resin, place into manhole, pressurize with air or water and cure with hot water, steam or hot air following manufacturer's recommendations
5. When finished, liner forms a monolithic structure from the manhole frame to the bench.
6. All safety rules and regulations applicable laws and insurance requirements shall be observed, by the Contractor, in storing, handling, use and application of the liner materials, resins and any solvents.

F. CIPM TUBE LINER INSTALLATION

1. The manhole is prepared by pressure washing, sand blasting, and filling large voids.
2. The manhole depth is measured and the technicians cut the liner from a bulk roll to match the depth of the manhole.
3. Resin is mixed and introduced into the liner under a controlled vacuum impregnation process.
4. The liner tube has the ability to stretch and accommodate barrel sections while adapting to an eccentric or concentric corbel section of a manhole.
5. The tube liner is inverted through the center of the retaining ring until the liner is fully turned inside out and positioned within the manhole
6. CIPM Tube Liner is fully inverted
7. The inflation device is inserted within the manhole tube liner.
8. Pressure is applied causing the one-size liner to conform to the manhole.
9. The tube liner is cured at ambient temperatures typically within two hours from mixing or accelerated with steam and can be installed during cold winter months as well as warm summer months.
10. The inflation device is removed and the CIPM tube liner is trimmed at the top of the manhole casting flush with the casting lid seat.

G. TESTING AND ACCEPTANCE

1. Visual Inspection. Liner should be free of severe wrinkles, areas deficient of resin, delamination of the fabric layers, infiltration, large hollow areas behind the liner and any other defects that will affect the life expectancy of the CIPM
2. Spark test to identify pin-holes and defects
3. Adhesion test to verify bonding to the host structure if specified
4. Core sample to verify thickness
5. Vacuum Testing as specified in the contract documents
6. Dye Testing – For non-bonded systems to verify no leakage from an annular space

3.6 COMPOSITE LINER (Fiberglass/Carbon Fiber Reinforced epoxy composite)

1. The protective composite liner shall be hand crafted in place to follow the shape and contour of the manhole. A layer of epoxy, shall be placed and firmly troweled to force the epoxy into and even out any and all imperfections of the final prepped surface and ensure 100% bonding with no gaps or voids. A fiberglass fabric coated with a chemical binder shall be applied and incorporated into the epoxy (encapsulated) by application of another layer of epoxy.
2. Refer to section 1.1.F for design requirements.

A. TESTING AND ACCEPTANCE

1. Visual Inspection. Liner should be free of severe wrinkles, areas deficient of resin, delamination of the fabric layers, infiltration, large hollow areas behind the liner and any other defects that will affect the life expectancy of the Composite Liner.
2. Spark test to identify pin-holes and defects
3. Adhesion test to verify bonding to the host structure if specified
4. Core sample to verify thickness
5. Vacuum Testing as specified in the contract documents
6. Dye Testing – For non-bonded systems to verify no leakage from an annular space

3.7 PROTECTIVE PANEL LINERS

A. HIGH DENSITY POLYETHYLENE (HDPE)

1. All manhole steps shall be removed prior to installing the protective liner.
2. A bonding agent compatible with grout or concrete shall be applied to manhole wall before placing liner sheets.
3. Adequate annular space between 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 manufacturers recommendations.

8. Place the concrete or grout, as recommended by the manufacturer, with no wrinkling of 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 manufacturer.

B. POLYVINYL CHLORIDE (PVC) PROTECTIVE SHEET LINERS

1. Apply mastic primer to manhole wall and cure following manufacturers recommendations.
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 manufacturer's recommendations

C. TESTING AND ACCEPTANCE

1. Visual Inspection – To verify that there are no loose panels, peeling, bubbles, or other areas that may hinder the performance of the liner.
2. Weld inspection – Performed by using a putty knife to verify weld is solid.
3. Liner thickness shall be the minimum value as specified herein.
4. Spark test – To verify liners are pinhole free and welds are sealed.
5. Adhesion Test – To verify bonding.
6. Vacuum Testing, as specified in the contract documents
7. Dye Testing – For non-bonded systems to verify no leakage from an annular space.

3.8 PRECAST INSERTS

A. DIVERSION PUMPING

1. Install and operate sewage diversion pumping equipment to maintain sewage flows without backup, overflow, or spillage.

B. CLEANING AND SURFACE PREPARATION

1. 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.
2. 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 without allowing any to enter the sewage flows in the manhole.

C. REPAIRS

1. Active leaks, if present, shall be sealed by application of leak repair material in accordance with the manufacturer's instructions.
2. 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.

D. PRECAST INSERT 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 to both. Seal the cut edges with resin as recommended by the manufacturer.
3. Lower the insert into a 4-inch deep layer of quick-setting grout mixture, making sure that the sewer lines and insert openings align.
4. Place a 6-inch deep 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 if any was removed

E. PROTECTIVE COATING, CHIMNEY BENCH AND INVERT

1. All oil and grease shall be removed from the chimney surface 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. All surfaces 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 (2) 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.

F. TESTING AND ACCEPTANCE

1. Visual Inspection – Inserts shall be inspected for workmanship and no leakage.
2. Vacuum Testing, as specified in the contract documents

3.9 MANHOLE CHIMNEY SEALS

A. MECHANICAL FRAME SEAL

1. The contact surfaces for the sleeve and/or extensions shall be reasonably 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. Realign manhole frame and cover if offset is greater than Three (3) inches between the frame and top of the manhole structure.
2. After any 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 water tight 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.
3. 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, insuring the seal is properly placed on the manhole cone, chimney and frame and expand as required to provide an effective seal.
4. Installation procedures shall be in accordance with the manufacturer's recommended instructions.
5. TESTING AND ACCEPTANCE
 - a. Visual Inspection
 - b. Leakage test - Following the expansion of the lower band a quality assurance test shall be performed to insure effective sealing by pulling the upper section of the seal or extension inward to create a recess behind the seal where water can be poured. Pour the water behind the seal and observe the lower sealing area for any visible leaks. The sealing shall be considered effective if no water leaks from behind the seal at the lower sealing area.

B. POLYMER CHIMNEY SEAL

1. All loose and protruding mortar and brick that would interfere with the polymer chimney seal's performance shall be removed. Any lips for gravel pan supports shall be cut off flush with the manhole casting. All loose material or excessive voids shall be repaired using patching cement, as recommended by the manufacturer. The Contractor shall obtain from the polymer chimney seal manufacture, in writing, the material compatibility and the recommended time required for the patching cement to properly cure prior to installing the polymer chimney seal.
2. Preparation of the chimney surface and casting may include using high pressure water, sandblasting, wire brushing, or other methods as described by the manufacturer, to ensure a clean surface. Active leaks (infiltration) shall be sealed by a method as recommended by the polymer chimney seal manufacturer prior to installing the chimney seal. After water or sandblasting, pressure wash the entire area remove any loose sand that may have been deposited. The substrate surface must be free of sand, loose debris, latencies, dust, oil, grease or chemical

contamination. A blower may be required to completely dry the substrate surface or as recommended by manufacturer.

3. The polymer chimney seal shall require the proper mixing of several components, is recommended by the manufacture. If a primer is required, ensure that all surfaces are clean and dry before applying. After proper curing of the primer, the polymer chimney seal may be applied evenly by brush over the entire chimney area, including the frame joint area and the area above the manhole cone including all extensions to the chimney area.
4. Installation procedures shall be in accordance with the manufacturer's recommended instructions.
5. TESTING AND ACCEPTANCE
 - a. Visual Inspection - Final liner system shall be completely free of pinholes or voids
 - b. Holiday Detection Test
 - c. Adhesion Testing

C. CURED-IN-PLACE (CIPM) CHIMNEY LINER

1. The installation shall include a coated non-woven textile liner of a length specific to each manhole and a silicate based thermo-set resin. The liner is vacuum impregnated (saturated) on-site with the thermo-set resin. The saturated liner is then lowered into the manhole and is temporarily held in position. The installation device is then lowered and properly positioned inside of the liner. The bladder on the installation device is then pressurized so that the liner is pressed against the existing structure. Once the resin-saturated liner is cured, the installation device is removed. The liner is then trimmed flush with the manhole cover seat.
2. All surfaces to be lined must be stringently pressure washed as recommended by the manufacturer Other alternatives to clean the structure may be used along with pressure washing such as abrasive blasting. The existing casting shall be cleaned using a grinder or by sand blasting. Large voids and missing bricks shall be filled with hydraulic cement to provide an area that liner can press up against. Smaller voids and missing mortar may go un-patched, since these areas will be filled with excess resin. Steps that are located in the area to be lined shall be removed.
3. The liner 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 all voids in the liner material at nominal thickness and diameter. No dry or unsaturated areas in the liner shall be acceptable upon visual inspection.
4. Installation Device – The liner is placed with the saturated resin side facing the substrate to allow for resin migration. Once the liner is placed in the manhole and rested on the spacing rings, then the installation device is inserted inside 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 inserted, the bladder is pressurized. The installation device stays in place and pressurized until the liner is cured.

5. Curing – 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 be document the cure time, pressure, resin usage, and other pertinent information.
6. Trimming – Once cured, the installation device is removed and the liner is trimmed at the manhole cover seat.
7. The finished cured-in-place manhole chimney liner shall be continuous from the manhole cover seat to the overlap onto the cone/corbel section. The liner shall provide a smooth surface that conforms to the existing structure. The liner shall be free of dry spots and de-laminations. The finished product must provide an air and watertight corrosion resistant liner protecting the manhole chimney.
8. TESTING AND ACCEPTANCE
 - a. Visual Inspection to insure bonding, resin saturation, complete cure and a smooth surface free from cracks or hollow spots.
 - b. The liner shall be subjected to several freeze/thaw cycles either in the field or simulated in a freezer with no cracking or bond breakage. This test or equivalent test shall be as recommended by the manufacturer and the test results recorded in writing by the Owner representative.
 - c. Adhesion Testing
 - d. Dye Testing – For non-bonded systems to verify no leakage from an annular space

D. COMPOSITE CURED IN PLACE CHIMNEY SEAL

1. The protective composite liner shall be hand crafted in place to follow the shape and contour of the manhole. A layer of epoxy, shall be placed and firmly troweled to force the epoxy into and even out any and all imperfections of the final prepped surface and ensure 100% bonding with no gaps or voids. A fiberglass fabric coated with a chemical binder shall be applied and incorporated into the epoxy (encapsulated) by application of another layer of epoxy.
2. Refer to section 1.1.F for design requirements. Greater thickness can be accomplished by either increasing the thickness of the epoxy layers or by using additional fiberglass layers.
3. TESTING & INSPECTION
 - a. Visual Inspection to insure bonding, resin saturation, complete cure and a smooth surface free from cracks or hollow spots.
 - b. The liner shall be subjected to several freeze/thaw cycles either in the field or simulated in a freezer with no cracking or bond breakage. This test or equivalent test shall be as recommended by the manufacturer and the test results recorded in writing by the Owner representative.
 - c. Adhesion testing
 - d. CIP Material Property Tests
 - e. Dye Testing – For non-bonded systems to verify no leakage from an annular space

3.10 REPLACE FRAME AND COVER

- A. The manhole frame and cover shall be manufactured and installed to the dimensions shown on the contract documents.
- B. Measurement shall be by each manhole frame and cover removed and replaced.
- C. Payment shall be at the unit price each Bid in the Proposal.
 - 1. Payment includes removal of existing frame and cover, replacing frame and cover, and disposal of old frame and cover as required.

3.11 MANHOLE ADJUSTMENT MATERIALS

- A. ADJUSTMENT MATERIAL INSTALLATION
 - 1. The contractor shall furnish all materials, equipment, tools and labor required for the adjustment of rings and covers to grade.
 - 2. The ring and cover to be adjusted shall be located and clearly marked.
 - 3. The existing road or ground surface shall be cut all around the ring & cover, either by triangular, square or round cut (being careful to not create stress fracture points in the corners by over-cutting) to an adequate depth that will allow the desired adjustments to be accomplished. If the cut is not deep enough, the increase in depth may be accomplished with the use of various digging investments.
 - 4. All of the road or ground inside of the cut shall be removed to allow safe working conditions during the adjustment and restoration to the proper height or level.
 - 5. The ring shall be positioned, either by suspension or by placement on the correct amount of adjustment rings, If the positioning is accomplished by suspension, the required retainer shall be installed properly.
 - 6. Once the ring is 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 specs.
 - 7. 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 of time that will allow the fill to properly cure before allowing traffic to resume.

3.12 MANHOLE STEPS

- A. Manhole steps shall be driven into pre-cast or drilled holes. Steps shall be installed no more than 16 inches apart vertically on the interior of the manhole wall at a point 4" below the base flange of the manhole casting.
- B. Measurement shall be for each manhole step provided
- C. Payment shall be at the price per each Bid in the Proposal.

1. Payment includes the removal and replacement of manhole steps per each Bid in the Proposal.

3.13 QUALITY ASSURANCE AND TESTING

A. GENERAL

1. The Contractor shall test the installed SYSTEM's as specified by these contract documents. 10% of the installed SYSTEM's shall be tested using a testing procedure as further delineated below. If more than 5% of the tested SYSTEM's fail the test than an additional 10% of the manholes are selected for further testing. This process continues until the SYSTEM's tested meet the requirements of these contract documents, to the satisfaction of the Owner.

B. CHAIN OF CUSTODY

1. The Contractor shall perform all testing in the presence of the Owner's representative. The Owner's representative shall receive test samples from the Contractor and transmit samples to a third party testing laboratory. The Owner's representative will maintain the chain of custody of all samples that are transmitted and tested to verify SYSTEM compliance with these contract documents.

C. TEST REQUIREMENTS

1. Visual Inspection
 - a. All manholes shall be visually inspected. Any leakage into themanhole in areas where SYSTEM's were installed by the Contractor shall be identified.
 - b. The Contractor shall provide samples for testing to the Owner from the actual installed SYSTEM. Samples shall be provided, at a minimum from one location per every ten (10) SYSTEM's installed.
2. Cementitious Material Property Testing
 - a. Where specified one 2 X 2 inch sample cube shall be taken for every 50 bags of material used. Samples shall be sprayed from nozzle, identified in the presence of the Owner's representative and sent, by the Owner's representative, to an independent test laboratory for compression strength testing as described in ASTM C-109.
3. Vacuum Testing
 - a. Where specified if the entire manhole including invert and pipe penetrations is rehabilitated to as new condition then a Vacuum Test may be performed according ASTM F1244. If vacuum test fails then the contractor shall spray entire manhole with a soap solution and retest to determine where air is entering the manhole. Inspector shall determine if failure was due to improper rehabilitation or poor pipe condition or improperly seated plugs. If inspector determines that the failure is due to improper rehabilitation then the Contractor shall repair manhole according to manufacturer recommendations and retest until a successful vacuum test is achieved. If inspector determines that the

failure was due to poor condition of the pipes, or annular space between the pipe and its liner, or the inability to seat the plugs properly and that there are no visible defects in the applied product then it will be determined that the manhole has passed.

4. Film thickness Measurements
 - a. Where applicable and specified during application a wet film thickness gauge, meeting ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages, shall be used. Measurements shall be taken, in the presents of the Owner's representative, documented and attested to by Contractor for submission to Owner.
5. Holiday Detection Test
 - a. Where specified Holiday Detection shall be performed for all coating systems installed in corrosive environments.
 - b. After the epoxy coating product have set in accordance with manufacturer instructions, all surfaces shall be inspected for holidays with high-voltage holiday detection quipment. Reference NACE RPO 188-99 for performing holiday detection.
 - c. All detected holidays shall be marked and repaired by abrading the coating surface with grit disk paper or other hand tooling method. After abrading and cleaning, additional coating can be hand applied to the repair area.
 - d. All touch-up/repair procedures shall follow the coating manufacturer's recommendations.
 - e. Documentation on areas tested, results and repairs made shall be provided to the Owner, in writing, by Contractor.
6. Adhesion Testing
 - a. Where specified a minimum of 10% of the manholes coated shall be tested For adhesion/bond of the coating to the substrate. Testing shall be conducted in accordance with ASTM D4541, ASTM D7234, or NACE SP018. Owner's representative shall select the manholes to be tested.
 - b. A minimum of three (3) - 50 mm dollies shall be affixed to the coated surface at the cone area, mid section and at the bottom of the structure or in areas suspect from non-destructive evaluation and testing The adhesive used to attach the dollies to the coating shall be rapid setting with tensile strengths in excess of the coating product and permitted to cure in accordance with manufacturer recommendations. The coating and dollies shall be adequately prepared to receive the adhesive.
 - c. Failure of the dolly adhesive shall be deemed a non-test and require retesting. Prior to performing the pull test, the coating shall be scored to the substrate by mechanical means without disturbing the dolly or bond within the test area.
 - d. Two of the three adhesion pulls shall exceed 300 psi or concrete failure with more than 50% of the subsurface adhered to the coating.
 - e. Should a structure fail to achieve two successful pulls as described above, additional testing shall be performed at the discretion of the Owner. Any areas detected to have inadequate bond strength shall be evaluated by the Owner.

- f. Further bond tests may be performed in that area to determine the extent of potentially deficient bonded area and repairs shall be made by Contractor.
- 7. All testing shall conform to these contract specifications and the submitted PWS.

3.14 SAMPLE BID ITEMS

- A. Mobilization – Lump Sum – Includes all PWS info, submittals, safety plan, as built drawings, test samples and mobilization/demobilization of labor, equipment and materials to the project site.
- B. SYSTEM (One for each SYSTEM Specified)– Lump Sum – per each vertical foot including all labor, materials and equipment required by the Contractor to furnish a leak proof manhole to the Owner, complete.
- C. SYSTEM Inspector Training (One for each SYSTEM Specified) – price per day – includes the cost of all labor, equipment and materials required to train the Owner’s inspectors on the SYSTEM technology, at the Owner’s project location.
- D. Replace Manhole Frame and Cover – Lump Sum – per each manhole including all labor, materials and equipment required by the Contractor to remove and dispose of the existing manhole frame and cover and furnish and install a new manhole frame and cover to the Owner, complete.
- E. Manhole Adjustment Materials – per vertical inch – includes all labor, equipment and materials required, by the Contractor, to adjust each manhole as required by the Owner, complete.
 - 1. Bench Rebuild – Some manholes may require structural construction of a bench to promote proper flow. Merely lining the existing flat bench is not consistent with good rehabilitation practice
- F. 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

****END OF SECTION****