



PERFORMANCE SPECIFICATION GUIDELINE

FOR THE
RENOVATION
OF

Manholes Structures

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Prepared by

Gerry Muenchmeyer, Muenchmeyer Associates, LLC

Peer Review Committee

Lee Haessig – Cretex
Bill Shook AP/M Permaform
Joanne Hughes – Raven Lining Systems
Jerry Gordon – Sprayroq
C. Karl Sauereisen – Sauereisen
Roger Dollar – Quadex
William Strong, Jr. – Strong Seal
Kathy Romans – NPC
Mike Rosasco – Poly-Triples Technologies
Bill Oberti – Terre Hill Composites
Steve Henning – Standard Cement
Danny Warren – Warren Environmental
Sims Rhyne – Spectrashield
Jerry Trevino – Protective Liners
John Nelson – Visu-Sewer
Jim Harris – Murfreesboro, TN

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GENERAL DISCUSSION OF PRODUCTS AND TECHNOLOGIES

1. The renovation of manholes can be complicated and the selection of the correct technology can, at times, be confusing. There are many methods available for the renovation of manholes and many new technologies are emerging on the market each year. 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 renovation and what family of products best meet the project requirements.

- a. Thoroughly evaluate the condition of the manhole to be renovated 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.
- b. Define the type of defects as structural defects, operational & maintenance defects, construction features and other.
- c. Based on the defined defects classify each manhole into the general renovation technology or technologies to be considered.
- d. Technologies can be classified into general renovation needs including grouting, cementitious reconstruction, polymer coatings/linings, cured-in-place lining, panel liners, mechanical seals and pre-cast inserts.
- e. Select the right solution based on the problems identified.
- f. What are the problems being addressed?
- g. Does the selected technology provide the desired long-term solution to the problem?

- h. Does the technology go beyond solving the immediate need and is there a cost for the added benefit?
- i. Insure compatibility of all materials being used to complete the repair?
- j. Is the selected technology Contractor friendly? Does it work in a laboratory but not consistently in the field?
- k. Select products that have viable, proven installation techniques.
- l. Can the Contractor capabilities and experience be quantifiable during the bid process?
- m. Can the qualifications of the personnel, working for the Contractor and applying the product be verified?

2. There are many products and product variations available. Only general 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. In many cases multiple renewal components will be required to totally renovate the manhole structure. Products and Technologies are generally referred to herein as Renewal Component Systems (RCS's) and include the following:

- a. **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 verified through the grout manufacturer.
- b. **Cementitious Manhole Restoration** – Cementitious materials can be standard Portland cement, Calcium Aluminates based cement or a polymer modified Portland Cement containing a dry densified microsilica powder admixture. The Calcium Aluminates and Microsilica cements typically have a higher resistance to corrosion and will attain a significantly high structural strength after curing. They also can be top coated in a relatively short period of time while standard Portland cements typically require a 28

day cure before top coating. Cementitious materials can be sprayed or spun cast or poured in place using forms to create a new manhole inside the existing manhole. 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.

c. **Polymers** (Epoxy, Polyurethane, Urea) coatings – generally used in highly corrosive environments, eliminate I/I and 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 new concrete will off-gas air when the temperature structure is rising and will inhale when the concrete temperature drops. The Manufacturer of each system should be contacted to determine what the affect off-gassing has on the product and the best procedures for the application of polymers directly onto new concrete structures. In most cases the Contractor should be experience in coating both new and old concrete structures

d. **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 molded tightly to fit the inside shape of the existing manhole then heat cured into a hard structure within the manhole.

- e. **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 glued to the manhole wall using a special adhesive.

- f. **Chimney Seals** – includes chimney and joint seals, for defects in the rim and casting area of the manhole in which defects often are a key contributor to rainwater or inflow into a manhole. Seals can be applied both internally and externally to the manhole structure.

- g. **Barrel Joint Seals** – Includes joints between pre-cast manhole sections where leaking joints are contributing groundwater infiltration and no structural deficiencies are present.

- h. **Pre-cast Inserts** - bench and invert inserts, wall inserts, casting adjusting rings, replacement of castings, covers and manhole steps to complete the total renovation of a manhole structure

References:

1. 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.
2. ASCE Manual 92 – excellent description and overview of the manhole components, deterioration modes and rehabilitation methods available for manholes
3. Various specifications supplied by RCS manufacturers.

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PART 1.0 GENERAL

1.0.1 These Specifications include the minimum requirements for the renewal of manholes as shown on the plans included as part of these contract documents.

1.0.2 The renewal of manholes shall be accomplished by the application or installation of a number of components either individually or together with other components. These may include grouts, protective coatings, a variety of linings, inserts, seals and mechanical devices that, when installed, shall protect the manhole structure, rebuild it structurally 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 renewed. The Contractor is responsible for the proper, accurate and complete installation of each manhole Renewal Component System (RCS) specified by the Customer.

1.0.3 The manhole RCS's installed shall cause no adverse effects to any of the Customer'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 Customer 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 RCS'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.

1.0.4 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, the manhole RCS'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 renewal 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

1.1.1 These Specifications cover all work necessary to furnish and install, a variety of protective manhole RCS'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.

1.1.2 The RCS's furnished shall be complete integrated systems including all materials, manufacturer's recommended equipment and manufacturers installation procedures. The RCS manufacturer may submit to the Customer, a minimum of 14 calendar days in advance of a bid date, all required product information to obtain pre-approval RCS status. Those RCS's that have been pre-approved will not need to be re-submitted as required in the submittal section of these specifications unless specifically requested to do so by the Customer or if any of the system components have changed from those pre-approved by the Customer. All other component products will be required to meet the submittal requirements as contained herein.

1.1.3 The RCS's installed shall be free of all defects that will affect the long term life and operation of the manhole.

1.1.4 The RCS installed shall bond to or fit sufficiently tight within the existing manhole so as to eliminate water leakage into the manhole or allow 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 RCS applied and as specified by the manufacturer. If leakage occurs through any RCS applied to the manhole, the RCS shall be repaired or removed as recommended by the

manufacturer. All repair materials shall have the same estimated life expectancy than the RCS installed. Final approval of the RCS installation will be based on meeting the acceptance test requirements for each RCS applied/installed.

1.1.5 The component shall be designed for a minimum life of thirty (30) years or greater against corrosion and typical chemicals found in sewage, unless otherwise specified in the detailed section of the contract documents.

1.1.6 Coatings or linings may be designed as a coating to rehabilitate the existing manhole against corrosion and I/I or as a structural lining. Where specified in the contract documents the installed lining shall be a structurally designed liner, meet or exceed all contract specified physical properties, fitting tightly within the existing manhole all within the tolerances specified. The installed liner shall withstand all applicable surcharge loads (soil overburden, live loads, etc.) and external hydrostatic (groundwater) pressure, if present, for each specific installation location.

1.1.7 All manhole steps shall be removed prior to a coating or lining application and reinstalled as required by these contract specifications.

1.1.8 Flow from existing active service connections entering the manhole shall be maintained, if the flow will affect proper RCS application/installation.

1.1.9 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.

1.1.10 Testing and warranty inspections shall be executed by the Customer or its representative. Any defects found shall be repaired or replaced by the Contractor.

1.1.11 The Contractor shall furnish all samples for product testing as required in the contract documents. The Customer shall take possession of the samples for testing and shall maintain a chain of custody, deliver the samples to an approved laboratory and pay for all material and product testing performed under this contract.

1.1.12 Compensation for all work required for providing test samples shall be included in the various RCS items contained in the Bid Proposal.

1.2 SCOPE OF WORK INCLUDED:

1.2.1 A detailed description of each RCS included in the contract, complete with estimated quantities.

1.3 PERFORMANCE WORK STATEMENT (PWS) SUBMITTAL

The Contractor shall submit, to the Customer, a Performance Work Statement (PWS) at the pre-construction meeting, which clearly defines the proposed manhole RCS delivery in conformance with the requirements of these contract documents. Unless directed otherwise by the Customer, the PWS shall at a minimum contain the following:

1.3.1 Clearly indicate that the RCS's 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.

1.3.2 Certify, that at the time of the bid, that defined manholes, included in the contract documents, were visited, inspected and evaluated by the Contractor prior to submitting a bid. See a sample certification form located at the end of these specifications. If the specific manholes, to be renewed, are identified after the bid opening then this should be noted on the certification form.

1.3.3 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 RCS application/installation.

A detailed installation schedule shall be prepared, submitted and conform to the requirements of these contract documents.

1.3.4 The manufacturer's description of the RCS materials 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 RCS submission.

1.3.5 The Contractor's experience for each type of renewal 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.

1.3.6 Engineering design calculations, if specified in the detailed RCS specification, shall be in accordance with the applicable ASTM or industry standard, for each component to be installed. These calculations shall be performed and certified by a qualified Engineer. All calculations shall include data that conforms to the requirements of these contract specifications.

1.3.7 Information on the RCS intended for application and all tools and equipment required for a complete application/installation. The PWS shall identify which tools and equipment must be redundant on the job site in the event of equipment breakdown. All equipment, to be used for the application of RCS's, including proposed back-up equipment, shall be clearly described. The Contractor shall outline the mitigation procedure to be implemented in the event of key equipment failure during the installation process.

1.3.8 A detailed description of the Contractor's proposed procedures for cleaning and preparing the manhole structure, prior to applying/installing the renewal component shall be submitted as part of the PWS.

1.3.9 Compensation for all work required for the RCS submittal of the PWS shall be included in the Mobilization Item contained in the Bid Proposal.

1.4 SUBMITTALS

Product data submittals required for all renewal RCS's proposed for installation under this contract shall include:

1.4.1 RCS 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)

1.4.2 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 RCS material. (PWS)

1.4.3 Manufacturer's detailed description of the recommended material installation/application process including mixing, additives, set time and all equipment required for quality product delivery. (PWS)

1.4.4 Technical data sheet on each renewal 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)

1.4.5 Manufacturer's detailed description of all required field testing processes and procedures. (PWS)

1.4.6 Copies of independent testing performed on the renewal component, indicating that the product meets the requirements as specified in these contract documents. (PWS)

1.4.7 Technical data sheet and project specific data for manhole repair materials to be used in conjunction with each renewal component(s) including application cure time and surface preparation procedures. (PWS)

1.4.8 Certification that backup installation equipment is available on the job site or can be delivered to the job site within 24 hours. (PWS)

1.4.9 Shipping information including: (Jobsite)

1. Date shipped including origination and delivery locations
2. Shipping method and carrier
3. Shipped item, including manufacturer, stock and lot number
4. All shipping, storage and safety requirements including MSDS documents.
5. Date delivered to project site including name and signature of receiver

1.4.10 By-Pass Pumping Plan if applicable to the RCS's being installed. (PWS)

1.4.11 Traffic Control plan, if applicable for the RCS's being installed.

1.4.12 Certified statement, from the manufacturer, that the contractor/installer is an approved installer of the RCS with certificates of completed training for each crew member involved in each renewal component. This requirement shall comply with the specific RCS requirements specified in the contract documents. (PWS)

1.4.13 For each manhole renewal, a complete and accurate record of all RCS's installed/applied shall be prepared. The record shall include identifying manhole number,

location, quantities of renewal components installed, estimated quantity of Infiltration/Inflow removed from the manhole and the results of the post renewal inspection. (After Renewal Completion) An example record summary sheet is included at the end of these contract documents.

1.4.14 Submittal of all quality assurance documentation and test reports for RCS's installed. (After Renewal Completion)

1.4.15 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.

1.5 QUALITY ASSURANCE PLAN (QAP)

1.5.1 A detailed quality assurance plan (QAP) shall be submitted to the Customer that fully represents and conforms to the quality control requirements of these specifications. At a minimum the QAP shall include the following:

1.5.2 A detailed description of the proposed quality assurances to be performed by the Contractor.

1.5.3 Defined responsibilities, of each of the Contractor's personnel, for assuring that all quality assurance requirements, for this contract, are met. These shall be assigned, by the Contractor, to his specific personnel.

1.5.4 Proposed procedures for quality assurance, product sampling and testing shall be defined.

1.5.5 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.

1.5.6 A scheduled performance and product test result reviews between the Contractor and the Customer at a scheduled job meeting.

1.5.7 Inspection forms and guidelines for quality assurance inspections shall be prepared in accordance with the standards specified in this contract and submitted with the QAP. Sample forms are included at the end of these contract documents.

1.5.8 One (1) or two (2) days of inspector training, by the manufacturer or qualified trainer, for the Customer's inspectors shall be provided as further defined in Section 1.9. This training shall be prior to RCS 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 renewal work, the system manufacturer shall furnish a check list containing key elements of the RCS criteria, represented in the QAP, for the Customer's representative to ensure that quality assurance and testing requirements are performed in accordance with the contract documents.

1.5.9 Proposed methods and procedures for RCS repair or replacement, (as defined in Section 1.6) in the event of product defects or total failure.

1.5.10 Compensation for all work required for the preparation and submittal of the QCP shall be included in the various RCS items contained in the Proposal. Compensation for inspector training shall be at the price bid therefore in the Proposal for inspector training for each RCS.

1.6 RENEWAL COMPONENT SYSTEM (RCS) REPAIR/REPLACEMENT

1.6.1 Occasionally installation of RCS's will result in the need to repair or replace a portion of the installed product. The Manufacturer shall outline specific repair or replacement procedures for potential defects that may occur during the application of the RCS. Repair/replacement procedures shall be as recommended by the RCS Manufacturer and shall be submitted as part of the PWS.

1.6.2 Defects, that may not affect the operation and long term life of the product, shall be identified and defined by the Manufacturer.

1.6.3 Repairable defects that may occur in the RCS 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.

1.6.4 Un-repairable defects that may occur in the RCS shall be clearly defined and 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 RCS.

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

1.7 REFERENCES

1.7.1 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

1.8.1 Renewal component materials are to be kept dry, protected from weather and stored under cover and in accordance with manufacturer's recommendations.

1.8.2 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

1.9.1. The Contractor shall provide training for the Customer's representatives/inspectors in each of the RCS's to be furnished under the contract documents. The training shall be provided by an individual that has been trained and has the experience to train others in the proper inspection of the RCS.

1.9.2. 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 RCS is being installed by the Contractor. The inspector training shall also include a sufficient amount of time to instruct the inspectors on what to look

for in the field, what needs to be inspected for each RCS and what documentation is need to verify that the RCS has been installed in accordance with the contract documents.

1.9.3. Compensation for inspector training shall be at the number of days specified and the unit price Bid therefore in the Proposal.

1.10 SAFETY

1.10.1 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.

1.10.2 The Contractor shall perform all of the Work in accordance with applicable OSHA standards. Emphasis shall be placed upon the requirements for entering confined spaces and with the equipment being utilized for manhole renewal 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.

1.10.3 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
7. This equipment to be available for use, in sufficient quantity, by the Contractor,

Engineer and Customer for the duration of the project.

1.10.4 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.

1.10.5 The Contractor shall submit a proposed Safety Plan to the Customer, prior to beginning any work, identifying all competent persons, equipment and operating procedures. The plan shall include a description of a daily safety program 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.

1.10.6 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

1.11.1 The materials used for the project shall be certified by the manufacturer for the specified purpose. The manufacturer shall warrant the RCS to be free from defects in raw materials for one (1) year after installation and from the date of acceptance by the Customer. The Contractor shall warrant the installation of the renewal component for a period of one (1) year. During the one (1) year warranty period if the renewal 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 repaired at the Contractor's expense in accordance with procedures included in Section 1.6 Renewal Component Repair/Replacement.

1.11.2 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 Customer may inspect all or portions of the renewed manholes. The specific locations will be selected at random by the Customer and will include all types of structures from this project.

1.11.3 If it is found that any of the renewal 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 Renewal Component System (RCS)

Repair/Replacement. If, after inspection of a portion of the renewed manholes under the contract, problems are found, the Customer may inspect all manholes where RCS's have been applied/installed under this contract.

1.11.4 All verified defects shall be repaired and/or replaced by the Contractor and shall be performed in accordance with Section 1.6 Renewal Component System Repair/Replacement and per the original specifications, all at no additional cost to the Customer.

1.12 WARRANTY INSPECTIONS

1.12.1 Visual inspection to determine integrity of RCS materials and water-tightness will be conducted within 3 months before the expiration of the guarantee period.

1.12.2 If possible, inspection should be performed, in the spring, during high groundwater and frequent rainfall events.

1.12.3 The Customer shall perform all warranty inspections together with the Contractor.

1.12.4 Twenty Five (25) percent of manholes renewed shall be inspected, at locations randomly selected, by the Customer.

1. No infiltration or inflow shall be visible in the renewed manhole.
2. If any RCS fails the warranty inspection, the Customer shall inspect all RCS's installed in the contract, together with Contractor.

1.13 MEASUREMENT AND PAYMENT

1.13.1 Measurements for each item furnished and installed to the satisfaction of the Customer shall be at the units of measure contained in the Bid Proposal. Manhole coatings and linings will be measured from the top of the invert to the bottom of the manhole casting. Coating and/or lining of the invert shall be at the Lump Sum price bid therefore in the Proposal.

1.13.2 Payment for each RCS furnished and installed, in accordance with the contract documents and to the satisfaction of the Customer, will be at the unit or lump sum prices bid therefore in the Bid Proposal

PART 2.0 – RENEWAL COMPONENT SYSTEM (RCS) PRODUCTS

2.1 CHEMICAL GROUTS

2.1.1 REFERENCES

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

2.1.2 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.

2.1.2 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. Solutions 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 be rigid or brittle when subjected to a dry environment. The material shall be able to withstand freeze/thaw and moving load conditions.

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. Additives

- a. 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.

2.1.3 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

2.2.1 REFERENCES

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

2.2.2 GENERAL

1. The Contractor shall provide a quick setting, high strength cementitious or calcium aluminates, corrosion-resistant, leak-resistant, lining material consisting of infiltration control, invert repair and cementitious coating (liner) material specifically designed for manhole walls and benches.

2.2.3 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.

- b. Infiltration Control Materials shall have the following minimum characteristics:

- i. Compressive Strength (ASTM C109)

1 day:	2000psi
7 days:	3500psi
28 days:	4500psi
- ii. Tensile strength (ASTM C109)

	1 day:	175psi
	7 days:	250psi
	28 days:	350psi
iii.	Bond Strength (ASTM C321)	
	30 min:	50psi
	1 day:	85psi
iv.	Freeze Thaw Durability	
	100 cycles (ASTM C666)	No Loss
v.	Set Time at 70 degrees F	
	Initial	30 -60 seconds
	Final	1 hour
vi.	Shrinkage (ASTM C157)	0 %

2. Infiltration Control - Oakum Water Plugs

- a. Rapid setting, oil free oakum and hydrophilic grout to seal active water leaks prior to applying other RCS's
- b. Oil-free oakum meeting Federal Specification HH-P-117
- c. Two-part urethane resin.
- d. Initial Set Time: 5 – 10 minutes

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 be applied in accordance with the manufacturers recommendations.

Repair and Patching Materials shall have the following minimum characteristics:

i. Compressive Strength (ASTM C109)

1 day:	3500psi
7 days:	4900psi
28 days:	5500psi

ii. Tensile Strength (ASTM C109)

1 day:	200psi
7 days:	250psi
28 days:	550psi

iii. Freeze-Thaw (ASTM C666)

100 cycles with no damage

iv. Setting Time (Gilmore ASTM C266)

Initial	15-18 minutes
Final	22-25 minutes

4. Grouting mix:

For stopping very active 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 (Liner) Materials for Manhole Walls and Benches

The Contractor shall install cementitious coating (liner) 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 either low-pressure spray or centrifugal spin casting application of cement mortars. All cement liner materials must be capable of a placement thickness of ½" to 4" in a one pass monolithic application.

Cementitious Coating Materials shall have the following minimum characteristics:

a. Minimum Physical Properties

All cementitious coating materials shall conform to the following 28-day minimum physical properties.

- i. Compressive Strength (ASTM C109) - 8000psi
- ii. Flexural Strength (ASTM C293) - 1000psi
- iii. Bond Strength (ASTM C882) – Substrate failure
- iv. Permeability (AASHTO T-277) - Not to exceed 400 coulombs
- v. Freeze-Thaw (ASTM C666) - No damage in minimum 300 cycles
- vi. Material Wet Density - Minimum 140 PCF 120PCF

6. Material Design

All cementitious coating materials shall be designed based upon the following conditions:

- a. Low to mild hydrogen sulfide environments (pH > 2.0) - Cementitious coating materials shall be manufactured from Type II Portland cement, and enhanced with silica fume. Materials shall contain poly-fiber reinforcement,

chemical admixtures, and siliceous aggregates. The coating manufacture should be contacted for a recommendation on specific project applications.

b. Extremely harsh hydrogen sulfide environments (pH < 2.0) -

Cementitious coating materials shall be manufactured from 100% pure calcium aluminates or Microsilica based cements and enhanced with high-density chemically stable aggregates. Materials shall contain poly fiber reinforcement and chemical admixtures. The coating manufacture should be contacted for a recommendation on specific project applications.

2.3 CAST-IN-PLACE CONCRETE LINER

2.3.1 GENERAL

1. This method, includes a formed in place seamless concrete manhole with-in 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 manhole conforming generally to the existing inside and shape.
2. The new interior wall shall have a cross-sectional dimension of sufficient thickness to be structurally independent and allow for the maximum new inside diameter. It shall be constructed of high strength ready mixed concrete and specifically designed to be applicable for municipal and industrial sewer collection systems.

2.3.2 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

2.3.3 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 producing an average compressive strength of 4,000psi at full cure. Other formulations and filler materials may be selected to meet specific needs as recommended by the manufacturer.

2.3.4 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 bench and pipe openings to form a water tight connection.
5. Removable from within new cast concrete manhole wall.

2.3.5 PLASTIC INTERIOR WALL SURFACE

1. Provide PVC or Polyethylene liner on new manhole interior wall surface.
 - a. Minimum thickness 0.065 inches
 - b. Ribbed or studded for embedment into the concrete.
 - i. Minimum pull-out strength: 100 pounds per linear inch
 - c. Fit securely to exterior of concrete forms.
 - d. Heat fuse or extrusion weld seams

2.4 SPRAY ON EPOXY LINER

2.4.1 REFERENCES

ASTM C109 - Compressive Strength Hydraulic Cement Mortars.

ASTM C579 - Compressive Strength of Chemically Setting Silicate and of Shotcrete.
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 D2584 - Volatile Matter Content.
ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages
ASTM D4541 - Pull-off Strength of Coatings Using a Portable Adhesion Tester.
ACI 506.2-77 - Specifications for Materials, Proportioning, and Application Silica Chemical Resistant Mortars.
SSPC SP-13/NACE No. 6 – Surface Preparation of Concrete
NACE RPO 188-99 for performing holiday detection

2.4.2 EXISTING PRODUCT 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 coating product(s) which may affect the performance and adhesion of the coating product(s).
3. Thoroughly clean and prepare existing products to effect a seal with the coating product(s).

2.4.3 REPAIR AND RESURFACING PRODUCTS

1. Repair products shall be used to fill voids, bugholes, and/or smooth transitions between components prior to the installation of the coating product(s). Repair materials must be compatible with the specified coating product(s) and shall be used and applied in accordance with the manufacturer's recommendations.
2. Resurfacing products shall be used to fill large voids, lost mortar in masonry structures, smooth deteriorated surfaces and 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 epoxy grout specifically formulated for epoxy topcoating compatibility.
- b. Factory blended, rapid setting, high early strength, fiber reinforced, non-shrink repair mortar that can be trowelled or pneumatically spray applied may be approved if specifically formulated to be suitable for epoxy topcoating with the specified product. The length of resurfacing material cure required before epoxy topcoating, shall be as recommended by the manufacturer.

2.4.4 COATING PRODUCTS

1. 100% solids, solvent-free ultra high-build epoxy system exhibiting the following characteristics:

- a. Product Type: amine cured epoxy
- b. VOC Content (ASTM D2584): 0
- c. Compressive Strength, psi (ASTM D695): 18,000 (minimum)
- d. Tensile Strength, psi (ASTM D638): 7,500 (minimum)
- e. Flexural Modulus, psi (ASTM D790): 600,000 (minimum)
- f. Adhesion to Concrete, mode of failure (ASTM D4541): Substrate (concrete) failure
- g. Chemical Resistance (ASTM D543/G20) all types of service for:
 - i. Municipal sanitary sewer environment
 - ii. Sulfuric acid, 30%
 - iii. Sodium hydroxide, 5%

2.4.5 COATING APPLICATION EQUIPMENT

1. Manufacturer recommended and approved heated plural component spray equipment.
2. Hard to reach areas, primer application and touch-up may be performed using hand tools

2.5 SPRAY ON POLYURETHANE LINER

2.5.1 REFERENCES

ASTM C109 -Compressive Strength Hydraulic Cement Mortars.

ASTM C307-03-Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacing

ASTM D638-91-Test Method for Tensile Properties of Plastics.

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

ASTM D790-91-Test Methods for Flexural Properties of Un-reinforced and reinforced Plastics and Electrical Insulating Materials.

ASTM C1244-05ae1 Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill

2.5.2 MATERIALS

1. Minor Infiltration Control mix - Cementitious Grout

- a. A rapid-setting cementitious grout or chemical grout specifically formulated for leak control should be used to stop minor water infiltration. It should be mixed and applied according to the manufacturer's recommendations and should meet the following minimum requirements.

Compressive strength	ASTM C 109	1,800 psi @ ½ hr 4,000 psi @ 24 hrs 5,000 psi @ 7 days
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Tensile strength	ASTM C 190	300psi @ 7 days 350psi @ 28 days
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2. Very Active Infiltration - Chemical Grout

- a. A chemical grout shall be used for stopping very active infiltration, filling voids and should be mixed and applied according to manufacturer's recommendations. The cementitious grout should be volume stable having a minimum 1 day compressive strength of 50psi and a 28 day compressive strength of 250psi.
- b. Chemical grouts shall be used for stopping very active infiltration and should be mixed and applied per manufacturer's recommendations.

3. Patching and profiling mix - Cementitious Compound

- a. A quick setting cementitious material can be used to bring the substrate to profile by filling voids, cracks, missing mortar and other substrate defects. It should be mixed and applied according to the manufacturer's recommendations and should meet the following minimum requirements.

Compressive strength	ASTM C 109	1000 psi @ 1 hr 3500 psi @ 48 hrs 5000 psi @ 28 days
Tensile strength	ASTM C 307	200psi @ 24 hrs 300 phi @ 7 days

4. Resin Based Liner:

a. The resin based material shall be used to form the sprayed on/structural enhanced monolithic liner covering all interior surfaces of the structure including benches and inverts of manholes. The finished liner shall conform to the minimum physical requirements listed below.

Compressive strength	ASTM D 695	10,500psi
Tensile strength	ASTM D 638	7,000 phi
Flexural strength	ASTM D 790	12,000psi
Bond		Shall exceed tensile strength of substrate
Flexural modulus (initial)	ASTM D 790	730,000psi
Density		87 ± pcf

b. The finished structure shall be corrosion resistant to: Hydrogen Sulfide; 20% sulfuric Acid; 17% Nitric Acid; 5% Sodium Hydroxide; road salts for winter conditions as well as other common ingredients of the sanitary sewage environment.

c. The wall of the resin based liner will be structurally designed to withstand the hydraulic load generated by the groundwater table & restore structural integrity. The long term (50 yr.) value of the flexural modulus of elasticity will be a minimum of 500,000psi and used to design the wall thickness of the structural liner.

d. The proposed products minimum flexural modulus will be certified by an independent, third party testing lab and submitted with the design calculations for each individual structure included in these contract documents.

e. Definition- Long term value will be identified as initial flexural modulus less the reduction in value caused by Creep over a fifty (50) year minimum period and verified by DMA testing.

5. Other Materials

a. No resin based materials other than polyurethane shall be used to achieve the specified structural design as recommended by the manufacturer.

2.6 MODIFIED POLYMER STRESS SKIN PANEL LINER

2.6.1 REFERENCES

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

ASTM D2240-05 Standard Test Method for Rubber Property—Durometer Hardness

ASTM D4060-07 Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abrader

ASTM D4541-02 Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

CIGMAT - Evaluation of Liner System for Wastewater Concrete and Clay Brick Facilities

2.6.2 MATERIALS AND EQUIPMENT

1. The materials to be utilized in the lining of manholes shall be designed and manufactured to withstand the severe effects of hydrogen sulfide in a wastewater environment. Manufacturer of corrosion protection products shall have long, proven experience in the production of the lining products utilized and shall have satisfactory installation record.
2. Equipment for installation of lining materials shall be high quality grade and be as recommended by the manufacturer.

3. The lining system to be utilized for manhole structures shall be a multi-component stress skin panel liner system as described below:

a. Liner.

Installation	Liner
Moisture barrier	Modified Polymer
Surfacer	Polyurethane/Polymeric blend foam
Final corrosion barrier	Modified polymer

b. Modified polymer shall be sprayable, solvent free, two-component polymeric, moisture/chemical barrier specifically developed for the corrosive wastewater environment.

Chemical Analysis Modified Polymer

Resin

Viscosity, 77° F, cps	450
Physical State	Liquid
Color	Clear to amber
Hygroscopicity	Reacts with water

Curing Agent

Viscosity, 77° F, cps	500
Physical State	Liquid
Color	Flamingo Pink
Non-Volatile	100%

Reaction Profile (100 grams, 175° F sample)

Gel Time, seconds	10
Tack Free Time, seconds	20
Cure Time, seconds	90

Processing

A System / B System, volume ratio	1.00 /1.00
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Typical Physical Properties

Tensile Strength, PSI	>3600
Elongation, %	>300
Tear Strength, PLI	>5000
Shore A Hardness	96
100% Modulus, PSI	>2500

d. Polyurethane/Polymeric blend foam, low viscosity two-component, containing flame retardants.

Chemical Analysis

Resin

Viscosity, 77° F, cps.,	200
Physical State	Liquid
Color	Dark Brown
Hygroscopicity	Reacts with water and evolves CO2 gas

Curing Agent

Viscosity, 77°F, cps	660
Physical State	Liquid

Color	Transparent Dark
Hydroscopicity	Absorbs water rapidly thus changing ratio

Reaction Profile (100 grams, 77° F sample)

Cream Time, seconds	1-4
Tack Free time, seconds	5-8
Rise Time, seconds	6-10

Processing

Resin / Curing Agent, volume ratio	1.00 /1.00
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Typical Physical Properties

Density, nominal, core, lbs/ft ³ ASTM D-1622 @ 74° F	4-10
Compression Strength ASTM D1621 @74C F parallel rise; PSI	90-150
Closed Cell Content, % - @ 74° F	Over 95
Shear Strength, PSI - ASTM C-273 @ 74° F	225-250

- e. Total thickness of multi-component stress panel liner shall be a minimum of 500 mils.

2.7 CURED-IN-PLACE MANHOLE LINERS

2.7.1. 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

2.7.2 BAG LINERS

2.7.3 GENERAL

1. The new liner system shall consist of multiple structural layers of fiberglass with a non-porous membrane layer between fiberglass, or Polyvinyl Chloride/Polyester (PVCP) liner with a fiberglass layer, installed to fit tightly against the manhole wall using pressure and heat.

2.7.4 MATERIALS

1. Manhole interior walls and benches shall be patched with 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. The primary layer shall be manufactured from 20 mils PVC with 10 ounce per square yard polyester fiber. The surface hairs of the fiber must be embedded in the molten PVC during the manufacturing process of the PVCP laminate. Glued laminates are not allowed.
4. The fibrous body will be impregnated with a modified epoxy resin. Add fiberglass and resin, for additional liner thickness.

5. Liner Thickness: The anticipated hydrostatic head “h” in feet above the bottom of the invert and the Radius “R” in feet of the structure shall determine the necessary liner thickness “t” in mils.

2.7.5 FORMED and CURED IN PLACE PROTECTIVE LINER
(Fiberglass Reinforced epoxy composite)

1. GENERAL

a. 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.

2. MATERIALS

- a. 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.
- b. Manhole invert channels shall be reconstructed with cements as required and specified elsewhere herein.
- c. 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.

2.8 CONCRETE PROTECTIVE LINERS

2.8.1 REFERENCES

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

ASTM C307-03 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 D638-03 Standard Test Method for Tensile Properties of Plastics

ASTM D792-00 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 D4787-93(1999) Standard Practice for Continuity Verification of Liquid or Sheet Linings Applied to Concrete Substrates

2.8.2 HIGH DENSITY POLYETHYLENE (HDPE)

Protective liners shall be integrally extruded complete with a minimum of 39 anchoring studs per square foot. The minimum thickness of liner sheet with anchoring studs shall be 2mm. The minimum thickness of flat liner sheet at joint overlaps shall be 3mm. All joints shall be sealed using thermal welding as recommended by the manufacturer.

1. HDPE Material Properties

- a. Material density as per ASTM D792: 0.945 gm/cm³
- b. Elongation at break as per ASTM D638: Greater than 400%
- c. Minimum abrasion resistance as per ASTM D4833: 160 pounds
- d. Steel profiles for mounting liner material
 - i. Maintain minimum of 2 ½ inches annular space clearance when filling with flow-able concrete.

- ii. Maintain minimum of one (1) inch annular space clearance when filling with grout.
- iii. Anchor bolt penetration of concrete in manhole wall: 1 ½ inches
- iv. Countersink screws to mount liner to profiles

2. Cement used to fill annular space between the liner and the manhole wall shall have:

- a. Minimum compressive strength: 4,000psi in 28 days
- b. Minimum aggregate size: 8mm
- c. Maximum aggregate size 32mm

3. Grout used to fill annular space between the liner and the manhole wall shall have:

- a. Minimum compressive strength: 6,000psi in 28 days
- b. Low viscosity, high flowability to fill annular space without voids
- c. Bonds to manhole wall.

2.8.3 POLYVINYL CHLORIDE (PVC) PROTECTIVE SHEET LINERS

- 1. The resin shall have a minimum of 99 percent PVC by weight
- 2. Copolymer resins or recycled resins shall not be allowed
- 3. The minimum liner thickness shall be 1.65mm with integrally extruded anchor points 2 inches on center and extending a minimum of ¼ inch in depth.
- 4. All joints and seams to be thermally sealed.
- 5. Physical Properties
 - a. Tensile Strength as per ASTM C307: Minimum 2,200psi
 - b. Elongation at break as per ASTM D638: 200 percent minimum
- 6. Mastic primer and two (2) part mastic to seal to manhole wall

2.9 FRP MANHOLE INSERTS

2.9.1 REFERENCES

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

2.9.2 WALL CLEANING

1. High Pressure Water at 3500psi minimum pressure

2.9.3 BENCH-FORMING AND REPAIR MATERIALS

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

2.9.4 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 delaminations 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 between the FRP insert and the manhole wall shall be either of the following or equal:

b. Portland cement type I; 5 sacks per cubic yard; water to cement ratio of 0.5 or less.

c. A grouting system, as recommended by the manufacturer having a compressive strength of 1500psi at 28 days.

4. Protective Coating

a. As recommended by the manufacturer, a vinyl ester material with demonstrated successful long term service life in sanitary manhole wall surface application shall be applied as a filler/sealer. Filler-sealer shall be a 100 percent solids amine cure epoxy or vinyl material, compatible with the

vinyl ester material above and appropriate for forming a relatively smooth surface on concrete when applied with a squeegee.

2.10 MANHOLE CHIMNEY SEALS

2.10.1 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

2.10.2 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 through these areas throughout a minimum 50-year design life.
3. The contractor shall have a manufacturer's recommended expansion tool, removal tool if necessary and all other equipment/tools required to install the specified frame seals.

2.10.3 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, with a minimum thickness of 3/16 inch.
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. The extension flap shall have a minimum thickness of 3/32 inches and the remainder of the extension shall have a 3/16" thickness and have an expansion band recess capable of restraining the band during expansion and after installation.
5. The expansion bands used for compressing the sleeve and extensions against the manhole shall be fabricated from a minimum thickness 16 gauge stainless steel, Type 304, conforming to the applicable section 4.2 of ASTM C 923. The expansion

bands shall have a minimum adjustment range of 2 ½ diameter inches and 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
- b. Minimum tensile strength as per ASTM D412: 1,200psi.
- c. Maximum compression set: decrease of 25%, max, of original deflection as per ASTM D395, Method B, at 70°C for 22 h
- d. Hardness (Durometer): +/- 5 from the connector manufacturer's specified hardness.
- e. Minimum thickness: 3/16 inch.
- f. Top and bottom expansion bands: 16 gauge Type 304 stainless steel with a minimum width of 1 inch.

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 throughout the design life of the sealing material.

2.10.4 POLYMER CHIMNEY SEAL

1. Polymer manhole 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 made of corrosion resistant aromatic flexible urethane resin and applied to the inside wall of the entire chimney area as specified in the contract documents.
3. Mil thickness may vary depending on the local climate. The Contractor shall apply a minimum thickness of 160 mils or greater for durability and resistance elongation and tearing as recommended by the manufacturer.
4. The polymer chimney seal shall have a minimum elongation of 800% and hardness (Durometer) of 75. The installed polymer chimney seal shall have a minimum tensile and adhesion strengths of 1150psi and 175 lb. /in. respectively. The manhole sealing system shall conform to the physical requirements of ASTM D412.
5. The polymer chimney seal shall have an aromatic urethane primer resin applied to the entire surface before applying the polymer chimney seal. 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 12 vertical inches over the joint area.
6. The installed seal shall remain flexible, to allow for repeated vertical movements of the frame due to frost lift, ground movement or other cause of not less than 2 inches and/or repeated horizontal movement of the frame due to thermal movement of pavement or other causes of not less than ½ inch throughout the design life.

2.10.5 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. 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 catalyst system when properly cured within the stretchable liner, forms a tenacious bond with well prepared surfaces, withstands multiple freeze/thaw cycles without cracking, and meets the physical properties stated herein.

Table 1 Cured-In-Place Manhole Structural Properties

PROPERTY	TEST	MINIMUM VALUE
Compressive	ASTM D 695	1500psi
Bond	Peel Test	Concrete Failure
Hardness	ASTM D 2240	74
Freeze/Thaw Resistance	Simulated Freeze/Thaw	No cracking or bond failure

6. Design Assumptions

- a. The existing structure is carrying the soil and live loads.

b. The liner will only be subjected to hydrostatic pressure; therefore the pressure exerted on the liner will be uniform around the structure, placing the liner in compression. The minimum liner thickness shall be as recommended by the manufacturer.

2.10.6 FORMED AND CURED IN PLACE PROTECTIVE 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, will 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 cementitious patching/plugging compounds as specified elsewhere herein for use in manholes.
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 6 inches of the corbel.

2.11 REPLACE MANHOLE FRAME AND COVER

2.11.1 REFERENCE

ASTM A48/A48M-03 Standard Specification for Gray Iron Castings Class 35B

AASHTO Standard Specifications for Highways and Bridges

2.11.2 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

2.12 MANHOLE ADJUSTMENT MATERIALS

2.12.1 REFERENCE

ASTM D4976-06 Standard Specification for Polyethylene Plastics Molding and Extrusion Materials

AASHTO Standard Specifications for Highways and Bridges

2.12.2 MATERIALS

Manhole adjustments shall be steel, cast iron, HDPE, PVC, urethane, rubber, brick, cement or poured concrete as shown in detail on the contract documents.

1. Measurement shall be by vertical linear foot of adjustment materials provided and/or installed.
2. Payment shall be at the price per vertical linear foot or as a lump sum as stated in the bid documents.

2.13 MANHOLE STEPS

2.13.1 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

2.13.2 MATERIAL

1. Reinforced 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 3.0 – EXECUTION

3.0.1 GENERAL

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

3.0.2 CONTRACTOR EXPERIENCE

1. Current documentation, from the RCS 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 renewal must have been completed by the Contractor in the previous three (3) year period.
3. For all RCS products except coatings and linings, to be considered for this project, a minimum of a three (3) year 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 RCS 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.

3.0.3 MANHOLE PREPARATION

1. Bypass Pump sewage 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 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 specified in these contract specifications
6. Trim and grout incoming laterals and pipes
7. Remove debris from manhole and incoming sewer connections.
 - a. Handle cleaning water in closed discharge hoses 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 Customer and authority having jurisdiction over area where work site is located.

3.1 CHEMICAL GROUT

3.1.1 GENERAL

1. Grouting should only be performed on a structurally sound manhole. 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.

3.1.2 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 renewal 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.

3.1.3 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 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 manufacturer.

3.1.4 TESTING AND ACCEPTANCE

1. Visually inspection – all leakage must be eliminated
2. Vacuum Test

NOTE: Testing of grouted manholes, shall be limited to those manholes that have been entirely sealed with grout. It may be impractical to test manholes built over or part of large diameter sewers or manholes where the testing will affect the structural condition of the manhole. The Manufacturer shall be consulted, for a

recommendation, for testing the effectiveness of the grout applications under these conditions.

3.2 CEMENTITIOUS RESTORATION

3.2.1 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 down stream 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 Customer 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 renewal of the manhole are compatible with each other. Do not use any materials that have not been verified for compatibility.

3.2.2 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 in Section A1 Manhole Cleaning and Preparation.
- 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. Oil-free Oakum Water Plugs.
 - i. Saturate oakum with resin following approved submittals.
 - ii. Use additives as required.
 - iii. Place and cure following manufacturer's recommendations.

3.2.3 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 inverts 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 inverts.

- 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 inverts shall be re-established within 30 minutes of material.

3.2.4 APPLICATION OF CEMENTITIOUS MANHOLE LINER

1. The work consists of 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.

3.2.5 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 no less than ½ inch. Material shall be applied to the bench area in such a manner as to provide for proper drainage without ponding of flow in the manhole.

3.2.6 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.
 - i. 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.

- d. Material shall be applied only when manhole is in a damp state, with no visible water dripping or running over the manhole walls.
- e. 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.
- f. 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. Precautions should be taken not to over-trowel.
- g. 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.
- h. 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.

3.2.7 TESTING AND ACCEPTANCE

- 1. Visual inspection – all leakage must be eliminated
- 2. Vacuum Testing
- 3. Cementitious Material Property Testing

3.3 CAST-IN-PLACE CONCRETE LINER

3.3.1 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 coating has been applied and cured.

3.3.2 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.

3.3.3 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, usually 3 inches and no less than 1½ inches. 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 thickness of three inches at the wall tapering to 1/2" at the edge of the invert channel.
7. Prior to the overlay, a hydrophylic sealing strip 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.

3.3.4 FINISH

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

3.3.5 CLEANUP

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

3.3.6 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.

3.3.7 TESTING AND ACCEPTANCE

1. Visual Inspection
2. Vacuum Testing
3. Material Property Testing

3.4 SPRAY ON EPOXY LINERS

3.4.1 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 and 120 deg F.
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.
7. Prior to commencing surface preparation, Contractor shall inspect all surfaces specified to receive the coating and notify Customer, 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.

3.4.2. 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 epoxy coating product, as recommended by the manufacturer.

4. Surface preparation method, 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 suitable for the specified epoxy coating product.

5. Infiltration shall be stopped by using a material which is compatible with the repair products and is suitable for topcoating with the epoxy coating product. The manufacturer shall verify the product compatibility, in writing, to the Customer.

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.

3.4.3 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 in accordance with Section B, Surface Preparation. The exposed rebar shall then be abrasive blasted and coated with the epoxy 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 epoxy 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 the unit price bid therefore 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.

3.4.4 APPLICATION OF EPOXY 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 epoxy coating product, shall be in proper working order and shall be as recommended by the product manufacturer.
3. Contractors qualified in accordance with Section of these specifications shall perform all aspects of epoxy coating product installation.
4. Prepared surfaces shall be coated by spray application of the coating product(s) described herein to a minimum wet film thickness of as recommended by the manufacturer to meet the requirements of these contract documents.

NOTE: Coating thickness recommendations are available through the epoxy coating product manufacturer based upon project assessment. Contact the manufacturer of the epoxy coating for project specific recommendations.

5. Subsequent top coating or additional coats of the epoxy coating product shall occur within the product's recoat time. Additional surface preparation procedures will be required if this recoat time is exceeded. The epoxy manufacturer's re-coat time for the specific application, based on temperature and project conditions, shall be strictly followed by the applicator.
6. The epoxy coating product shall 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 epoxy coating product manufacturer.
7. Termination points of the coating product(s) shall be made at the manhole chimney joint, 1" below normal flow levels at the bench or within the invert, (unless invert is specified to receive coating), and a minimum of 1" interfacing with each pipe penetration.
8. If required sewage flow shall be stopped, bypassed or diverted for application of the epoxy coating product to the invert and interface with pipe materials.

3.4.5. TESTING AND ACCEPTANCE

1. Visual Inspection - Final liner system shall be completely free of pinholes or voids
2. Film thickness Measurements - Liner thickness shall be the minimum value as specified herein.
3. Holiday Detection Test (Spark Testing)
4. Adhesion Testing

3.5 SPRAY ON POLYURETHANE LINER

3.5.1 PREPARATION

1. Place covers over all pipe openings to prevent extraneous material from entering the sewer system. All foreign material shall be removed from the structures' wall and bench/floor using a pressure water spray (minimum 3000psi). The use of acid for cleaning purposes, no matter how dilute, will not be allowed. Loose or protruding brick, mortar and concrete shall be removed by using a mason's hammer and chisel. Fill any large voids with quick setting patch mix. The surface to be repaired must be clean and free of any loose materials.
2. Minor leaks shall be stopped using the quick-setting specially formulated infiltration control mix and shall be mixed and applied per manufacturer's recommendations. When severe infiltration is present, drilling may be required in order to pressure grout outside the structure using either a cementitious or chemical grout. Manufacturer's recommendations shall be followed when pressure grouting is required.
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.

3.5.2 INSTALLATION/APPLICATION

1. Application of liner shall not be made unless the ambient temperature inside the structure is 50° degrees or higher.

3.5.3 BENCH/INVERT REPAIR

1. After blocking flow through the structure and thorough cleaning/preparatory work has been achieved. The sprayed on resin-based liner shall be applied to the invert, bench and wall areas in the same manner as specified for the liner application below. The spray shall be applied such that the entire structure receives a structurally enhanced monolithic liner.
2. The finished invert surfaces shall be smooth, free of ridges and will be sloped in the direction of flow. Special care shall be used to insure a smooth transition between

the new manhole invert and intersecting pipeline inverts such that flow will not be impaired.

3.5.4 LINER APPLICATION

1. The resin based liner shall be manually sprayed on to all surfaces by a trained technician who is experienced in the application of a spray applied resin and has been certified by the manufacturer. Appropriate personal protection equipment shall be utilized but in every case when applying the liner, the sprayer and personnel in direct contact with the spray atmosphere, will always be protected by supplied air.
2. The minimum thickness of the material applied is to be no less than 250 mils (1/4") in order to support structural integrity. No other products such as cement or grouts shall be used as part of the structural reinstatement, however, said products may be used as part of the repair process prior to sprayed application of the structure.
3. Application of the spray applied material shall be completed in one (1) mobilization in order to minimize the disruption and cost of excessive bypassing, pipeline plugging, traffic control and all other support services.
4. The finished manhole shall be returned to full service immediately after the spray application is complete.

3.5.5. CURING

1. The structure should be allowed to cure for 24 hours and return to ambient temperature prior to any physical testing, including vacuum testing.

3.5.6. TESTING AND ACCEPTANCE

1. Visual Inspection - Final liner system shall be completely free of pinholes or voids
2. Liner thickness shall be the minimum value as specified herein.
3. Vacuum Testing

3.6 MODIFIED POLYMER STRESS SKIN PANEL LINER

3.6.1 INSPECTION

1. Applicator shall take appropriate action to comply with all local, state and federal regulations including those set forth by OSHA, ERA, the Customer and any other applicable authorities.
2. Prior to conducting any work, perform inspection of structure to determine need for protection against hazardous gases or oxygen depleted atmosphere and the need for flow control or flow diversion.
3. New Portland cement structures shall have endured a minimum of 28 days since manufacture prior to commencing installation of the liner system.

3.6.2 SURFACE PREPARATION

1. Conduct surface preparation program to include monitoring of atmosphere for hydrogen sulfide, methane, low oxygen or other gases, approved flow control equipment, and surface preparation equipment.
2. Surface preparation methods may include high pressure water cleaning, hydro blasting, abrasive blasting, grinding, detergent water cleaning and shall be suited to provide a surface compatible for installation of the liner system as recommended by the manufacturer.
3. Surface preparation method shall produce a cleaned, abraded and sound surface with no evidence of laitance, loose concrete, brick or mortar, contaminants or debris, and shall display a surface profile suitable for application of liner system.
4. After completion of surface preparation, the Contractor should perform a seven point check list, which is the inspection for:

- | | |
|------------------|------------------------------------|
| a. Leaks | e. Ring and Cover condition |
| b. Cracks | f. Invert Condition |
| c. Holes | g. Inlet and Outlet Pipe Condition |
| d. Exposed Rebar | |

5. After the defects in the structure are identified, repair all leaks with a chemical or hydraulic sealant designed for use in field sealing of ground water. Severe cracks shall be "repaired with a urethane based chemical" sealant. Product to be utilized shall be as recommended by the manufacturer, prior to installation. Repairs to exposed rebar, defective pipe penetrations or inverts, etc. shall be repaired utilizing non-shrink grout or approved alternative method.

6. 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.

3.6.3 MATERIAL INSTALLATION

1. Application procedures shall conform to recommendations of the manufacturer, including materials handling, mixing, environmental controls during application, safety and spray equipment.

2. Spray equipment shall be specifically designed to accurately ratio and apply the specified liner system.

3. Application of multi-component liner system shall be in strict accordance with manufacturer's recommendation. Final installation shall be a minimum of 500 mils. A permanent identification and date of work performed shall be affixed to the structure in a readily visible location.

4. Provide final written report to owner/engineer detailing the location, date of report, and description of repair.

3.6.4 TESTING AND ACCEPTANCE

1. Visual Inspection - Final liner system shall be completely free of pinholes or voids

2. Liner thickness shall be the minimum value as specified herein.

3. Vacuum Testing

3.7 CURED-IN-PLACE MANHOLE LINERS.

3.7.1 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 Customer and accepted. No plugging of existing Utility System Gravity Mains will be made without submitting a plan to the Customer 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.

3.7.2 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 Customer for proceeding with the work.
2. All manhole steps shall be removed before the CIP liner is installed.

3.7.3 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 expansion type grouts

3.7.4 CHANNEL RECONSTRUCTION

1. Remove all loose grout and rubble of existing channel. Rebuild channel if required 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. 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.
2. Inverts shall only be lined where indicated on the plans "lined inverts".

3.7.5. BAG LINER INSTALLATION

1. The Contractor shall furnish all materials, equipment, tools, and labor as required for the renewal of the manholes specified, including the installation of the CIP 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 CIP 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.

2.7.6 FORMED and CURED IN PLACE PROTECTIVE LINER
(Fiberglass Reinforced epoxy composite)

1. The protective composite liner shall be hand crafted in place to perfectly fit and follow the shape and contour of the manhole. A layer of epoxy, 80-100 mils in thickness, 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. This heavy layer provides the first impervious non-porous layer of protection. A Type E fiberglass fabric (minimum of 11 oz. stitch bonded, coated with a chemical binder and having a tensile strength of 500,000 psi) shall be applied and incorporated into the epoxy (encapsulated) by application of another impervious layer of epoxy (approx. 40 mils).
2. A minimum of 125 mils thickness shall be applied, in certain circumstances, if greater thickness or strength is specified, it can be accomplished by either increasing the thickness of the epoxy layers or by using additional layers.

3.7.6 TESTING AND ACCEPTANCE

1. Visual Inspection
2. Liner thickness shall be the minimum value as specified herein.
3. Vacuum Testing

3.8 CONCRETE PROTECTIVE LINERS

3.8.1. HIGH DENSITY POLYETHYLENE (HDPE)

1. All manhole steps shall be removed prior to installing the protective liner.

2. The liner sheets shall be inserted into the manhole and supported as per the manufacturer's recommendations.
3. A bonding agent compatible with grout or concrete shall be applied to manhole wall before placing liner sheets.
4. Adequate annular space between liner sheet and manhole wall shall be provided to allow placement of concrete or grout.
5. The liner sheet supports shall be secured to the manhole walls.
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.

3.8.2 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

3.8.3. TESTING AND ACCEPTANCE

1. Visual Inspection
2. Liner thickness shall be the minimum value as specified herein.
3. Vacuum Testing

3.9 FRP MANHOLE INSERTS

3.9.1 DIVERSION PUMPING

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

3.9.2. CLEANING AND SURFACE PREPARATION

1. Remove dirt, grease, and debris from floor and interior walls of manhole using high pressure water and cleaners as recommended by the manufacturer.
2. Deteriorated invert and bench surfaces shall be abrasive blasted to roughen 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 stream.

3.9.3 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.

3.9.4. FRP 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 FRP 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 FRP insert for a close fit within 1 inch to both. Seal the cut edges with resin as recommended by the manufacturer.

3. Lower the FRP 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 FRP 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

3.9.5 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 equivalent No 80 grit sandpaper.
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 FRP 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 of 40 mils.

3.9.6 TESTING AND ACCEPTANCE

1. Visual Inspection
2. Liner thickness shall be the minimum value as specified herein.
3. Vacuum Testing

3.10 MANHOLE CHIMNEY SEALS

3.10.1 MANUFACTURED 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.
3. If an extension is used; the 3/32" thick 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.

3.10.2 TESTING AND ACCEPTANCE

1. Visual Inspection
2. 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. Document in writing all test results

3.10.3 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 shall include using high pressure water with a sandblaster attachment at a minimum of 3500psi and wire brushing of surface to ensure a clean surface as recommended by manufacture. 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. Ensure that all surfaces are clean and dry before applying the urethane primer. After proper curing of the urethane 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.

3.10.4 TESTING AND ACCEPTANCE

1. Visual Inspection - Final liner system shall be completely free of pinholes or voids
2. Holiday Detection Test
3. Adhesion Testing

3.10.5 STRETCHABLE CURED-IN-PLACE LINER

1. The installation shall include a stretchable 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 with a minimum of 5,000psi @ 5 gal/min pressure washer. 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.

3.10.5.1 TESTING AND ACCEPTANCE

1. Visual Inspection to insure bonding, resin saturation, complete cure and a smooth surface free from cracks or hollow spots.

2. 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 Customer representative.

3. Adhesion Testing

4. CIP Material Property Tests

3.10.6 FORMED AND CURED IN PLACE PROTECTIVE SEAL

1. The installation of the protective composite liner shall be comprised of a layer of 100% solids epoxy, 80-100 mils in thickness, 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. Into this heavy layer a layer of Type E fiberglass fabric (minimum of 11 oz. stitch bonded, coated with a chemical binder and having a tensile strength of 500,000 psi) shall be applied and encapsulated into the epoxy by application of another impervious layer of 100% solids epoxy (approx. 40 mils).

2. A minimum of 125 mils thickness shall be applied, greater thickness or strength, if specified, and can be accomplished by either increasing the thickness of the epoxy layers or by using additional layers of either the fiberglass cloth, the epoxy or both.

3.10.6.1 TESTING & INSPECTION

1. Visual Inspection to insure bonding, resin saturation, complete cure and a smooth surface free from cracks or hollow spots.
2. 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 Customer representative.
3. Adhesion testing
4. CIP Material Property Tests

3.11 REPLACE FRAME AND COVER

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

3.12 MANHOLE ADJUSTMENT MATERIALS

3.12.1 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.

3.13 MANHOLE STEPS

1. 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.
- 2 Measurement shall be for each manhole step provided
- 3 Payment shall be at the price per each Bid in the Proposal.

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

3.14 QUALITY ASSURANCE AND TESTING

3.14.1 GENERAL

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

3.14.2 CHAIN OF CUSTODY

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

3.14.3 TEST REQUIREMENTS

1. Visual Inspection

- a. All manholes shall be visually inspected to identify any leakage into the manhole in areas where RCS's were installed by the Contractor.

2. CIP Material Property Tests

- a. The physical properties of the RCS installed shall be verified through field sampling and laboratory testing. All materials for testing shall be furnished by the Contractor to the Customer for testing. All materials testing shall be performed at the Customer's expense, by an independent third party laboratory. All tests shall be in accordance with applicable ASTM test methods to confirm compliance with the requirements specified in these contract documents and submitted with the PWS.
- b. The Contractor shall provide samples for testing to the Customer from the actual installed RCS. Samples shall be provided, at a minimum from one location per every ten (10) RCS's installed.

3. Cementitious Material Property Testing

- a. 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 Customer's representative and sent, by the Customer's representative, to an independent test laboratory for compression strength testing as described in ASTM C-109.

4. Vacuum Testing

- a. Manholes lined in their entirety shall be vacuum tested as specified in these contract documents. All pipes entering the manhole should be plugged, taking care to securely place the plug from being drawn into the manhole. The test head shall be placed and the seal inflated in accordance with the manufacturer's recommendations. A vacuum of ten (10) inches of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum to drop to nine (9) inches.

Following are minimum allowable test times for manhole acceptance at the specified vacuum drop

Depth (ft)	Time (Seconds)		
	48" Dia.	60" Dia.	72" Dia
4	10	13	16
8	20	26	33
12	30	39	49
16	40	52	67
20	50	65	81
24	59	78	97

Add for 2ft more depth	5	6.66	8
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Note: These numbers have been taken from ASTM C 1244-93 (re-approved 2000).

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

5. Film thickness Measurements

a. 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 Customer's representative, documented and attested to by Contractor for submission to Customer.

6. Holiday Detection Test

- a. 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 equipment. 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 Customer, in writing, by Contractor.

7. Adhesion Testing

Adhesion Testing shall be performed as follow:

- a. 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 as modified herein. Customer's representative shall select the manholes to be tested.
- b. A minimum of three (3) - 20 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 within 30 mils of the substrate by mechanical means without disturbing the dolly or bond within the test area.
- d. Two of the three adhesion pulls shall exceed 200 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 Customer. Any areas detected to have inadequate bond strength shall be evaluated by the Customer.
- d. 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.

8. Exfiltration Test

- a. Manholes lined in their entirety (including invert) may be subjected to an exfiltration test. Incoming and outgoing sewer and service lines shall be plugged, the plugs restrained and the manhole filled with water to the top of the manhole frame. A soaking period of up to 1 hour will be allowed if

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

Depth of Manhole	Maximum Allowable Loss
Under 8 feet deep	1 inch in 5 minutes
Over 8 feet deep	1/8" per foot of depth in 5 minutes

9. All testing shall conform to these contract specifications and the submitted PWS.

3.15 SAMPLE BID ITEMS:

3.15.1 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. Generally limited to 5% of the total amount bid for the project.

3.15.2 RCS (One for each RCS Specified)– Lump Sum – per each manhole including all labor, materials and equipment required by the Contractor to furnish a leak proof manhole to the Customer, complete.

3.15.3 RCS Inspector Training (One for each RCS Specified) – price per day – includes the cost of all labor, equipment and materials required to train the Customer’s inspectors on the RCS technology, at the Customer’s project location.

3.15.4 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 Customer, complete.

3.15.5 Manhole Adjustment Materials – per vertical foot – includes all labor, equipment and materials required, by the Contractor, to adjust each manhole as required by the Customer, complete.

3.15.6 Manhole Steps – per each – includes all labor, equipment and materials required, by the Contractor, to install each manhole step as required by the Customer, complete

END OF SECTION