

SECTION 06017 – CENTRIFUGALLY OR PNEUMATICALLY CAST CONCRETE PIPE

PART 1 - GENERAL

1.01 SUMMARY

This section covers materials and related work for applying cementitious liners via Centrifugally Cast Concrete Pipe (CCCP) or Pneumatically Cast Concrete Pipe (PCCP) for the purpose of waterproofing, sealing, structural reinforcement, and antimicrobial corrosion protection of existing gravity lines 36 inches in diameter and larger.

1.02 SPECIFICATION MODIFICATIONS

A. It is understood that throughout this section these Specifications may be modified by appropriate items in Section 01015 – Specific Project Requirements or as indicated in the Contract Drawings.

1.03 RELATED SECTIONS

- A. Section 01000 – General Project Requirements.
- B. Section 01015 – Specific Project Requirements.
- C. Section 01270 – Adjustment Unit Prices and Measurement Procedures.
- D. Section 01300 – Submittals.
- E. Section 01500 – Temporary Facilities.
- F. Section 01566 – Cleanup Operations.
- G. Section 01700 – Traffic Control.
- H. Section 02686 – Cleaning and Assessment of Gravity Lines.
- I. Section 06012 – Rehabilitation of Sewer Laterals and Sewer Lateral Connections.

1.04 CODES AND STANDARDS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.
- B. American Society for Testing and Materials (ASTM):
 - ASTM C76 Standard specifications for Fly Ash content in Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
 - ASTM C109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars
 - ASTM C157 Modified Standard Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete
 - ASTM C309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
 - ASTM C403 Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance
 - ASTM C469 Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
 - ASTM C496 Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
 - ASTM C666 Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
 - ASTM C882 Standard Test Method for Bond Strength of Epoxy Systems Used with Concrete by Slant Shear

ASTM C1202	(AASHTO T 277 Equivalent) Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
ASTM C1609	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
ASTM D4783	Standard Test Methods for Resistance of Adhesive Preparations in Container to Attack by Bacteria, Yeast, and Fungi

1.05 DEFINTITIONS

- A. Not used.

1.06 INFORMATION PROVIDED BY THE CITY

- A. As provided in the Contract Documents.

1.07 SUBMITTALS

- A. Submit as specified in Section 01300 – Submittals.
- B. Product Data:
 1. Design approach and formula(s).
 2. Diameter, length and wall thickness for each segment of sewer.
 3. Fittings and adapters.
 4. Method and material of sealing liner at structures.
 5. Manufacturer's storage and handling requirements.
- C. Certificates, Affidavits and Qualifications.

1.08 INSTALLER QUALIFICATIONS

- A. The Installer and its key field installation personnel scheduled for the project shall have experience within the last five (5) years, from the date of submittal, with the installation of CCCP or PCCP liner as specified herein:
 1. The Contractor shall provide a minimum of five (5) references for projects that the installer and key personnel have completed at least 10,000 linear feet of CCCP or PCCP liner in diameters ranging from 36 to 120 inches with the specified and proposed product. These project references shall include the name and telephone number of the contact person who has direct knowledge of the performance of the Installer. The reference must indicate an acceptable performance by the Installer.
 2. Resumes of key field installation personnel (superintendent, foreman, cutter operator) shall be submitted to the City/Design Professional. All changes of key personnel during the execution of the Project requires submittal of the resumes for the personnel to be substituted.

1.09 QUALITY ASSURANCE

- A. The Contractor is responsible for the quality assurance and quality control of the Work.
- B. Furnish the following prior to shipment or installation as applicable:
 1. Affidavit of compliance with applicable standards for CCCP or PCCP liner materials.
 2. Certification sealed by an insured registered professional engineer that the liner design and thickness meet the minimum structural design criteria specified herein or as otherwise required by the project.
- C. Furnish the following after installation and testing:
 1. Affidavit of compliance for minimum liner thickness.

1.10 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Delivery and storage of lining and other materials shall conform to requirements of the manufacturer.
- B. Contractor shall furnish required storage facilities.
- C. Handle lining materials in compliance with the manufacturer's recommendations.
- D. Damaged material, as determined by the City/Design Professional, is unacceptable for installation.

PART 2 – PRODUCTS

2.01 ANTIMICROBIAL ADDITIVE

- A. An antimicrobial additive shall be introduced to the cementitious liner mix in order to provide protection against Microbial Induced Corrosion (MIC).
- B. The antibacterial additive shall be used to render the concrete uninhabitable for acid producing bacterial growth and shall have successfully demonstrated the prevention of MIC in sanitary sewers for a minimum of fifteen years.
- C. The antimicrobial shall only be used by contractors that have been certified by the manufacturer of the antimicrobial additive. The antimicrobial additive shall be an EPA and state registered material. Both EPA and state registration numbers shall be submitted for approval
- D. The active ingredient of the antimicrobial shall be a silicone quaternary ammonium salt and shall not contain heavy metals, nor volatile organic compounds (VOC's). Antimicrobial shall be delivered as a liquid from the manufacturer. Powders or slurries produced from powders shall not be acceptable.
- E. The antimicrobial additive shall be ConShield as manufactured by APM LLC or preapproved equal. Any equal must be approved no less than 21 days prior to bid date.

2.02 STRUCTURAL REQUIREMENTS FOR CENTRIFUGALLY CAST CONCRETE PIPE (CCCP)

- A. The liner shall be designed in accordance with the material manufacturer's Design Guide. The design shall be based on a fully deteriorated pipe condition and shall be designed to withstand the structural requirements within this specification and designed for a minimum service life of not less than 50 years.
- B. The Manufacturer and Contractor shall certify and provide structural calculations that the product at the installed thickness will adequately support all loads.
- C. The pipe lining material shall be a high strength, high build, abrasion resistant and corrosion resistant mortar, based on advanced cements and additives. When mixed with the appropriate amount of water, a paste-like material which can be sprayed, cast, or pumped into areas ¼ inch and larger shall be obtainable.
- D. Fibers are to be added as an aid to CCCP casting process, for increased cohesion and to enhance flexural strength. Additional crystalline waterproofing additives shall be incorporated that enhance the autogenous healing process of the cured liner.
- E. Per ASTM C-76, in no case, however, shall the proportion of Portland cement, blended with hydraulic cement or a combination of Portland cement and supplementary cementing materials, be less than four hundred seventy (470) pounds per cubic yard. No products containing more than ten percent (10%) fly ash shall be considered.

- F. The pipe lining material shall be the PERMACAST PL-8,000 material or engineer's approved equal with the following minimum physical properties:

Initial Set:	Approximately 170 Minutes
Final Set:	Approximately 300 Minutes
Flexural Strength per ASTM C-293:	28 day Minimum, 1,200 psi
Compressive Strength per ASTM C-109	24 hours: 3,200 psi 28 days: 8,000 psi
Split Tensile Strength Per ASTM C-496	805 psi
Shear Bond per ASTM C-882	2,600 psi
Modulus of Elasticity per ASTM C-469	28 day Minimum: 5.26×10^6 psi
Freeze Thaw ASTM C-666	300 Cycle Pass
Rapid Chloride Permeability ASTM C-1202 (AASHTO T-277)	< 50 Coulombs

- G. The Contractor is required to field verify the mean diameter, minimum diameter, and depth of cover of the existing pipeline, prior to ordering the liner material. All measurement information and the calculated liner thickness shall be provided to the City/Design Professional prior to ordering the liner. Based on field conditions, the Contractor may request a Live Load variance (from HS-25 to HS-20) to adjust the calculated CCCP liner thickness.

2.03 STRUCTURAL REQUIREMENTS FOR PNEUMATICALLY CAST CONCRETE PIPE (PCCP)

- A. The liner shall be designed in accordance with the material manufacturer's peer reviewed Design Guide. The design shall be based on a fully deteriorated pipe condition and shall be designed to withstand the structural requirements within this specification and designed for a minimum service life of not less than 50 years.
- B. The Manufacturer and Contractor shall certify and provide structural calculations that the product at the installed thickness will adequately support all loads.
- C. The pipe lining material shall be a high strength, high build, rapid hardening, early entry, abrasion resistant and corrosion resistant mortar, based on advanced cements and additives. When mixed with the appropriate amount of water at the water ring, a paste like material which can be sprayed, cast, into areas $\frac{1}{4}$ inch and larger shall be obtainable.
- D. Fibers are to be added as an aid to PCCP casting process, for increased cohesion and to enhance flexural strength. Additional crystalline waterproofing additives shall be incorporated that enhance the autogenous healing process of the cured liner.
- E. Per ASTM C-76, in no case shall the proportion of Portland cement, blended with hydraulic cement or a combination of Portland cement and supplementary cementing materials, be less than four hundred seventy (470) pounds per cubic yard. No products containing more than ten percent (10%) fly ash shall be considered.
- F. The pipe lining material shall be the PERMACAST PL-8,000D material or Engineer approved equal. With the following minimum physical properties.

Initial Set:	Approximately 10 Minutes
Final Set:	Approximately 15 Minutes

Flexural Strength per ASTM C-293:	28 day Minimum, 1,900 psi
Compressive Strength per ASTM C-109	24 hours: 6,000 psi 28 days: 11,000 psi
Split Tensile Strength Per ASTM C-496	805 psi
Shear Bond per ASTM C-882	2,700 psi
Modulus of Elasticity per ASTM C-469	28 day Minimum 5.14 x 10 ⁶ psi
Freeze Thaw ASTM C-666	300 Cycle Pass
Rapid Chloride Permeability ASTM C-1202 (AASHTO T-277)	< 100 Coulombs

- G. The Contractor is required to field verify the mean diameter, minimum diameter, and depth of cover of the existing pipeline, prior to ordering the liner material. All measurement information and the calculated liner thickness shall be provided to the City/Design Professional prior to ordering the liner. Based on field conditions, the Contractor may request a Live Load variance (from HS-25 to HS-20) to adjust the calculated PCCP liner thickness.

PART 3 - EXECUTION

3.01 GENERAL

- A. The Contractor shall comply with the following procedures unless other procedures are approved by the City.
- B. Prior to the commencement of the actual liner installation process, the Contractor shall plan its work after review of preliminary CCTV television inspection performed by the contractor and reviewed by the City/Design Professional. All point repairs shall be satisfactorily completed, adequate quantity of material confirmed onsite and equipment confirmed in writing as available if not mobilized to site. The City shall be informed on the impending work schedules (see paragraph C. below) for CCCP or PCCP liner installations.
- C. General construction sequencing is as follows: cleaning of mainline, CCTV of mainline, all obstructions removed, mainline point repairs made where needed, bypass pumping established, mainline CCCP or PCCP liner installed, laterals reinstated.

3.02 SAFETY

- A. The Contractor shall carry out its operations in accordance with all OSHA and manufacturer's safety requirements. Particular attention is drawn to those safety requirements involving working with scaffolding and entering confined spaces.
- B. The Contractor shall inform City of any hazardous material encountered during this project.
- C. Traffic control shall be performed in accordance with Section 01700 – Traffic Control.

3.03 CLEANING OF THE SEWER LINE

- A. The Contractor shall be required to remove all internal debris from the sewer lines, so the entire pipe can be thoroughly inspected and successfully reconstructed. Pipe to be lined shall be cleared of protruding service connections, debris or other obstructions that could hinder the cementitious liner installation. Cleaning shall be performed as specified in Section 02686 – Cleaning and Assessment of Gravity Lines.

3.04 BYPASS PUMPING

- A. The Contractor shall provide for the flow of sewage around the section or sections of pipe designated for rehabilitation and inspection and at a cost incidental to the installation of the CCCP or PCCP liner. The bypass shall be made by plugging the line at an existing upstream structure or adjacent system. The pumping system shall be of adequate capacity and size to handle at least two times the max month flow rate. The contractor shall work with the City/Design Professional to verify flow rates for each section of pipeline to be lined and determining the max month flow rate. The Contractor shall submit a flow control implementation plan for the City's acceptance prior to construction.
- B. Bypassing includes all mainline bypassing and service line bypassing, if required.
- C. Wastewater shall not be allowed to spill into storm drains, street gutters or open excavations. Any spills that occur must be taken care of properly and immediately. The City shall be immediately notified, and the Contractor shall bear all costs associated with any spills from its bypass system.
- D. The Contractor shall take all necessary steps to prevent flooding of any residence or business and shall be liable for any damages incurred because of the Contractor's operation.
- E. Once liner is completely installed and service connections are reinstated:
 - 1. Place rehabilitated sewer sections back in service.
- F. All accumulated debris that is built up behind the bypass plug shall be removed in accordance with Section 02686 – Cleaning and Assessment of Gravity Lines.

3.05 CCTV INSPECTIONS

- A. CCTV shall be performed as specified in Section 02686 – Cleaning and Assessment of Gravity Lines.
- B. The CCCP or PCCP liner installer shall provide inspection of gravity lines by experienced personnel specially trained in locating breaks, obstacles and active service connections by CCTV, as specified in other sections. All inspections shall be in accordance with NASSCO PACP standards.
- C. The inspection of pipelines is also to aid in the determination of active service connections and the addresses which they serve.
- D. The interior of the gravity line shall be carefully inspected to determine the location of all active lateral connections, the location and extent of any structural failures, pipe deflections, offset joints or other factors that will affect the installation or performance of the CCP or PCCP liner system.
- E. Contractor shall notify City when point repairs are required where existing sewer pipe sections must be removed or replaced to successfully install the CCCP or PCCP liner. Point repairs shall be completed in accordance with Section 02503 – Sewer Mainline Open-Cut Point Repair.

3.06 LINE OBSTRUCTIONS

- A. It shall be the responsibility of the Contractor to clear the line of obstructions such as solids and roots that will prevent the installation of the CCCP or PCCP liner.

- B. If pre-installation inspection reveals an obstruction such as a protruding service connection, dropped joint, excessively deformed section, mineral deposits or a collapse that will prevent the liner installation process and it cannot be removed by conventional sewer cleaning equipment, then the Contractor will notify the City and Contractor shall make a point repair excavation to uncover and remove or repair the obstruction:
 - 1. Such excavation shall be approved in writing by the City prior to the commencement of the work and shall be considered as a separate pay item as provided in the Bid Schedule.
 - 2. Where sections of the existing sewer pipe must be removed (open cut point repair), a circular form or new pipe with couplings, shall be installed as approved by City.
 - 3. This work shall be performed by the Contractor as recommended by the CCCP or PCCP liner materials manufacturer and as directed by the City.

3.07 EXISTING VOIDS

- A. Field locate and record all voids and holes to be filled. Record shall include the following dimensions and measurements:
 - 1. Distance from both upstream and downstream structures to each void or hole.
 - 2. Length, width and depth of each void or hole, such that approximate volume of fill material may be calculated.
 - 3. Location of each void or hole in the sewer crown stated in clock position as viewed from downstream.
- B. Prior to installation of the CCCP or PCCP liner, submit recommendations for filling voids, including those to be filled after installation of the liner. The City will issue a Request for Proposal and after acceptance of the Contractor's proposal, a Work Change Directive and Change Order will be issued for performance of the required Work.
- C. Fill all voids or holes recorded. All large voids or holes shall be filled with concrete, non-shrink grout or other material. Voids and holes below the centerline elevation of the existing sewer shall be filled prior to installation of the liner. Voids and holes above the centerline elevation of the existing sewer may be filled after installation of the liner. Perform in a manner to ensure that voids and holes are filled. Plug any holes in the liner wall with a manufacturer's approved method. Submit documentation of manufacturer's approved method of plugging holes.

3.08 PUBLIC COMMUNICATIONS

- A. Notification of affected property owners shall be in accordance with Section 01581 – Public Communications.
- B. Contact any home or business which cannot be reconnected within the time stated in the written notice.

3.09 TEMPORARY FACILITIES

- A. See Section 01500 – Temporary Facilities.

3.10 CCCP LINER INSTALLATION

- A. CCCP liner installation shall be in accordance with the materials manufacturer's recommendations, with the following additional requirements:
 - 1. Immediately prior to installing the liner, the contractor will completely flush and televise the pipeline for inspection by the City representative to ensure a clean, debris free pipeline.

2. Mortar mixers, compressors and pumps shall be standard commercial models. A high-speed, bi-directional rotating applicator device shall be used to provide a densely compacted liner of uniform thickness and thorough coverage.
3. The Contractor shall mix and prepare the liner material in accordance with manufacturer's Instructions including the antimicrobial additive specified in Section 2.01 above. Mixing shall be accomplished with a high-speed shear type mixer until proper consistency is obtained. The Contractor shall continue to agitate the mortar to prevent thickening beyond the desired fluidity. The working time is defined by the material manufacturer's specification.
4. The Contractor shall position the high pressure bi-directional rotating casting applicator within the pipe as required by the material manufacturer's specification and commence pumping the mortar. As the mortar begins to be centrifugally cast evenly around the interior, the Contractor shall retrieve the applicator head at the best speed for applying a uniform liner. Multiple passes may be required to achieve the design thickness.
5. Curing:
 - (a) Liner installer shall be required to maintain humidity levels within the pipe as to achieve optimum curing conditions.
 - (b) The City representative may also monitor the installation of the liner to verify general compliance with the recommended manufacturers cure schedule.

3.11 PCCP LINER INSTALLATION

- A. PCCP liner installation shall be in accordance with the materials manufacturer's recommendations, with the following additional requirements:
 1. Dry mix conveyance machine, compressors and equipment shall be standard commercial models. A bi-directional rotating pneumatic applicator device shall be used to provide a densely compacted liner of uniform thickness and thorough coverage.
 2. Mixing shall be accomplished with a water ring and airstream at the nozzle of the bi-directional rotating applicator. Water supply to the water ring shall include the antimicrobial additive specified in Section 2.01 above. The working time is defined by the material manufacturer's specification.
 3. The Contractor shall position the high pressure bi-directional rotating casting applicator within the pipe as required by the material manufacturer's specification and commence pumping the mortar. As the mortar begins to be pneumatically cast evenly around the interior, the Contractor shall retrieve the applicator head at the best speed for applying a uniform liner at the design thickness.

3.12 SEALING CCCP AND PCCP LINERS AT STRUCTURES

- A. Contractor shall ensure that all entries into/out of each structure provides a smooth transition at the invert and interior walls. Any hand applied material shall conform to all structural standards set forth in Section 2.02 or 2.03 above.

3.13 SERVICE CONNECTIONS

- A. Prior to lining, installer shall place pneumatic plugs in all service connections to prevent lining material from entering the connection.
- B. After initial cure of the lining, installer will remove liner at the connection and retrieve pneumatic plugs.
- C. It is the intent of these specifications that active service connections and branch connections be reopened without excavation and in the case of non-man entry pipes, from the interior of the pipeline utilizing a remotely controlled cutting device, monitored by a closed-circuit television camera, which fully opens the service connections. Reinstatement

of sewer service shall provide a full diameter hole, free from burrs or projections and finished with a smooth edge.

- D. Contractor shall submit a connection reinstatement schedule to by City prior to the installation process.

3.14 INSPECTION

A. Visual Inspection:

1. All defects discovered during the post liner CCTV inspection shall be corrected by the Contractor at the Contractor's expense before the work will be considered complete by the City.
2. Cracks in the liner greater than 1/16th in width and 18" in length shall be addressed and repaired by the Contractor at no additional cost to the City.
3. The post-construction CCTV data shall be conducted once all work in a line segment is complete (main line, point repairs, laterals and manhole rehabilitation).
4. Direct flow around sections being televised using the same method required for installation.

3.15 FIELD QUALITY CONTROL

A. Finish:

1. The finished CCCP or PCCP shall be continuous over the entire length of an installation between two structures and shall be free from all defects.
2. Any defects which will affect the integrity or strength of the liner shall be repaired at the Contractor's expense, in a manner recommended by the manufacturer and mutually agreed upon by the City and the Contractor.

B. Sampling:

1. A minimum of three 2" x 2" test samples of the mixed CCCP or PCCP mortar material shall be taken randomly throughout each line segment as directed by the Engineer, at the Contractor's expense, to verify compressive strengths of the liner system at 28 days in accordance with ASTM C109 testing protocol.
2. A minimum of three 2" x 2" test samples of the mixed CCCP or PCCP mortar material shall be taken from each line segment as directed by the Engineer, at the Contractor's expense, to verify the presence of the antimicrobial additive in accordance with ASTM D4783 Modified.
3. Liner thickness for the CCCP or PCCP process shall be verified at two points in any line segment. For any line segment greater than 500' an additional verification point will be required.
4. Thickness verification shall be obtained by the measuring the ID of the pipe prior to application and recording measurements from the vertical and horizontal axis. Like measurements at the same points shall be taken after liner application. The average resulting difference of the measurements shall be no less than the design thickness.

3.17 WARRANTY

- A. The Contractor shall warrant the CCCP or PCCP liner installation for a period of three (3) years. During the Contractor warranty period, any defects which affect the integrity or strength of the pipe, as identified by the City during routine inspections, shall be repaired at the Contractor's expense in a manner recommended by the manufacturer and mutually agreed by the City and the Contractor.
- B. This shall include but not be limited to all material, excavation, backfilling, cutting, concrete, pipe, shoring, temporary pavement, permanent pavement, permits, bypass pumping, surface restoration and other incidental work required to remove the liner from

- the existing pipe.
- C. If removal is not feasible or if removal will cause more harm than acceptable to the host pipeline, alternatives may be proposed by the Contractor to the City for review and approval.
 - D. The integrity of the existing pipe where the liner was removed shall be rehabilitated by installing another liner or if this procedure is not feasible by installing a new pipe section.
 - E. There shall be no direct payment, to the Contractor, for this work.

3.18 PROTECTION OF EXISTING WORK

- A. CCCP or PCCP liner installations associated with this work may be along or through existing structures, manholes or pipe segments that have previously been rehabilitated.
- B. Damage to existing linings (manhole coatings, existing CIPP installations, lateral linings, LCRs, etc...) due to the installation of the new liners or any work associated construction shall be repaired at no additional cost to the City. Requirements include, but is not limited to, the following:
 - 1. Manhole wall corrosion protection top coats that are damaged or removed due to the installation or the installation of the new CCCP or PCCP liner.
 - 2. The previously rehabilitated manhole structure shall be repaired with a similar, compatible product as recommended by the manhole coating material manufacturer.
 - 3. If repair of the existing structure coating is impossible, the existing manhole corrosion prevention product should be removed, and the entire structure recoated.

3.19 REJECTION

- A. Materials and installation may be rejected for failure to meet the requirements of this Section.

3.20 CLEANUP

- A. After installation and testing, the Contractor shall clean up the entire project area. All excess material and debris shall be disposed of by the Contractor.
- B. Cleanup shall be in accordance with Section 01566 – Cleanup Operations.

END OF SECTION