#### SP- XX CURED-IN-PLACE PIPE (CIPP) LINING

Version Date: 8/20/2021 Revision Date: MM/DD/YYYY by XXX

1. **DESCRIPTION**

Work covered by this specification includes providing all labor, materials, equipment, and incidentals required to clean/prepare pipe, install, and test Cured-In-Place Pipe (CIPP) lining and appurtenances complete as shown on the Drawings and specified herein. CIPP lining is specified as a resin-impregnated flexible liner, which fits against the original pipe. The CIPP will be continuous and tight fitting.

1. **MATERIALS**

Standards:

ASTM F1216 (Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube).

ASTM F1743 (Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured in Place Thermosetting Resin Pipe (CIPP)).

ASTM D5813 (Cured-in-Place Thermosetting Resin Sewer Pipe).

ASTM D543 (Standard and Practice for Evaluating the Resistance of Plastics to Chemical Reagents).

ASTM C790 (Test Methods for Flexural Properties of Un-Reinforced and Reinforced Plastics and Electrical Insulating Materials).

ASTM D2990 (Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics).

ASTM D2412 (Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading).

ASTM C581 (Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass Fiber Reinforced Structures, Intended for Liquid Service).

ASTM F2019 (Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP)).

Lining:

* 1. The liner shall consist of one or more layers of absorbent, flexible, non-woven polyester with or without additives such as woven fiberglass or other fibers. The liner material shall be impregnated with a thermosetting polyester resin and catalyst, vinyl ester and catalyst or epoxy resin and hardener.  The liner material and resin shall be completely compatible.  The outside layer of the liner shall be coated with an impermeable material compatible with the resin and fabric.  The liner shall be marked for distance at regular intervals along its entire length, not to exceed 5 feet.  Such marking shall include the Manufacturer’s name or identifying symbol.
	2. The liner material shall be capable of fitting into irregularly shaped pipe sections and through bends and dips within the pipeline.
	3. The liner shall be able to cure in the presence of water at a temperature of 180 degrees F or less, or UV light based on manufactures specifications.
	4. The wall color of the interior pipe surface of CIPP after installation shall be a relatively light reflective color so that a clear detailed examination with closed circuit television inspection equipment may be made.
	5. The liner shall be chemically resistant to chemicals found in stormwater runoff; such as but not limited to gasoline, oil products, grass clippings, and fertilizers. It is required that CIPP samples with and without plastic coating meet these chemical testing requirements.
	6. When cured the liner shall form a continuous, tight fitting, hard, watertight and impermeable liner. The liner shall be fabricated to a size that will tightly fit the storm drain being rehabilitated after being installed and cured. Allowance for longitudinal and circumferential expansion shall be taken into account when sizing and installing the liner. Field measurements shall be used to ensure maximum closure between the new liner and the existing storm drain pipe.
	7. The application of the resin to the liner (wet-out) shall be conducted under factory conditions and the materials shall be fully protected against UV light, excessive heat and contamination at all times.
	8. The existing pipe conditions shall be reflected in the design of the liner thickness. In particular, the ovality of the existing pipe and, thus, the liner pipe shall be accurately estimated and reflected in the design calculations.
	9. The thickness to be used for the liner shall be the largest thickness as determined by calculations for deflection, bending, buckling, and minimum stiffness.
1. **qualifications**

The Contractor performing the CIPP lining work shall be fully qualified, experienced and equipped to complete this work expeditiously and in a satisfactory manner and shall be certified and/or licensed as an installer by the CIPP manufacturer.

* 1. The Contractor shall have successfully installed a minimum of 75,000 linear feet of CIPP liner, 25,000 linear feet of liner greater than 18” in diameter and at least one project of proposed liner equal to or greater than 36” in diameter, as documented by verifiable references and documented in the CIPP Material and References Document.
	2. The Superintendent shall have successfully installed a minimum total of 100,000 linear feet of CIPP liners of any diameter and over 5,000 linear feet of liner greater than 18”.
	3. Provide name of the CIPP manufacturer and list of prior work for the CIPP lining manufacturer and supplier. Acceptable manufacturers include Insituform, Liner Technologies, Premier-Pipe USA, Improved Technologies Group, or approved equal.
	4. Provide certified statement from the manufacturer that contractor is certified and / or licensed for the proposed CIPP lining system.
	5. Provide list of municipal clients for whom the Contractor has performed this type of work. Include reference contact information and a description of work that includes diameter of pipe and linear footage installed.
1. **Submittals**

The Contractor shall submit for review and approval by the Engineer the following information, fifteen (15) days prior to beginning work on the site:

* 1. Shop drawings of all CIPP materials including resin, felt, coatings, and catalysts. Shop drawings shall be prepared by a North Carolina Registered Professional Engineer. The following supplemental information shall also be included: product MSDS sheets and manufacturers shipping, handling, and storage recommendations.
	2. A CIPP lining production schedule with location manufactured, lengths, and sizes.
	3. Certified test report from a Testing Laboratory or Manufacturer, that the CIPP was manufactured and tested in accordance with all ASTM standards specified and referenced herein.
	4. Detailed description of wet-out, storage, shipping, and installation procedures. The application of resin to the liner (wet-out) shall be conducted under factory conditions and the materials shall be fully protected against UV light, excessive heat, and contamination at all times.
	5. Engineering calculations specifying the design and required thickness for each CIPP installation, which are signed and sealed by a North Carolina Registered Professional Engineer. The CIPP liner shall be designed to the following minimum criteria:
		1. All sections of pipe shall be considered fully deteriorated.
		2. All pipes shall be subjected to soil loads of 120 pounds per cubic foot.
		3. The soil modulus shall be no more than 1,000 psi.
		4. All pipes located shall be assumed to carry AASHTO HS20-44 live loads
		5. The existing pipe shall be assumed to have an ovality of 2%.
		6. The contractor shall assume a factor of safety of 2.0.
		7. Ground water is assumed 3 feet below surface elevation unless site-specific data is available.
		8. The depth of cover is as shown on the plans.
		9. The design flexural modulus shall be 300,000 psi.
		10. CIPP design life shall be 50 years or greater.
		11. Hydraulic Capacity – Overall, the hydraulic cross-section shall be maintained as large as possible. The CIPP shall have a Manning’s “n” value of 0.010 or less after installation.
	6. Health and Safety Plan, including confined space safety plan.
	7. Emergency Response Plan. The Contractor shall include a plan to address reported backups or other problems resulting from the work, including personnel contact, equipment, disposal, etc. The minimum response time to address any issues shall be two hours unless otherwise directed by the Engineer.
	8. Maintenance of Base Flows plan. The plan shall include but not be limited to pump sizes, capacity, power requirements, pump selection and other calculations, pump curves, and piping sizes and locations. Bypass pumping systems shall include as a minimum one or more pumps capable of handling the base flow and storm events without the stored water level exceeding the crown of the pipe and one standby pump equal to the largest pump used.
	9. Odor Control Plan. The Contractor shall develop and submit to the Engineer a protocol for addressing odor complaints during the CIPP installation process (primarily styrene odor complaints). The protocol shall include steps to be taken by on-site personnel when the complaint is received, including discussing the odor with the property owners and Engineer to address their concerns and alleviating the odor from the home or business using fans or other means as necessary. The Contractor shall also maintain a calibrated portable styrene test unit to immediately document the atmospheric concentrations of the styrene on the site and in the house/business when a complaint is received. The styrene concentrations must be tested prior to exhausting the odors from the housed/business. The Contractor shall also utilize blowers (vacuum blowers) during the CIPP installation to exhaust odors from the pipes and into the atmosphere during the installation. The blowers shall be strategically placed to exhaust the concentrated odors in an isolated location.
	10. If applicable, identification of water source(s) that will be used during CIPP installation. Contractor is responsible for securing and providing the necessary water for curing the CIPP. Contractor shall coordinate with the City of Charlotte if proposed water is obtained from fire hydrants. The Contractor is responsible for obtaining permits from Charlotte Water for water and sewer usage.
	11. Identification of staging area(s) necessary for CIPP installation.
	12. Comply with the most current Work Area Traffic Control Handbook (WATCH).
	13. Contingency plan for equipment malfunctions or equipment that becomes immovable.
	14. Contractor shall provide a hard copy summary of all inspections performed, defining all pipe sections inspected, measured lengths to features (pipe penetrations, structures, damage, etc.), and inspection date. An electronic copy of the inspection report, inspection still images, the pipe inspection video files, and inspection database provided on a USB drive, shall also be provided. Pre-installation video inspections shall be submitted a minimum of two weeks prior to installation of the liner.
1. **CONSTRUCTION METHODS**

**Site Preparation**

The Contractor shall verify site conditions prior to commencing any construction activities. Site conditions include, but are not limited to, inlet and access port accessibility, accessibility to remote locations and encroachment onto private or publicly owned property. Selection of inspection equipment shall be based on the conditions of the storm drainage piping, structures, and inlets at the time the work commences. All dimensions shall be field verified by the Contractor.

The Contractor shall conduct a PACP compliant color digital television inspection of each length of pipe prior to ordering liner. The purpose of this inspection is to confirm that existing conditions are suitable for the installation of the proposed lining process, to document the location of all service lateral connections and to confirm point repair locations. Digital recordings on a USB drive shall be prepared and retained by the Contractor and submitted with the post-lining inspection recordings prior to request for payment. Where this television inspection reveals conditions that are not suitable for lining, the digital recordings shall be immediately provided to the Engineer for review.

The Contractor shall protect the storm drainage system and adjacent properties from damage that might result from construction. Any damage caused by the Contractor’s operations shall be repaired to the complete satisfaction of the Engineer at no additional cost.

Protruding lateral connections, if encountered, shall be cut or ground with a robotic cutter flush with the pipe to be lined prior to CIPP liner installation. All lateral connections for reconnection after CIPP liner installation shall be documented. The cutting operation shall be monitored by CCTV equipment to verify proper execution of work. Cutter shall be capable of cutting the following materials: vitrified clay pipe, polyvinyl chloride pipe, ductile iron pipe, high-density polyethylene pipe, or reinforced concrete pipe. Equipment specifically designed for cutting roots from storm drainage pipes (such as a chain cutter) shall not be allowed for this purpose.

If, in the opinion of the CIPP liner manufacturer, the rate of infiltration in the storm drainage pipe presents washout risk of the resin, then the Contractor shall perform measures as required to minimize infiltration prior to lining. Any infiltration gusher identified shall be brought to the attention of the Engineer. The Contractor shall submit for approval to the Engineer the measures to prevent any adverse issues to the installation of the final product. The submittals shall be reviewed and approved prior to installation.

**Delivery, Handling and Installation**

Care shall be taken in shipping, handling and storage to avoid damaging the liner. Any liner damaged in shipment shall be replaced as directed by the Engineer. Any liner showing a split or tear, or which has received a blow that may have caused damage, even if the damage may not be visible, shall be marked as rejected and removed at once from the job site. The liner shall be maintained at a proper temperature in refrigerated facilities to prevent premature curing at all times prior to installation. The liner shall be protected from UV light prior to installation. Any liner showing evidence of premature curing will be rejected for use and will be removed from the site immediately.

The bypass pump(s) shall be setup and ready for immediate operation. Pumps shall be automatically controlled. The Contractor shall properly maintain the bypass pumping system. A responsible operator shall be on site at all times during bypass pumping operations. Drainage flows from existing storm drainage pipes shall not be allowed to enter the rehabilitated facilities until those facilities have been cleaned and CIPP completely installed including curing.

Pipe inversion using hydrostatic head shall be performed in compliance with this specification and the requirements of the CIPP manufacturer. Care shall be taken not to overstress the liner at the elevated curing temperatures, which may cause damage or failure prior to cure. The Contractor may submit a proposal for a product that uses a pull-in method as defined in ASTM F1743, for review and approval by the City. If pulled into place, a power winch or equivalent should be utilized and care should be exercised not to damage the liner as a result of pull-in friction. The Contractor shall use a slip sheet or preliner or method recommended by the manufacturer to reduce the friction.

If using hot water to cure the liner, contractor shall supply a suitable heat and water source to uniformly raise the water temperature above the temperature required to affect a cure of the resin. The heat source shall be fitted with suitable monitors to gauge temperatures of the incoming and outgoing water supply. Another gauge shall be placed between the layers of the impregnated liner in the upstream, downstream, and intermediate inlets to determine the temperature during curing. Water temperature in the line during curing shall be per the manufacturer’s recommendations. Initial cure may be considered complete when the remote sensing device indicates the temperatures to be adequate, as recommended by the resin/catalyst system manufacturer. The Contractor shall maintain a log of the temperatures at each sensor during the entire curing process.

If using UV light to cure the liner, follow the manufacture’s recommendation for proper curing methods.

The Contractor shall cool the hardened CIPP to a temperature below 100 degrees F or temperature specified by the manufacturer, whichever is less, before relieving the water column. Cool water may be added to the water column while draining hot water from the CIPP, thus maintaining a constant water column. Careful attention should be taken not to cool too quickly to eliminate the possibility of thermo-shock. Careful attention should be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed liner.

The CIPP shall meet the chemical resistance requirements of ASTM 1216, Appendix X2. CIPP samples for testing shall be of liner and resin system. The CIPP samples with and without plastic coating must meet these chemical-testing requirements.

All cutting and sealing of the liner at drainage structures shall provide a watertight pipe and inlet seal using quick set cement grout or approved equal.

Contractor shall reopen all existing lateral connections in each length of pipe following liner installation. Lateral connections shall be determined from the pre-installation CCTV inspection. The lateral connections shall be reopened from inside the pipe by means of a television camera controlled cutting device appropriate for the liner material and the pipe. All pipe connections shall be completely opened, clean and neatly cut, shall be flush with the lateral pipe and the cut shall be wire polished. The bottom of the opening shall be flush with the bottom of the lateral pipe so that there is not a lip. All liner penetrations shall be watertight. The Contractor shall be fully responsible for all backups and damage caused by unopened or not fully opening lateral connections, including paying all costs associated with repairing damage as required by the Engineer, Owner and/or property owner.

Contractor shall, with approval from Charlotte Water, discharge all water used for cooling, heating, and curing to the existing sanitary sewer system. Contractor may utilize a vacuum truck to remove the water from the site and discharge directly to a wastewater treatment plant. No water used for the installation of the CIPP lining shall be discharged into the downstream storm drainage system.

**Post-Installation Inspection and Testing Requirements**

After all liner installation and lateral connection work has been completed, the contractor shall inspect via CCTV all new CIPP liners within 3 weeks of installation. Inspection of pipelines shall be performed by PACP certified, experienced personnel, trained in locating breaks, obstacles, and service connections using CCTV inspection techniques. For every segment of CIPP installed, the Contractor shall generate a report that documents the installation including date, time, temperature, curing temperature, curing time, resin type and volume. The reports shall be submitted along with the post-installation CCTV inspection to the Engineer prior to acceptance of work and submittal of payment request.

The camera equipment used for the CCTV inspections shall be one specifically designed and constructed for such inspection. Lighting for the camera shall be suitable to allow a clear picture for the entire circumference of the pipe. The camera shall be a color, pan, tilt, and zoom camera. Video inspections not inspected to the Engineer’s satisfaction shall be re-inspected at no additional cost to the Owner.

All cameras shall move through the main pipes via self-powered tractor assemblies. The tractor shall be the appropriate size assembly for the pipe being inspected according to the manufacturer of the television equipment. The tractor assemblies shall be capable of being configured to be centered horizontally and vertically in pipes up to at least 72-inches in height.

The CCTV inspections shall begin at the center of the structure, shall clearly show the pipe connection of the pipe to be inspected at the structure and shall pan and tilt around the structure to provide a clear view of the structure and all pipe connections. At every downstream structure, the camera shall be panned and tilted within the structure to provide a clear view of the structure and all pipe connections.

The camera shall move through the storm drain in either direction at a uniform rate but not greater than 30 feet per minute. Inspect the full length of all assigned pipes from structure to structure. The camera should be centered horizontally and vertically in the pipe during the inspection. The camera shall be stopped at all defects and connections and shall be panned, tilted, zoomed and rotated to fully view the defects and connections. All such inspections shall be documented in the video and computer-generated logs. Footages and locations of any defects and connections shall be documented. During inspections of cured in place pipe liners, the Operator should pan around to fully view the pipe wall(s) at least every ten (10) feet, unless the City representative requires more frequent intervals.

Each video shall include an overlay / text display. Each inspection start shall include the overlay display of section details including at a minimum:

* Owner Name;
* Project Name;
* City supplied Pipe Video number (Storm Water Services only);
* Consultant Name;
* Street Name;
* Date / Time of inspection;
* MH Start # / MH End #
* Pipe Material;
* Pipe size;
* Direction of Video with respect to flow;
* Weather;
* Flow Level.

A constant display of the Structure Begin # and the Structure End #, date and distance shall appear on the screen. As an observation / defect is noted by the inspector, a text display shall appear with the text describing the observation / defect. Text shall be displayed for a minimum of 4 seconds.

The City will provide pipe network sketches with asset ID’s to be used as references on video. Utilize the City’s asset IDs to represent the manholes or other structures and pipes in the PACP compliant database and any other locations where the assets are referenced by an ID.

All pipe video inspections shall be completed using PACP (Pipeline Assessment and Certification Program) standards by PACP certified professionals. A current PACP certification number shall be included for each person creating / gathering inspection reports.

If the television equipment becomes lodged in the pipe being inspected during the work, the Contractor shall be responsible for removing the equipment, including excavation of the pipe, if necessary, and paying all costs associated with the removal unless otherwise agreed to by the Engineer.

Provide the City with the following on a USB drive or through a City approved data transfer site within 24 hours of the inspection:

* A .MPEG-4 H.264 video file of the recorded closed-circuit television (CCTV) inspection
* A digital copy of the PACP compliant database and associated files for importing into the City’s pipe video application
* A .pdf of the report including:
	+ All mandatory PACP fields
	+ A completed PACP Inspection Form Details Section with all fields included with entries, where applicable
	+ A pipe sketch plan with locations of defects and defect coding
	+ Include condition grades based on PACP Condition Grading System
	+ Still photos of all defects, the defect coding, and station of defect

The digital recording shall include both audio and video information that accurately reproduces the original picture and sound of the video inspection. The video portion of the digital recording shall be free of electrical interference and shall produce a clear and stable image. The audio portion shall be sufficiently free of background and electrical noise as to produce an oral report that is clear and discernible.

There shall be no dry spots, lifts, ridges, splits, cracks, uncured resin, delaminations or other defects in the CIPP lining. There shall be no visible infiltration through the liner or from behind the liner at manholes and service connections. Wrinkles in the finished liner that cause backwater, reduce the pipe’s hydraulic capacity or structural stability or that create voids between the liner and pipe wall will be unacceptable. Defective lining will be removed and the pipe re-lined at no additional cost.

The Contractor shall remove two specimens from each pipe diameter or two per 25,000 linear feet of CIPP installed, of at least 18 inches in length for testing of liner thickness and flexural properties. The Contractor shall provide a constrained pipe sample for pipe diameters less than 18 inches and a constrained plate sample for pipe diameters greater than 18 inches. The Contractor shall create two specimens by cutting out a section of uncured saturated liner and curing the sample in the same water and at the same time, the mainline pipe is cured. Additional tests may be required by the Engineer at no additional cost if any of the first specimens fail to meet the requirements of this specification. The Contractor shall send specimens to an independent laboratory for testing. Specimens shall be clearly marked to indicate the installed liner location, date of installation, pipe diameter, and resin used. Results of the test for each liner shall be submitted within 30 days after the liner is installed.

Installed CIPP lining that does not meet the specified strength and / or thickness requirements, regardless of the deviation from these specified requirements, shall be corrected by the Contractor in a manner approved by the Engineer. Options for correcting deficient CIPP liner installations that will be considered by the Engineer include removal of the existing CIPP liner and re-lining the pipe or complete replacement of the storm drainage pipe. Installation of a second lining shall not be considered.

1. **MEASUREMENT**

The quantity of Cured-in-Place Pipe Lining to be paid for will be the actual number of linear feet of pipe liner, which has been installed and accepted.  Measurement will be made horizontally along the centerline of the installed liner defined as the distance between the upstream and downstream structures using applicable structure inside walls as the beginning and ending point. Measurement from center of structure to center of structure will not be permitted. Measurement will not be made across precast bends or other drainage structures.

1. **PAYMENT**

The quantity of Cured-in-Place Pipe Lining, measured as provided above, will be paid for at the contract unit price per linear foot for "Cured-in-Place Pipe Lining." Such payment will be full compensation for all work covered by this special provision including but not limited to: engineering and design costs, permitting costs, submittals, pipe cleaning/preparation, CCTV inspections and reports, installation, materials, labor, equipment, odor control, bypass pumping, and materials testing and laboratory services.

 Payment will be made under:

**XX – Inch Cured-In-Place Pipe (CIPP) Lining LF**