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

Version Date: 5/31/2024 Revision Date: MM/DD/YYYY by XXX

1. **DESCRIPTION**

This work shall consist of the rehabilitation of existing storm water pipes and/or culverts using the Cured-in-Place Pipe (CIPP) lining process. The CIPP liner system shall be designed, fabricated, and installed in such a manner to provide a continuous tight fit to the internal circumference of the host pipe for its entire length. The installation shall adhere to the cure times and temperatures stipulated in the manufacturer’s recommended installation and cure specifications. The finished product shall be free of de-lamination, bubbling, rippling, infiltration, or other signs of installation failure.

This specification covers materials, design, installation, acceptance, sampling/testing, submittals, and warranties. This specification also covers sectional repairs using CIPP.

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)).

Liner System:

* 1. The liner shall consist of one or more layers of absorbent non-woven felt fabric, felt/fiberglass, felt/carbon fiber, carbon fiber or fiberglass and meet the material requirements of ASTM F1216, ASTM 1743, or ASTMF2019 and ASTMD5813 as applicable.
	2. The liner shall be capable of absorbing and carrying resins, constructed to withstand installation pressures, and curing temperatures and have sufficient strength to bridge missing pipe segments and stretch to fit irregular pipe sections.
	3. The resin shall be a corrosion resistant polyester or vinyl ester resin and catalyst system or epoxy resin and hardener system that, when properly cured within the liner, meets the requirements of ASTM F1216, ASTM1743 or ASTM F2019
	4. 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.
	5. The liner shall be marked for distance at regular intervals along its entire length, not to exceed 5 feet. Such markings shall include the name of the Manufacturer, lot/batch # and production footage.
	6. The outside and inside of the liner (before inversion) shall be coated or covered with an impermeable, flexible membrane that will contain the resin and prevent contamination of the interior of the cured liner.
	7. 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.
	8. The installed liner shall comply with the chemical resistance requirements of the relevant ASTM standard(s) F1216, or ASTM D5813 (Section 6.4.1), ASTM F1743 or ASTM F2019.
	9. The minimum length of liner shall be deemed as necessary by the contractor to effectively span the starting access point to the ending access point plus the amount required to run-in and run out for the installation process. Expansion/contraction of the cured product should also be considered.
	10. The existing pipe conditions shall be reflected in the design of the liner thickness. In particular, the ovality of the existing pipe shall be accurately assessed and reflected in the design calculations.
	11. The nominal liner wall thickness shall be constructed to a sufficient thickness that exceeds the required design thickness for that section of installed/cured CIPP.
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 48” in diameter.
	2. The Superintendent shall have successfully installed a minimum total of 75,000 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 a work plan that includes the following information, fifteen (15) days prior to beginning work on the site:

* 1. Engineering calculations specifying the design and required thickness for each segment of 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:

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| **Material Properties and Design Requirements** |
| Design Life | 50 years or greater |
| Pipe Condition | Fully Deteriorated |
| Pipe Diameter | As specified or indicated within Contract Documents |
| Depth of Cover | Highest ground elevation for each segment of pipe to be lined, measured from the crown of pipe to surface. |
| Ovality | 2% to be assumed unless otherwise specified within the contract documents. Ovality that exceeds 10% will require alternative design methods and calculations to be provided. |
| Groundwater Depth | Unless otherwise specified within the contract documents, assume groundwater table elevation to be at the greater of the crown of the pipe or ½ the distance between the lowest invert of pipe and highest ground elevation over the pipe. |
| Flexural Strength | 2250 PSI |
| Design Flex. Modulus | 300,000 PSI |
| Long Term Flex. Modulus | 150,000 PSI (no greater than 50% of design flexural modulus) |
| Soil Enhancement Factor | ≤7 |
| Poisson’s Ratio | .3 |
| Soil Modulus | < 1000 PSI |
| Soil Density | 120 PCF |
| Highway Live Loads | All pipes located shall be assumed to carry AASHTO HS20-44 live loads. Neglect after 8 ft of cover on single barrel culverts if span length is 8 ft or less. For multiple span culverts, the effects may be neglected where the depth of fill exceeds the distance between inside faces of endwalls. See AASHTO LRFD Bridge Design Specifications for additional information. |
| Safety Factor | ≥2 |

* 1. A CIPP lining production schedule with location manufactured, lengths, and sizes.
	2. 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.
	3. Installation Plan – Includes manufactures specifications/requirements for 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. Installation plan shall also describe sequencing and methods of cleaning, inspection, point repairs, etc. Access points, staging areas, water source (if applicable) shall also be identified.
	4. Health and Safety Plan, including confined space safety plan.
	5. 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.
	6. Baseflow Maintenance Plan - includes but is not limited to pump and pipe sizing, capacity (includes calculations), power requirements and setup locations.

* 1. 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.
	2. Disposal Plan – Indicates how by-products and waste are to be contained, captured and transported and disposed of in accordance with project permits and local, state and federal regulations. It shall be the contractor’s responsibility to report and take appropriate corrective actions to remediate any water quality concern.
	3. 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.
	4. Traffic Control Plan - Comply with the most current Work Area Traffic Control Handbook (WATCH).
	5. Contingency plan for equipment malfunctions or equipment that becomes immovable.
	6. 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.
1. **CONSTRUCTION METHODS**

**Site Access**

Contractor to locate and designate all existing structure/manhole access points as necessary to complete pipe inspections, cleaning, and lining operations.

**Pre-Installation Inspection and Assessment**

Contractor shall field verify the pipe lengths to ensure that the liner will have sufficient length to extend the entire length of the run. Contractor shall also field verify the inside diameter and ovality of the existing pipes. The contractor shall immediately notify the City of any discrepancies between the field conditions and contract documents.

**Pre-Installation Inspection**

The Contractor shall perform a pre installation inspection of all storm drainage pipes and culverts identified within the contract documents for rehabilitation. This inspection, performed by the Contractor shall use closed circuit television (CCTV) and/or confined spaced entry (CSE) to perform an internal inspection of the existing infrastructure verifying the infrastructure is clean and in suitable condition to host CIPP. Any service connections or taps that protrude into the mainline will require trimming flush with the host pipe to facilitate installation and curing of the liner. Any observed active infiltration shall be assessed by the contractor. 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 recommend measures as required to address infiltration. Defects, if observed shall be assessed for severity. The Contractor shall notify the City of any additional adverse issues that would compromise the installation of the CIPP. An inspection report will be provided to the City at their request. The City shall be notified of any observances that may compromise the installation of the CIPP. Where cleaning and/or repairs are warranted, a reinspection of the asset will be required to verify that the pipe is properly prepared for lining.

**Pre-Installation Cleaning**

The Contractor shall clear the existing pipe designated for rehabilitation of any debris, sediment, protrusions greater than ½ inch in height, and any other potential obstructions prior to the start of rehabilitation efforts. The Contractor shall then thoroughly clean and prepare the host pipe prior to the liner installation. Cleaning shall conform to the recommendations of the liner manufacturer, and any additional requirements of this special provision. In the absence of manufacturer recommendations, the Contractor shall submit his/her proposed method for cleaning and preparing the host pipe for the Engineer’s review and acceptance at least 15 working days prior to beginning the work at that location.

**Point Repairs and Grouting**

The Contractor shall complete all point repairs and grouting work described in the contract documents, prior to pipe liner installation to correct existing deficiencies, such as severe offsets, collapses, voids, etc. The contractor shall notify the City of any additional repairs are identified through the pre-installation inspection or cleaning. Repairs will be measured and paid for by their respective line items.

**Inlet & Outlet Sealing** – All pipe liner installations shall provide a watertight seal between the liner and host pipe at the terminal ends of the liner to prevent flow between the liner and host pipe. In the absence of manufacturer recommendations, the Contractor shall submit his/her proposed method for sealing the host pipe for the Engineer’s review and acceptance at least 15 working days prior to beginning the work at that location.

**CIPP Installation**

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.

The Installation shall be completed per specification or standard practice for installation (ASTM F1216 inverted CIPP, or F1743 pulled in-place CIPP, or F2019 pulled-in-place GRP CIPP, or F2599 sectional inverted CIPP). The installation shall adhere to the cure times and temperatures stipulated in the manufacturer’s recommended installation and cure specifications and the finished product shall be free of de-lamination, bubbling, rippling or other signs of installation failure.

All Cured-In-Place Pipe installations shall be performed in the dry. The bypass pump(s) shall be setup and ready for immediate operation. Pumps shall be automatically controlled. A responsible operator shall always be on site 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 completely cured and cleaned.

Curing for styrene-based, epoxy-based, and vinyl ester-based CIPP may be accomplished by water, steam, or ultraviolet light and shall be completed according to the liner manufacturer's instructions.

The Contractor shall place an impermeable barrier immediately upstream and downstream of the host pipe, prior to liner insertion, to capture any possible raw resin spillage during installation and shall dispose of any materials in accordance with the submitted disposal plan.

The Contractor shall ensure there is no loss of impermeability of the inner and outer plastic films or pre-liner during installation. The Contractor shall promptly repair any pinholes or tears in the plastic films or pre-liner before proceeding with the installation. Where such damaged areas cannot be repaired, the Contractor shall promptly replace the impermeable plastic films or pre-liner before proceeding with the installation.

The Contractor shall monitor pressure during inversion and curing and maintain pressure between minimum and maximum allowable pressures as provided by the manufacturer.

The Contractor shall automatically log cure time, temperature, and pressure data at 30 second intervals with a data logger and provide such information in a format acceptable to the Engineer. For every segment of CIPP installed, The Contractor shall monitor temperature via thermocouples on the outer surface of the liner and automatically log cure time-temperature data with a print-out from the data logger and provide such information to the City at the conclusion of the lining activities.

During and after installation the Contractor shall promptly remove and properly dispose of any waste materials.

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.

The Contractor shall thoroughly rinse the cured lined pipe with clean water prior to re-introducing flow. The Contractor shall capture all cure water and/or steam condensate and rinse water and dispose of, in accordance with the submitted disposal plan.

Where present, Contractor shall reopen all existing lateral connections in each length of pipe following liner installation. Lateral connections shall be determined from the pre-installation inspection. The lateral connections shall be reopened from inside the pipe by means of a cutting device appropriate for the liner material and 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.

**Post-Installation Inspection and Testing Requirements**

The contractor shall inspect via CCTV all new CIPP liners within 3 weeks of installation. Inspection of pipes shall be performed by PACP certified, experienced personnel, trained in locating breaks, obstacles, and service connections using CCTV inspection techniques. 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.

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 and name the manholes, structures, and pipes in the PACP compliant database and any other locations where the assets are referenced by an ID.

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 City’s satisfaction shall be re-inspected at no additional cost to the City.

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 inspect the full length of all assigned pipes from structure to structure begin at the center of the structure, shall clearly showing the 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, centered vertically and horizontally within the pipe shall move through the pipe at a uniform rate but shall not exceed more than 30 feet per minute. Unless otherwise specified by the City, operator will stop at a minimum of every 10 LF and pan to fully view the pipe wall(s). 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.

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.

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.

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.

CIPP may be rejected for the following:

* Actual temperature and curing time and schedule do not comply with those shown in the contractor provided site plan and/or manufactures minimum requirements.
* Pressure deviates more than 1 psi from the required pressure.
* At any time during installation the manufactures required minimum cool-down time or maximum cool-down rate is exceeded.
* There are defects including:
	+ Concentrated ridges, including folds and wrinkles exceeding 8% of the overall pipe diameter.
	+ Dry Spots
	+ Lifts
	+ Holes/Tears
	+ Soft Spots
	+ Blisters or bubbles
	+ Infiltration
	+ Delamination
	+ Gaps within the CIPP liner (not a continuous liner)
	+ Gaps, voids and/or annular space between the cured CIPP and the host pipe.
* Test results indicate one of the following:
	+ If heat cured, 2 of the 3 flat plate samples do not have any of the following:
		- The specified modulus of elasticity
		- The specified flexural strength
		- Either the specified modulus of elasticity or the specified flexural strength
	+ If UV cured, 2 of the 3 cured samples do not have any of the following:
		- The specified modulus of elasticity
		- The specified flexural strength
		- Either the specified modulus of elasticity or the specified flexural strength
* The liner thickness is less than the greater of either one of the following:
	+ Specified thickness
	+ Calculated minimum thickness shown in the work plan.
* Materials and Installation methods are not consistent with the work plan.

Defective lining shall be corrected by the Contractor in a manner approved by the City and at no additional cost to the City. Options for correcting deficient CIPP liner installations that will be considered by the City include removal of the existing CIPP liner and re-lining the pipe or complete replacement of the storm drainage pipe. Installation of a second liner within the existing liner 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**