# UV and Thermal Cured CIPP Specification

## Reline America Inc.

The enclosed specification serves as a guide to both contractors and municipalities looking to spec in Reline America Inc. and the Blue-Tek™ CIPP product. The specification enclosed includes products that are both UV and thermally cured CIPP.

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**Ultraviolet Cured/Thermal Cured CIPP Specification**

## 1. Introduction

This document specifies a Cured In Place Pipe (CIPP) liner for the rehabilitation of sanitary sewer and storm water pipes. CIPP is a flexible tube made of either fiberglass or felt that is impregnated with thermosetting resin. The soft tube is placed inside a deteriorated host pipe either by inversion or insertion and then cured. The finished product is continuous and tight fitting to the host pipe. This specification is open to both fiberglass-based CIPP products that are cured with an ultraviolet (UV) light and felt-based CIPP that are cured with hot water. This specification defines minimum performance requirements and acceptable materials.

## 2. General Description

The method of rehabilitation shall be Cured In Place Pipe (CIPP) as described herein for the line (or lines) listed in the bid document. This method includes cleaning and video inspection of the designated line, identification of existing live taps, removal of protruding taps by remote methods, point repairs, installation of designated liner, curing of designated liner, reopening service taps into the line, testing, and cleanup. Final acceptance of each line segment is contingent on the approval of a post-rehabilitation video inspection as well as CIPP liner physical testing. Rehabilitation must be completed for the full length from manhole to manhole, resulting in a sound, watertight liner with a smooth interior surface.

The Contractor or Subcontractor shall not change any material, design values, or procedural matters stated or approved herein without informing the Owner and Manufacturer. Before any changes are made, express written approval from the Owner and Manufacturer must be received. Changes without express written consent constitute a breach of contract and shall result in rejection or removal of work done with the unapproved materials or processes at no cost to the Owner or Manufacturer.

Removal and replacement of fences, damage repair to yards, lawns, sidewalks, driveways, and other public or private property due to actions or processes related to the work being performed shall be included in the cost of the project.

Confined space entry, and work site protection shall be the responsibility of the Contractor and costs of these items are incidental to the project. The Contractor shall notify Police, Fire, and Ambulance agencies in advance of any and all road closures. The Contractor must comply with applicable OSHA trench safety rules.

### a. Weather Conditions

Contractor shall review the weather forecast prior to commencement of liner installation. When the anticipated weather conditions are such that the resulting sewer flow may impact the capacity of the by-pass pumping system or otherwise adversely affect the liner installation the Engineer shall be informed and the installation shall be delayed until

favorable weather is forecast.

**b. Site Cleanliness**

Containment of sewage and site cleanliness is the sole responsibility of the Contractor. Fines levied by State and Federal agencies in the event of a spill or unapproved discharge shall be paid by the Contractor. Spill cleanup as well as site cleanup shall be conducted by and paid for by the Contractor. All cleanup and costs are part of acceptance of the project by the Owner. Without Owner acceptance, final payment will not be made.

**c. Reference Standards**

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

ii. ASTM F1216 Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

iii. 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). Enclosed ASTM F1417 testing should be replaced by APS Water Porosity testing.

iv. ASTM D3567 Standard Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

v. ASTM D2990 Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics

vi. DIN EN 761 Plastics piping systems - Glass-reinforced thermosetting plastics (GRP) pipes- Determination of the creep factor under dry conditions

vii. APS Water Porosity Standard

In the case of conflicting requirements between this specification and these referenced documents, this specification will govern.

**d. Submittal/ Bid Information**

This project is bid on a “price per linear foot” basis. The distance stated on the bid is the Owner’s best estimate and shall be verified by the Contractor. The Owner will pay on the bid cost per linear foot based on the Contractor’s verified distance.

The Contractor shall list the following information on the Bid Form:

| Submittal Item |
|---|
| 1. Wall thickness of each segment of host pipe to be lined (Calculations are to be in accordance with ASTM F1216 Appendix X1, Fully Deteriorated pipe condition only). |
| 2. Cost of liner per linear foot with extended total. |
| 3. Cost of service tap re-openings with extended total. |
| 4. Shop drawings that indicate location of installation and liner dimensions. |
| 5. Bypass pumping plans to ensure that installation can be completed without a sewage spill. |
| 6. Emergency response plan in the event of bypass failure. |
| 7. Manufacturer's recommendations for storage procedures. |
| 8. Manufacturer's recommended maximum pulling force. |
| 9. Certification proving the Contractor is currently licensed by the appropriate UV CIPP liner Manufacturer to perform UV CIPP installation. |
| 10. A certified affidavit, signed by an officer of the company, shall be provided stating that the on-site construction Field Superintendent has received proper training by the Manufacturer for UV CIPP liner installation methods and procedures. |
| 11. The type of resin to be used. |
| 12. Third party or manufacturer's laboratory test results of ASTM F1216 Appendix X2 testing. |
| 13. Third party or manufacturer's laboratory test results of ASTM F2019 Table 1 CIPP Initial Structural Properties. |
| 14. Third party or manufacturer's test results of a long-term reduction factor. |
| 15. DEQ certification/permitting status of Manufacturer's wet-out facility. |
| 16. Third party or manufacturer's test data on seam strength (thermal cured products only). |

NOTICE: FAILURE TO PROVIDE THE PRECEEDING INFORMATION SHALL RENDER THE BID NON-RESPONSIVE AND THE BID WILL NOT BE CONSIDERED.

## 3. Product Qualifications

### a. General Product Qualifications

Since sewer products are intended to have a 50 year design life, and in order to minimize the Owner's potential risk, only proven products with substantial successful long term track records will be allowed. At a minimum, Products and Contractors must meet all of the following criteria to be deemed commercially acceptable:

1. For an installing Contractor to be considered commercially proven, the Contractor must satisfy all insurance, financial, and bonding requirements of the Owner. The Contractor must have a certification from the Manufacturer as a licensed installer of the Product and must include the certification with the bid.

2. Products must provide 3rd party or manufacturer's test results supporting the long-term performance and structural strength of the product. Testing will be in accordance with ASTM D2990 or DIN EN 761. No product will be allowed without independent 3rd party or manufacturer's testing verification.

### b. Resins

#### *1. Acceptable Resins*

**i. Polyester NPG**

**ii. Vinylester**

### c. Resin Definition and Physical Characteristics

The liquid thermosetting resin used in this rehabilitation project shall produce a properly cured tube, which will be resistant to abrasion caused by solids, grit, and/or sand. The CIPP system shall utilize thermosetting resins, which will withstand the corrosive effect of the existing residential commercial and industrial effluents, liquids, and or gases common to sewers.

The resin system to be used shall be manufactured by an approved company selected by the CIPP liner Manufacturer. Documentation of approved status is a pre-contract requirement. Only corrosion resistant polyester NPG or vinylester resins complying with the following definitions shall be used.

The chemical corrosion resistance of the actual resin system used by the Contractor shall be tested by the Resin Manufacturer in accordance with ASTM F1216 Appendix X1 Design Considerations.

### d. CIPP Liner Tube Qualifications

#### *1. Acceptable Materials*

**i. Fiberglass cured via ultraviolet light**

**ii. Felt cured with hot water**

### e. Tube Characteristics and Standards

At the time of manufacture, each lot of fiberglass or felt tube liner shall be visually inspected for defects. At the time of delivery, the liner shall be homogeneous throughout, uniform in color, free of cracks, holes, foreign materials, blisters, and deleterious faults.

For testing purposes, a production lot shall consist of all liner having the same marking number.

An innerfilm and outerfilm must be used for resin control (to prevent resin migration and contamination). The innerfilm and outerfilm must both be certified styrene gas barriers. The innerfilm must be removed during the installation process unless it is a permanent part of the liner system and is made an integral part of the carrier tube by bonding or fusing to the carrier tube.

The material shall be manufactured in such a manner as to result in a tight-fitting, continuous liner after installation. There shall be no measurable annular space. The ends shall be cut off and sealed with a system approved by the owner.

All wet-out or impregnation of the Tube must be done in an EPA-regulated, quality-controlled facility. No "over the hole" or "on-site" wet-out is allowed unless properly permitted.

***1. Fiberglass Tube (Ultraviolet Light Curing Application)***

The fiberglass tubing shall be seamless and spirally wound, including an innerfilm and outerfilm that protects and contains the resin used in the liner. The outerfilm will also serve as an ultraviolet blocking material.

a. The Tube shall consist of a seamless, spirally wound fiberglass that is flexible and has strain values (expandable) of up to ten (10) percent. The tube will not have a longitudinal seam, including a stitched seam, stitch-free-weld or bond, or stitch-free overlap. The tube shall be constructed to withstand installation pressures and have sufficient strength to bridge missing pipe.

b. The impregnated Tube shall have a thickness that when compressed at installation pressures and cured will meet or exceed the Design thickness in accordance with ASTM F2019.

c. The Tube shall be sized such that when installed, it will tightly fit the internal circumference and length of the original pipe.

d. The fiberglass Tube shall be saturated with the appropriate resin using a resin bath to allow for the lowest possible amount of air entrapment. The liner will then be formed into a spirally wound shape for the purpose of being seamless in its cured state. An innerfilm and outerfilm material will be added that are both impervious to airborne styrene, with the outerfilm also having UV blocking characteristics. The inner membrane will be removed after the installation and curing processes are completed.

e. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color so that a clear, detailed examination with closed circuit television (CCTV) inspection equipment can be made.

f. Fiberglass materials must be "direct sized" to enhance the fiberglass/resin bond. Certification of this coating and its compatibility with the resin system used is required.

g. The Tube shall be constructed to withstand installation pressures and have sufficient strength to bridge missing pipe.

***2. Felt Tube (Hot Water Curing Application)***

The Tube shall consist of one or more layers of absorbent felt fabric and meet the requirements of ASTM F1216 or ASTM F1743, Section 5.

a. For work performed under this specification, the following felt-based carrier tube materials may be used: Non-woven polyester felt and Non-woven fiberglass filament reinforced polyester felt.

b. The tube shall be constructed to withstand installation pressures and have sufficient strength to bridge missing pipe.

c. The Tube shall be sized such that when installed will tightly fit the internal circumference and length of the original pipe. Overlapped layers of felt in longitudinal seams that cause lumps in the final product shall not be utilized.

d. The Tube shall be homogeneous across the entire wall thickness containing no intermediate or encapsulated elastomeric layers. No material shall be included in the Tube that may cause delamination in the CIPP. No dry or unsaturated layers shall be evident.

e. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color so that a clear detailed examination with closed circuit television (CCTV) inspection equipment may be made.

f. Seams in the felt Tube shall be allowed, because non-seamed felt tubes are not currently available, but the seams must be leak free and stronger than the non-seamed felt. 3rd party test data documenting the strength of the seam is required for approval by the Owner.

**4. Design Parameters**

The newly installed liner shall be designed for a minimum fifty-year service life under continuous loading conditions. The design shall assume no bonding to the original pipe wall. The liner shall be designed to withstand all imposed loads. Design of the CIPP system should be based on a fully deteriorated host pipe condition as defined in ASTM

F1216.

Wall thickness design calculations for each pipe to be rehabilitated via the CIPP method must be submitted with all qualified bids. Calculations shall be based on ASTM F1216 Appendix X1 with a fully deteriorated host pipe condition. Felt based CIPP products shall conform to Table X1.1. Product specific strength values including short-term flexural modulus and long-term flexural modulus must be substantiated by 3rd party testing to be submitted with all qualified bids.

The CIPP system shall conform to the minimum structural standards provided in ASTM F2019 Table 1. The liner must also pass the APS Water Porosity Test.

The minimum allowable wall thickness for Fiberglass CIPP products is 2.8 mm and can be increased as necessary to meet the ASTM F1216 Design Formula. The minimum allowable wall thickness for Felt CIPP products is 6.0 mm and can be increased as necessary to meet the ASTM F1216 Design Formula. Fiberglass or Felt products below the stated minimum wall thickness will not be allowed under any circumstances.

The CIPP liner shall be manufactured to a diameter, that when installed will fit the internal diameter of the host pipe as specified by the Owner. Allowance for expansion in the radial direction shall only be made per the Manufacturer's standards and recommendations.

## 5. Installation

Installation of the impregnated liner may be via inversion or insertion as specified by the Manufacturer. All equipment, labor, materials, and processes required to complete the work must be ready on-site before installation begins.

The first segment shall be lined, completed and accepted by the Owner. It will become the "job standard" against which all-subsequent work is judged.

The Engineer shall be notified prior to installation. All liner is subject to inspection by the Manufacturer or Engineer before installation.

### a. Site Set-up

The installation area/equipment shall be securely protected and all damaged yards, driveways, walks, etc., shall be repaired at no cost to the Owner. Plastic sheeting will be used to cover the work area around the manholes and/or access points to eliminate the opportunity of environmental contamination to the aboveground setting during the installation process.

### b. Pre-Installation

Prior to installation of the liner, the following activities are required:

1. Receipt and approval of pre-installation submittals.
2. Notifications

a. The Contractor has the sole responsibility of notifying the public of the work to be done. Each home or business connected to the sewer must be informed via written notice a day prior (24 hours) to work being commenced. The contractor must also leave contact information so the public may call with questions or concerns about the project.
b. The Contractor must perform an inspection of the work area prior to the arrival of his equipment. Existing damage to sidewalks, driveways, and other structures must be documented. The Contractor shall take identifiable pictures of all defects in the vicinity of the jobsite before the commencement of work. The use of a video camera to record all conditions is recommended. The Contractor is shall be thorough with his installation site documentation as authenticity of claims by area residents will be based on this information.
c. The condition of area plant life shall be documented by the Contractor.
d. Photographs of the pre-existing installation site conditions will be made available by the Contractor to the Owner upon request.
e. The Contractor must coordinate operations with other utilities (i.e. telephone services, gas mains, etc…) that may be affected by installation of CIPP.

3. The Contractor must clean the host pipe to remove existing debris. The Contractor shall use a hydraulically propelled, high velocity jet or mechanically powered equipment. The equipment must be capable of removing dirt, grease, rocks, sand, and other obstructions from the host pipe. Any debris disposal and associated costs are the sole responsibility of the Contractor. The Owner must approve methods and cleaning equipment used.
4. The Contractor must inspect the host pipe condition via closed circuit television (CCTV) prior to CIPP installation. Personnel conducting CCTV inspection shall be experienced in operation of CCTV as well as analyzing host pipe condition. The host pipe should be inspected to determine if there are any structural failures. If structural failures are present the location from the center of the upstream manhole should be recorded so point repairs can be made. The Contractor must report any structural failures to the Engineer, Owner, and Manufacturer. The report must include the location from the center of the upstream manhole and the nature of failure. The Contractor must record in color all pre-installation inspections on DVD. The DVD disk should also contain the following information:
    a. Date/time
    b. Depth of flow
    c. Manhole to manhole identification numbers
    d. Locations of service connections and branch sewers. The distance should be determined from the centerline of the upstream manhole.
    e. Locations of any obstructions, structural defects, joint deterioration, leakage, and other host pipe abnormalities. The distance should be determined from the centerline of the upstream manhole.

    The Contractor shall present on color DVD a continuous image of no less than ninety percent (90%) of internal pipe circumference throughout the video. The maximum speed of the camera traveling through the host pipe is forty-five feet per min (45fpm).

5. Construct and complete any and all point repairs deemed necessary by the Engineer, Owner, and Manufacturer.
6. The Contractor shall not line over any offsets that are greater than 5% of the pipe diameter without first notifying the Engineer and Manufacturer.
7. Pipe Flow
    a. The Contractor will be responsible for establishing flow control, where required, in advance of all installations and pre and post CCTV inspections. Depending on the flow, there are two options the Contractor can use to control flow:
        i. Sewer plugs: If the sewer flow is low, plugs will be inserted into the upstream and downstream manholes to prevent flow. The plugs shall be removed once installation and inspections are complete.
        ii. Bypass Pumping: If the sewer flow is high, a bypass pumping system shall be used and operated in accordance with NASSCO Specifications. The bypass pumping system capacity must be sized to meet all potential flows. The Contractor will be held solely responsible for any damage caused by flooding and will take care to avoid this occurrence. The system must be kept in service for each section until that section is completed and ready to return to service. The Contractor is responsible for all installation, operation, and maintenance of the system. Manpower, fuel, and necessary utilities required by the systems must be provided and paid for by the Contractor. Stand by pumping must be available and achieved by backing up pumps size for size. This will allow for one hundred percent (100%) back up capacity in case of emergency situations or equipment malfunction.

**c. Slip Sheet/Outerfilm**

At all locations where the CIPP liner is inverted or inserted into the host pipe, an outerfilm shall be used to control resin loss, liner thickness, contamination of the resin by water or other contaminants, and prevent blocked or plugged services and laterals. The outerfilm shall be a tube sized to the host pipe and constructed such that it is continuous from manhole to manhole. The outerfilm shall be made of a styrene barrier material which is approved by the Owner or Engineer. Failure to install the required outerfilm or installation of the outerfilm over only part of the segment shall result in the completed CIPP for that segment being rejected (regardless of physical tests and thickness test results). During ASTM D3567 testing, the outerfilm shall be removed from the thickness test core sample along with the removable innerfilm. If there is any damage to the outerfilm prior to installation, it should be repaired immediately with styrene-proof tape.

**d. Tube Insertion (UV Cured Fiberglass Products)**

1. A slip sheet shall be installed on the bottom half of the pipe prior to liner insertion, for the purpose of smoothing out the bottom of the liner, bridging any missing areas of the host pipe, and optimizing flow characteristics.

2. The outerfilm must be inserted into the pipe prior to inserting the liner, unless it is manufactured on the exterior of the liner, which is a normal characteristic of most Fiberglass CIPP liners.
3. A constant tension winch should be used to pull the fiberglass liner into position in the pipe. The winch must have the capability of documenting the amount of tension used to pull the liner into the pipe. The Manufacturer's maximum pull in tension shall not be exceeded.
4. Once inserted, end plugs shall be used to cap each end of the fiberglass liner to prepare for pressurizing the liner. The end plugs should be secured with straps to prevent them from being expelled due to pressure. Liner restraints should be used in manholes.
5. The fiberglass liner shall be cured with UV light sources at a constant inner pressure as specified by the Manufacturer.
6. The UV light sources should be assembled according to the Manufacturer's specifications for the liner diameter. For the liner to achieve the required water tightness and specified mechanical properties, certain parameters must be controlled during the entire curing process. The Engineer is given a record of the curing parameters over every segment of the entire length of the liner. This will be accomplished using a computer and database that are tamper proof. During the curing process, infrared (IR) sensors will be used to record curing data that will be submitted to the Engineer with a post CCTV inspection on DVD. The parameters for curing speed, inner air pressure, and UV bulb wattage are defined in the quality protocol issued by the Manufacturer. The optimal curing speed, or travel speed of the energized UV light sources, is determined for each length of liner based on liner diameter and liner thickness as specified by the Manufacturer. This demonstrates that the entire liner is cured properly. Controlled parameters defined by the Manufacturer's quality protocol are the following:

    a. Curing speed
    b. Light source working & wattage
    c. Inner air pressure
    d. Exothermic (curing) temperatures
    e. Date and time
    f. Length of liner

7. The inner film material should be removed and discarded after curing to provide optimal quality of the final product.
8. Flushing of the cured fiberglass/UV cured CIPP liner (to reduce styrene residual) is not required for fiberglass/UV cured CIPP products that provide 3rd party test results that document styrene residual levels (without flushing) are within acceptable defined levels.

**e. Tube Insertion/Inversion (Hot Water Cured Felt Products)**

1. A slip sheet shall be installed on the bottom half of the pipe prior to liner insertion, for the purpose of smoothing out the bottom of the liner to increase flow characteristics.

2. The outerfilm must be inserted into the pipe prior to inserting the liner.
3. The resin impregnated tube shall be transported and stored in a refrigerated truck until it is installed in an existing line by using a water, air, or cable and winch to properly place the tube between the upstream and downstream manholes.
4. The wet-out felt tube shall be inserted, or inverted, through an existing manhole or other approved access. Liner installation head pressures as provided by the Manufacturer (minimum and maximum for hot and cold conditions) shall not be exceeded, regardless of which method of installation (stand pipe, pressure unit, etc.) is used.
5. Using the "Inversion Procedure" provided by the Manufacturer, the tube end shall initially be turned inside out and attached to a platform ring, standpipe, or other device as approved by the Owner and Manufacturer. The addition of water will be adjusted to sufficient height/pressure to cause the impregnated tube to invert from manhole to manhole, and hold the tube tight against the existing pipe wall.
6. End plugs shall be used to cap each end of the felt liner. The end plugs should be secured with straps to prevent them from being expelled due to pressure. Liner restraints should be used in manholes.
7. After the installation of the liner is completed, the Contractor shall use hot water system capable of providing the required amount of heat uniformly throughout the section for a complete cure of the resin. Steam cure will not be permitted. Boiler-truck operators must be fully certified by an approved certifying agency approved by the Engineer. Certification documentation of at least two (2) certified boiler-truck operators is a pre-contract requirement. Only fully-certified boiler-truck operators are permitted to operate the boiler trucks.
8. All water obtained from a City fire hydrant shall be metered and paid for by the Contractor. The cost of water shall be included in the bid cost of the felt liner. An air gap shall be provided between pipes/hoses connected to a fire hydrant and a storage tank/equipment used by the Contractor.
9. The curing temperature and schedule shall be as recommended by the resin/catalyst system Manufacturer. The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing heat supply. Additionally, the Contractor is required to utilize a remote temperature sensing method to ensure adequate curing for every foot of liner in the pipe. Temperatures monitored at the manholes do not guarantee an adequate representation of the temperatures for every foot of liner. Temperatures from each remote sensing device shall be recorded by a strip-chart recorder on a continuous tape. Graphs of the tape shall reflect readings from start of cure to completion of cure/draining of line. Tapes for each segment shall be submitted upon completion of each section. Initial cure may be considered completed when the remote sensing device(s) reflect that the cure temperatures, as recommended by the resin/catalyst system Manufacturer have been achieved. Curing temperatures and schedule shall comply with submitted data and shall include an adequate "cool down" as recommended by the resin Manufacturer.
10. Manhole samples shall be obtained for testing per section 6. The samples must be restrained by a device that has the same inside diameter as the host pipe. This will allow the sample to be a closer representation to the liner within the host pipe.
11. Since styrene is considered a volatile organic compound (VOC) and a carcinogen,

care must be taken to insure that styrene levels are below U.S.E.P.A. standards for airborne, surface, and water contamination. The EPA has set the maximum contaminant level at 0.1 ppm for drinking water and other water sources that impact drinking water. For sanitary sewer flow to a sewage treatment plant, styrene contamination must be kept below 2.1 ppm so as to not interfere with the effectiveness of the plant.

12. Effluent from the curing process must be disposed of directly to a Publicly Owned Treatment Works (POTW) in full compliance with the POTW's Industrial Pretreatment Program requirements. The POTW must provide written documentation that the effluent content complies with their Industrial Pretreatment Program requirements, a copy of which must be submitted to the Engineer for each rehabilitated pipe line, or for each day of lining work.
13. If EPA or wastewater treatment levels are exceeded on the surface of the liner for storm water or sanitary sewer pipes (respectively), the Contractor must flush the line until styrene levels in flush-water are brought within the appropriate standard. The responsibility for disposal of contaminated water is the sole responsibility of the Contractor, and must be delivered to POTW in full compliance with the POTW's Industrial Pretreatment Program requirements. POTW must provide written documentation that the effluent content complies with their Industrial Pretreatment Program requirements. Proof of proper disposal, as specified above, must be presented to the Engineer.

### f. Post Installation

Any defects which will affect the integrity or strength of the liner pipe or hydraulic capacity shall be repaired at the Contractor's expense, in a manner mutually agreed upon by the Contractor and the Owner.

1. Service Reconnection: After the cured-in-place process is completed, the Contractor shall reconnect the existing line service connections. The Contractor shall certify that a minimum of one (1) complete working cutter unit is on-site prior to insertion of the liner with the ability to obtain a backup unit. These services shall be reconnected by internal remote cutting method or external excavation. Service taps or branches reconnected internally shall be fully reopened to 95% service line size (minimum) and trimmed to a neat, clean, circular opening concentric with the service line pipe, free of jagged edges, "sawteeth", resin plugs or resin shelves. This work may be performed by either the Contractor or an Owner approved Sub-Contractor. No additional payment shall be made for excavations for the purpose of reopening connections unless previously approved by the Engineer.
2. Sealing at Manholes: The CIPP shall make a tight seal at the manhole opening with no annular gaps. Under all circumstances, the liner shall be sealed to the manhole and host pipe if no flair is present.
3. Finished Pipe: The CIPP shall be continuous over the entire length of each section lined, and be free from visual defects such as foreign inclusions, dry spots, pinholes, leaks, and delamination.

4. Hazardous Waste Disposal: All water or condensate needs to be disposed of in acceptance with all Federal, State and local regulations as approved by the Engineer or Owner and shall not be allowed to continue in sewage system.
5. Post Installation CCTV:
    a. The post-installation CCTV will be submitted to the Engineer in sufficient time to allow the Engineer to review before giving final approval.
    b. Any defects discovered during post-installation CCTV will be repaired and paid for by the Contractor. Once the repairs have been made the liner will be recorded CCTV and a DVD will be sent to the Engineer for final approval.
    c. The post installation television inspection payment shall be included in the cost of installing the liner.

**6. Requirements and Testing**

The layers of the cured CIPP shall be uniformly bonded. It shall not be possible to separate any two layers with a probe so that the layers separate cleanly. If separation of the layers occurs during testing of field samples, new samples will be cut from the manhole samples. Any reoccurrence may cause rejection of the work.

The Owner will pay for all initial testing described herein. The Contractor via a deductive line item on the pay estimate shall pay for retests of failed samples.

Regardless of the resin/carrier tube system used, the completed liner shall meet or exceed:

1. APS Porosity Standard (tight or non-porous result)
2. A minimum of 90% of wall thickness measured per ASTM D3567
3. ASTM F2019 Table 1 CIPP Initial Structural Properties

Values for the parameters above under the minimum values stated on the bid form are not acceptable. An under thickness liner may be brought into compliance at no additional cost to the Owner by:

1. Removal and replacement of the undersized liner, or
2. Addition of a second liner with the full wall thickness as stated on the liner design submittal (and after acceptable preparation of the undersized liner interior).

Option (2) will be considered by the Owner on a case by case basis considering the resulting loss of flow capacity, and can be refused by the Owner for that reason. The addition of a thin liner that makes up the amount of under sizing is not an acceptable remedy because the structural properties of CIPP liners are not additive if they are not cured simultaneously and therefore are bonded together to act as a single liner.

In the event of a liner failure of either/both the flexural strength and the modulus tests, another flat plate sample shall be tested. Should the second sample fail, the liner shall be brought into satisfactory compliance by the above methods.

### a. Samples

Samples will be submitted by the Contractor to the Engineer, including appropriate packing material and labeling, for shipment to an independent third party laboratory.

The cured sample shall be tested by an independent testing laboratory or recommended by the Manufacturer and approved by the Engineer. Final payment will not be made until acceptable test results are received by the Engineer. The Contractor shall be responsible for any deviation from the specified physical properties. Failure to meet the specified physical properties will result in the liner being considered defective work. The Contractor shall be responsible for all costs associated with repair of defective work.

Samples used for testing shall be individually labeled to record the following:

1. Contract number and title
2. Sample number
3. Date of installation
4. Location of installation
5. Contractor Name including person responsible for collecting samples
6. Upstream and downstream manhole numbers from where the sample was taken
7. Type of restraint used

1. Process 1

ASTM F1216 Section 8.1.1/ASTM F2019 Section 7.1.1 is the first option for liner sampling. It involves taking the sample from the manhole when the liner is installed. The best test specimens come from intermediate manholes because an unwrinkled, restrained sample can be removed for test. When there is no central manhole, it is critical that an unwrinkled sample is removed for test. It is critical that a restraint be used to hold the sample during the inflation and curing process. The use of the restraint will create a scenario for the sample section that mimics the pipe that is being cured. Once the sample area is cured, the restraint is removed and the sample section is cut from the end of the pipe with a Sawzall. The chain of custody is passed to a 3$^{rd}$ party laboratory. The samples are prepared by laboratory personnel and cut into specimens for ASTM testing. Once the 3rd party laboratory has completed testing and recorded results, they fax the results to both the Manufacturer and the installing Contractor.

2. Process 2

ASTM F1216 Section 8.1.2/ASTM F2019 Section 7.1.2 is the second method of sample preparation. It involves taking two (2) to four (4) feet of uncured liner directly from the manufacturing line for testing. The sample is cut from the end of the liner to be installed (i.e. same lot number). The sample is clearly marked with a permanent marker and the cutting and marking process is documented via a watermarked security camera. Pressure, bulb wattage, time to cure, and bulb distance from the sample need to be replicated to simulate field conditions. The sample is held under pressure during curing in a laboratory ultraviolet cure box using pressure as specified by the Manufacturer. The sample is cured at a distance to simulate the installed liner. The time to cure and wattage should simulate installation conditions as specified by the Manufacturer.

It is critical the sample preparation and testing be an accurate representation of liner that is installed in the field. Preparation and testing that is inconsistent with how test methods were designed should be approached with scrutiny. The Process 2 (ASTM F1216 Section 8.1.2/ASTM F2019 Section 7.1.2) is the preferred method for sample preparation and material testing for CIPP liner samples. The reasoning behind Process 2 as being superior is driven from the geometry of the samples to be tested. Process 1 (ASTM F1216 Section 8.1.1/ASTM F2019 Section 7.1.1) creates test specimens that are arched in nature. Process 2 creates test specimens that are flat. ASTM D790 and ASTM D638 testing standard is based on flat plate samples, which is consistent with the apparatus (i.e. Zwick or Instron) used to test the material specimens. Testing flat plate samples provides accurate results that are consistent with how the ASTM test methods were designed. Flat plate specimen testing also gives very repeatable test results which are critical during the determination of a material's acceptability. ASTM D3567 and APS Water Porosity Testing can be conducted with equivalent accuracy for both curved and flat plate samples. Process 2 is highly recommended in both the preparation and testing of all samples. This will provide the Owner with absolute certainty that specimen preparation and testing is being conducted accurately and consistently with the installed liner.

**b. Laboratory Testing**

Samples obtained by the Contractor for testing will be sent to a Manufacturer approved 3rd laboratory for testing. The Owner will pay for all testing. Testing shall include:

1. ASTM D3567
2. ASTM D790
3. APS Water Porosity Test

Final payment will not be made without approval by the Owner of test results. The Contractor will be responsible for any deviation from specified physical properties and laboratory testing results.

**c. Non-Conforming Work**

1. If the wall thickness of the installed CIPP is less than 90% of specified values, the product is considered unacceptable.
2. If the flexural strength, or flexural modulus of elasticity is less than the specified values the product is considered unacceptable.
3. For all instances where the CIPP is deemed unacceptable, the Contractor shall submit a method of repair or replacement for review and approval by the Owner.
4. All work required to remedy non-conforming work shall be at the sole cost of the Contractor.