

CIPP SPECIFICATION

Includes:
Quality Controls
Fiberglass/UV Cure CIPP
Felt/Thermal Cure CIPP

November 29, 2007

This document specifies a Cured-In-Place-Pipe (CIPP) liner for the rehabilitation of sanitary sewer and storm water pipes. This specification includes quality control measures that mandate a CIPP liner of consistent and high quality. The specification is open to both fiberglass-based CIPP products that are cured with ultra-violet light and felt-based CIPP products that are cured with hot water. It does not include steam-cured CIPP products due to the lack of reliable and established quality control procedures for steam-cured CIPP products. This specification is organized as follows:

- 1.0 General Description
- 2.0 Resins
- 3.0 Tube
- 4.0 Design Parameters
- 5.0 Installation
- 6.0 Requirements & Testing

1.00 General Description

The method of rehabilitation shall be Cured-In-Place-Pipe (CIPP) as described herein for the line (or lines) listed in this bid document. This method includes cleaning and videoinspection of the designated line, identification of existing live taps, removing of protruding taps by remote methods, performing point repairs, installation of a resin-impregnated tube into the existing pipe, followed by ultra-violet light or hot water curing as specified by the resin manufacturer, reopening service taps into the line, sampling and testing, and cleanup. Before final acceptance of each line segment, a post-rehabilitation video inspection and sample testing must be conducted and approved. Rehabilitation must be completed for the full length from the manhole to manhole, resulting in a sound, tight-fitting water-tight liner with a smooth interior surface.

The Contractor, or the sub-contractor, shall not change any material, design values or procedural matters stated or approved herein, without informing the Owner and receiving written approval of the change. Such changes constitute a breach of contract and shall result in rejection and removal of work done with the unapproved materials or processes at no cost to the Owner.

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.

Traffic control, 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 shall comply with applicable OSHA trench safety rules.

1.01 Experience Record of Contractors

The Contractor shall have successfully managed and completed CIPP rehabilitation projects on lines ranging in size from the smallest line on the project to the largest line on the project within the last three years previous to bid date. In the absence of this experience, a Manufacturer's representative will be on-site until the Owner states in writing that the Contractor has demonstrated sufficient capacity to continue on his own. Alternatively, the Owner may require that the Contractor install a Demonstration Project as defined by the Owner using the same system to be proposed/installed under this Specification prior to bidding on a particular project. Terms, conditions, and test results set forth in this Specification apply and shall be met by the Demonstration Project. Because of the uniqueness of individual systems, installers, and products, the Owner reserves the sole right to determine approval/disapproval of a system or product for any/all reasons based on a Demonstration Project. The testing shall be paid for by the Owner and conducted at a testing laboratory of the Owner's designation.

1.02 Reference Standards

ASTM C581 - Standard Practice for Determining Chemical Resistance of thermosetting resins used in glass fiber reinforced structures, intended for liquid service.

ASTM D543 - Test Method for resistance of plastics to chemical reagents.

ASTM D790 - Test Method(s) for flexural properties of un-reinforced and reinforced plastics and electrical insulating materials.

STM F1216 (including Appendix **XI**) - Standard practice for rehabilitation of existing pipelines and conduits by the inversion and curing of a resin-impregnated tube.

ASTM F1743-96 - Rehabilitation of existing pipelines and conduits by pulled-in-place installation of cured-in-place thermo-setting resin pipe (CIPP).

APS Standard - Water tightness standard for cured-in-place thermo-setting resin pipe/Porosity Test protocol.

1.03 Housekeeping

Containment of sewage and site cleanliness is the 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, without which final payment will not be made.

1.04 Bid Information

This project is bid on a "price per lineal foot" basis. The distance stated on the bid is the Owner's best estimate and shall be checked by the Contractor. The Owner will verify Contractor's measurement and payment will be based on the Bid cost per lineal foot based on the owner verified distance.

1.04 Bid Information (continued)

Contractor shall list the following information on the Bid Form in spaces provided:

- a. Thickness of each segment of pipe lined.
(Attach ASTM 1216 wall thickness formula calculations).
- b. Cost per foot with extended total.
- c. Cost of service tap re-openings with extended total.
- d. Trench safety cost per foot (with estimated quantity).

The Contractor shall attach the following to the Bid Form:

- a. Type of resin to be used.
(Attach _____ party test results for chemical corrosion resistance testing (Section 2.02).
(Attach statement that resin is approved to be used in the proposed CIPP system (Section 2.02).
- b. Initial (laminate design) modulus of elasticity used on the project (250,000 psi minimum). (Attach 3' party test results conducted in the last three (3) years.
- c. Initial (laminate design) flexural strength used on this project (4,500 psi minimum).
(Attach 3' party test results conducted in the last three (3) years.
- d. Long-term reduction factor.
(Attach 3' party test results conducted in the last three (3) years.
- e. Type of inner liner and outer liner to be used.
(Attach manufacturer's of 3' party certification for both the inner and outer liners stating styrene gas barrier status.
- f. DEQ certification/permitting status of the wet-out facility.
(Attach a copy of DEQ permit or other DEQ documentation if permit-exempt.
- g. Certificate of "direct sizing" - for fiberglass products only.
- h. _____ party test results stating the strength of the seam - for felt products only.
- i. Boiler Truck Operator Certification (OSHA) - for thermal cure products only.
- j. Distance from wet-out facility to job-site (300 mile maximum distance) - for thermal cure products only.

NOTICE: FAILURE TO DO SO SHALL RENDER THE BID NON-RESPONSIVE AND THE BID WILL NOT BE CONSIDERED.

2.00 Resins

2.01 Acceptable Resin Types

- a. Polyester npg.
- b. Orthothalic
- c. Vinylester

2.02 Resin Definitions 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 cured tube shall also be resistant to corrosion due to acids and gases such as sulfuric acid, carbonic acid, hydrogen sulfide, methane, and carbon monoxide. The cure-in-place pipe system shall utilize thermosetting resins which will withstand the corrosive effect of the existing residential commercial, and industrial effluents, liquids and/or gases.

The resin system to be used shall be manufactured by an approved company selected by the Cured-In-Place process manufacturer. Documentation of approved status is a precontract requirement. Only corrosion resistant polyester npg, orthothalic, and 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, D-543 or C-581 as applicable. Exposure to the chemical solutions listed below shall result in a loss of no more than twenty percent (20%) of the initial physical properties when tested in accordance with ASTM C-581-87.

Chemical Solution	Concentration (%)
Tap Water (pH 6-9)	100
Nitric Acid	5
Phosphoric Acid	10
Sulfuric Acid	10
Gasoline	100
Vegetable Oil	100
Detergent	0.1
Soap	0.1

3.00 Tube

3.01 Acceptable Materials

- a. Fiberglass (cured with ultra-violet light).
- b. Felt (cured with hot water).

3.02 Tube Characteristics & Standards

At the time of manufacture, each lot of glass fiber or felt tube liner shall be inspected for defects and tested in accordance with applicable ASTM standards. 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. It shall include any and all items produced during any given work shift and must be so identified as opposed to previous or ensuing production.

The ENGINEER may at any time direct the manufacturer to obtain compound samples and prepare test specimens in accordance with applicable ASTM standards.

An "inner liner" and "outer liner" film must be used for resin control (to prevent resin migration and contamination). The "inner film" and "outer film" must both be certified styrene gas barriers. The "inner liner" film must be removed during the installation process unless it is a permanent part of the 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 liner shall have a snug fit at manhole terminations as shall be evidenced by flares.

All wet-out or impregnation of the Tube must be done in an EPA-regulated, quality-controlled facility. Documentation of EPA permitting must be submitted with all qualified bids. No "over the hole" or "on-site" wet-out is allowed. For products that are cured with hot water, the wet-out must be conducted within 300 miles of the job site considering the time-sensitive characteristics of thermalcured products.

3.02.01 Fiberglass Tube (Ultraviolet Light Curing Application)

The glass fiber tubing shall be seamless and spirally wound, including an exterior and interior film that protects and contains the resin used in the liner. The exterior film will be provided with a UV light blocker foil.

1. Tube

- a. The Tube shall consist of a seamless, spirally wound glass fiber that is flexible and has strain values (expandable) of equal to eight (8) 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 uniform thickness, that when compressed at installation pressures, will meet or exceed the Design thickness. If voids are present in the pipe, the Design wall thickness must still be met or exceeded.
- c. The Tube shall be sized such that when installed, it will tightly fit the internal circumference and length of the original pipe.

3.02.01 Fiberglass Tube (Ultraviolet Light Curing Application (continued))

- d. The glass fiber Tube shall be saturated with the appropriate resin using a resin bath to allow for the lowest possible amount of air entrapment. Vacuum-suction impregnation methods are not allowed due to the introduction of air using this method. The liner will then be formed into a spirally wound shape for the purpose of being seamless in its cured state. An inner and outer material will be added that are both impervious to airborne styrene, with the outer material 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 inspection equipment may be made.
- f. The liner should be seamless in its cured state to insure homogenous physical properties around the circumference of the cured liner.
- g. The manufacturer will test the raw materials and liner materials at various stages of manufacturing on every liner, including taking samples of every finished liner and conducting tests for e-modulus, tensile, wall thickness and porosity.
- h. 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.
- i. The Tube shall be constructed to withstand installation pressures and have sufficient strength to bridge missing pipe while meeting or exceeding the Design wall thickness at ail pipe locations during installation conditions and pressures.

3.02.02 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.

1. Tube:

- 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 while meeting or exceeding the Design wall thickness at ail pipe locations during installation conditions and pressures.
- c. The Tube shall be sizes such that when installed will tightly fit the internai circumference and length of the original pipe. Overlapped layers of felt in longitudinal seams that cause 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 cured liner (CIPP). No dry or unsaturated layers shall be evident.

3.02.02 Felt Tube (Hot Water Curing Application (continued))

1. 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 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 stronger than the non-seamed felt. Third-party test data documenting the strength of the seam is required.
- g. The manufacturer will test the raw materials and liner materials at various stages of manufacturing on every liner, including taking samples of every finished liner and conducting tests for e-modulus, tensile, wall thickness and porosity.
- h. The outside of the Tube shall be marked for distance at regular intervals along its entire length, not to exceed 5 ft. Such markings shall include the Manufacturers name or identifying symbol.

4.00 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.

	Parameter	C.I.P.P. System
1 .	Pipe Condition	Fully deteriorated.
2 .	Soil Type	Saturated/unsaturated.
3 .	Design Thickness	Fiberglass: ASTM 1216 Design Formula, rounded up to nearest .7mm manufacturing increment. Felt: ASTM 1216 Design Formula plus 10% (in consideration of product stretch), rounded up to nearest 1.5mm manufacturing increment.
4 .	Ovality of Pipe	2% of circumference, unless measured and stated otherwise by Engineer in writing.
5 .	Soil Load	120 lbs/ft.'
6 .	Traffic Loads	Per AASHTO-HS-20-44 Highway Loading.
7 .	Modulus of Soil	500 psi.
8 .	Maximum Deflection	5%
9 .	Minimum Safety	2.0
1 0 .	Resin Migration	Not Allowed.
1 1 .	Soil Cover	Maximum distance in feet measured between the crown of the pipe and the highest point of soil cover over the length of the pipe.
1 2 .	Water Cover	Same as soil cover unless stated otherwise by the Engineer, in writing, for specific lines.

4.00 Design Parameters (continued)

Wall thickness design calculations for each pipe to be rehabilitated via the CIPP method must be submitted with all qualified bids, along with supporting formulas that document that version of formula used. Additionally, product-specific strength values, including the short term flexural modulus and the long term flexural modulus reduction factor, must be substantiated by third-party testing which will be submitted with all qualified bids. The materials utilized for the contracted project shall be of a quality equal to or better than the materials used in the long-term test with respect to the initial flexural modulus and long term reduction factor used in Design.

PHYSICAL PROPERTIES: The cured pipe shall conform to the minimum structural standards, as follows:

Tensile Stress ASTM D-638	3,000 psi
Flexural Stress ASTM D-790	4,500 psi
Modulus of Elasticity ASTM D-790	250,000 psi
Porosity/Water Tightness Test	Tight

4.01 Liner Thickness

The minimum allowable wall thickness for Fiberglass CIPP products is 2.8mm and can be increased as necessary to meet ASTM 1216 Design Formula in 0.7mm increments. The minimum allowable wall thickness for Felt CIPP products is 6.0mm and can be increased as necessary to meet ASTM 1216 Design Formula in 1.5mm increments. Fiberglass or Felt products below the stated minimum wall thickness (above) will not be allowed under any circumstances.

5.00 Installation

Installation of the impregnated liner may be by 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 to become the "job standard" against which all subsequent work is judged.

5.01 Pre-Installation

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

- a. Receipt and approval of pre-installation submittals.
- b. Verification of line condition and any obstructions by video inspection.
- c. Verification of existing taps in service by flowing water, dye test, or visually with a pan and tilt head camera or other means.
- d. Cleaning of line (recorded on video tape).
- e. Construct and complete any and all point repairs deemed necessary shall receive Owner approval before reworking the lines and the liner is installed.

Prior to installation, the diversion pumping system, including back-up pumps, shall be tested and running.

5.02 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 above-ground setting during the installation process.

5.03 Preliner/Outer Film/Outer Liner

At all locations where the CIPP liner is inserted or inserted into the host pipe, a preliner tube shall be used to control resin loss, liner thickness, a reduction in physical properties, contamination of the resin by water or other contaminants, and prevent blocked or plugged services and laterals. The preliner tube shall be reinforced plastic sheet formed into a tube sized to fit the host pipe being lined and shall be continuous from manhole to manhole. The preliner tube must be a rated gas barrier for styrene. Installation of the preliner tube shall be witnessed by the Owner or Engineer. Failure to install the required preliner tube or installation of preliner tube over only part of the segment shall result in the completed C.I.P.P. for that segment being rejected (regardless of physical tests and thickness test results). During thickness testing, the preliner tube shall be removed from the thickness test core sample along with the inner liner firm used. If there is any damage to the preliner tube, it should be repaired immediately with styrene-proof tape.

5.04 Tube Insertion (For Fiberglass/UV Cured 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 preliner tube, or outer film, 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 glass fiber liner into position in the pipe. Once inserted, end plugs shall be used to cap each end of the glass fiber 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.
4. The glass fiber liner shall be cured with UV light sources at a constant inner pressure. When inserting the curing equipment in the liner, care should be taken not to damage the inner film material.
 - a. 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, the following parameters must be controlled during the entire curing process, giving the Engineer a record of the curing parameters over every segment of the entire length of the liner. This demonstrates that the entire liner is cured properly. The recording will include:
 - Curing Speed
 - Light source working & wattage
 - Inner air pressure
 - Exothermic (curing) temperatures
 - Date and time
 - Length of liner

5.04 Tube Insertion (For Fiberglass/UV Cured Products (continued))

4. This will be accomplished using a computer and data base that are tamper proof. During the curing process, infrared sensors will be used to record curing data that will be submitted to the Engineer with a post CCTV inspection on DVD.
 - b. The parameters for curing speed, inner air pressure and wattage are defined in the Quality Tracker UV curing 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, liner thickness, and exothermic reaction temperature.

The inner film material should be removed and discarded after curing to provide optimal quality of the final product.

6. 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) within acceptable defined levels.

5.05 Tube Insertion/Inversion (For Felt/Hot Water Cured Products)

1. The resin impregnated tube shall be transported and stored in a refrigerated truck until it is installed in an existing line by using an application of water, air, or cable and winch to properly place the tube between the upstream and downstream manholes.
2. 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.
3. The preliner tube, or outer film, must be inserted into the pipe prior to inserting the liner.
4. The wet out felt tube shall be inserted, or inverted, through an existing manhole or other approved access. Liner installation head pressures (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", the tube end shall initially be turned inside out and attached to a platform ring, standpipe, or as approved. 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. Using the "Insertion Procedure", the tube is winched into position according to manufacturer's recommendations. The addition of water will be adjusted to sufficient height/pressure to cause the calibration hose to invert from manhole to manhole and hold the tube tight against the existing pipe wall.
7. Liner restraints should be used in manholes.

5.05 Tube Insertion/Inversion (For Felt/Hot Water Cured Products (continued))

8. 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. Boiler-truck operators must be fully certified by an approved certifying agency approved by the engineer. Certification documentation of at least two certified boiler-truck operators is a pre-contract requirement. Only fully-certified boiler-truck operators can operate boiler-trucks.
9. All water obtained from a City fire hydrant shall be metered and paid for by the Contractor. An air gap shall be provided between pipes/hoses connected to a fire hydrant and a storage tank/equipment used by the Contractor. The cost of said water shall be included in the cost of the project.
10. 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, considering the possibility of heat sinks. 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 stripchart 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.
11. Cool-Down - The Contractor shall cool the hardened pipe to a temperature below 100 degrees Fahrenheit, in accordance with the resin manufacture's recommendation, before relieving the water column or pressure. Cool water may be added to the water column while maintaining circulation as water is drained from a small hole at the opposite end of the cured-in-place pipe, so that a constant water column height is maintained until cool-down is completed. Care shall be taken in the release of the water column so that a vacuum will not develop that could damage the newly installed pipe. Coupon samples shall be obtained for testing (Section 5.0/Testing).
12. Since styrene is considered a volatile organic compound 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 not to interfere with the effectiveness of the plant.
13. Effluent from the curing process must be disposed of directly to a publicly owner 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 each day of lining work.

5.05 Tube Insertion/Inversion (For Felt/Hot Water Cured Products (continued))

14. 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 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. Proof of proper disposal, as specified above, must be presented to the engineer.

5.06 Post Installation

During the warranty period, which shall be defined as twenty-four (24) calendar months after acceptance by the Owner, 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 to by the Owner and Contractor.

Service Reconnection: After the cured-in-place process is completed, the Contractor shall reconnect the existing line service connections. These services shall be reconnected by internal remote cutting method or external excavation.

Service taps or branches reconnected internally shall be fully reopened to 90% 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 approved Sub-Contractor.

Sealing at Manholes: The cured-in-place 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.

Finished Pipe - The finished new cured-in-place liner shall be continuous over the entire length of each section lined, and be free from visual defects such as foreign inclusion, dry spots, pinholes, leaks and delamination.

6.00 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 or point of a knife blade so that the layers separate cleanly or the probe or knife blade moves freely between the layers. If separation of the layers occurs during testing of field samples, new samples will be cut from the work. Any recurrence may cause rejection of the work.

Testing of the completed, installed liner consists of:

- a. Field testing.
- b. Laboratory testing.
- c. Long term testing.

6.00 Requirements and Testing (continued)

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

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

- (1) the initial modulus of elasticity (ASTM D-790) (as stated in design calculations),
- (2) initial flexural strength (ASTM D-790),
- (3) APS Porosity Standard (tight or non-porous result), and
- (4) wall thickness values stated on each liner design sheet.

Values for the four parameters above which are 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 undersizing 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.

6.01 Sample Requirements

The following sample shall be taken for each section of sewer lined.

- a. 1 core of 12" diameter minimum taken from the inside of the pipe or an 18" full hoop sample as a restrained sample in the manhole equal to the exact ID of the lined pipe (field test).

6.02 Field Test (Thickness)

Remove the CIPP liner material from the host pipe core samples. Remove any inner liner film, preliner and resin that is not contained within the felt tube. Measure the liner thickness at three spots on each sample. The resulting six measurements will be averaged. The average thickness shall be equal to or greater than the required thickness for the particular section stated on the bid form. No undersize allowance is permitted. In accordance with D 790-03, referenced in ASTM 1216, the calculated wall thickness refers only to the part of the liner that consists of a saturated felt tube. Elements that are not part of the saturated felt tube do not contribute to the structural integrity of the liner, thereby excluding felt tube that is not fully saturated or portions of resin without the felt tube carrier.

6.02 Field Test (Thickness (continued))

If the Contractor takes his sample from inside the line he must repair the spot with a method approved by the Engineer.

"No Dig" option: At Owner's option, in lieu of excavation for core samples, the liner shall be run through 18" long section of line-sized pipe, or an appropriate restraint, to act as a mold for the liner and cured. One such sample shall be taken from liner at starting manhole and one at the ending manhole of the section being lined.

6.03 Laboratory Testing

Samples obtained for these tests will be sent by the Owner to an approved laboratory for testing. The Owner will pay for testing.