ITEM VI – TRENCHLESS TECHNOLOGY

6.01 Scope

(a) This Specification consists of the method and process to provide complete rehabilitation of gravity sanitary sewers, including all labor, materials, tools, equipment and incidentals necessary, by one of the following two methods:

(1) Fold and Formed Liner - Insertion of fold and formed poly-vinyl chloride (PVC) pipe that is heated, pressurized, and expanded to conform to the wall of the original pipe between manholes forming a new structural pipe-within-a-pipe.

(2) Cured-In-Place Pipe (CIPP) - Installation of a flexible polyester tube, vacuum impregnated, with a thermo setting, polyester or epoxy vinyl ester resin, having an impermeable inner surface.

(b) Sewers to be rehabilitated, tested and sealed under this process are shown on the Plans.

(c) All necessary bypass pumping, including appurtenances necessary to maintain sewer service is also part of the work specified under this Section.

(d) **Qualifications required with Bid**

(1) Contractor

All work shall be performed by a pre-qualified and appropriately licensed CONTRACTOR using one of the chosen trenchless rehabilitation methods listed above. In order to qualify for work on this project, CONTRACTOR shall have:

(a) Successfully installed a minimum of 150,000 linear feet of similar sized pipe;

(b) Own, rent, lease or otherwise have access for the duration of this project, all equipment necessary for a satisfactory and successful installation of the pipe;

(c) Supervisory personnel certified by the manufacturer of the trenchless pipe product as an installer of the product.

The pre-qualification submittal with the bid shall include:

(a) CONTRACTOR's name, license number and primary contact person;

(b) Address, telephone number and fax number of the CONTRACTOR's primary place of business and any secondary place of business that the CONTRACTOR will use during the project;

(c) List and description of previous projects completed by the CONTRACTOR totaling a minimum of 150,000 linear feet of similar sized pipe.

(d) At least 3 references who are familiar with the trenchless rehabilitation process and the quality of the CONTRACTOR's work. A contact name and telephone number shall be provided for each reference.

(2) Manufacturer

Any manufacturer wishing to qualify shall have successfully installed a minimum 150,000 linear feet of similar sized pipe as manufactured by their company. The manufacturer shall have a minimum of 3 years' experience in the manufacture of the pipe.

The qualification submittal with the bid shall include:

(a) Manufacturer's name, address, telephone number and fax number;

(b) List and description of previous projects which the manufacturer has provided the specified pipe of similar size totaling a minimum of 150,000 linear feet;

(c) The number of years the manufacturer has produced the product;

(d) Contact information for at least 3 references who are familiar with the process and the quality of the manufacturer's product.

6.02 SYSTEM DESCRIPTION

(a) FOLD AND FORMED

The fold and formed liner pipe shall be made from PVC compound which meets or exceeds all requirements as referenced in ASTM F 1871 – 98.

(b) CURED IN PLACE

(1) The CIPP when cured shall, at a minimum, meet or exceed the following values:

Physical Characteristic	Minimum Values	Test Method
Flexural Strength	4,500 psi	ASTM D790 mod.
Modulus of Elasticity	250,000 psi	ASTM D790 mod.
Tensile Strength	3,000 psi	ASTM D638
Chemical Resistance	Loss not to exceed the above values	ASTM D543

(2) The existing host pipe shall be considered **fully deteriorated** for design calculations.

(3) CONTRACTOR shall confirm loadings on buried pipe based on depths, soil conditions and water table. The height of water table shall be the same as the depth of soil above the pipe. The design soil unit weight shall be 120 pounds per cubic foot. The pipe shall also be designed for an additional AASHTO HS-20 highway live load condition.

(4) All pipes shall have a minimum of 2% ovality in the circumference. Any deviation must be approved by the ENGINEER.

(5) Thickness of CIPP shall be rounded to the next higher multiple of 1.5 mm, after adding an allowance of 5% to the design thickness for resin migration per manufacturer recommendation.

(6) The minimum CIPP design thickness shall meet the requirements of equations XI.1, XI.2, XI.3, and XI.4 in the appendixes of ASTM F 1216.

(7) The required structural CIPP wall thickness shall be based, as a minimum, on the physical properties of the cured composite and in accordance with the following design parameters, the design equations contained in ASTM F 1216 and all other applicable ASTM Standards:

Initial Flexural Modulus	=	250,000 psi
Long-Term CIPP Creep	=	50%
Overall Safety Factor	=	2.0
Soil Height	=	maximum project soil height
Modulus of Soil Reaction	=	1000 psi

Ground Water Height	=	maximum project soil height
Bending Stress Safety Factor	=	2.0
Initial Flexural Strength	=	4500 psi
Pipe Ovality or Deflection (as a %)	=	2.0%
Long-Term Flexural Modulus	=	125,000 psi
Long-Term Flexural Strength	=	2,250 psi
Water Buoyancy Factor	=	0.67 minimum
Poisson's Ratio	=	0.3
Enhancement Factor (K)	=	7

Values not listed in this Specification shall be approved by the ENGINEER prior to submittal of design calculations.

(8) The final liner thickness shall not include non-structural thickness of calibration tubes.

(9) The cured CIPP liner shall be rated as resistant, chemically and mechanically, to common municipal sewage.

6.03 Quality Assurance

(a) The materials and the method of installation shall be in accordance with ASTM standards and in accordance with manufacturer's recommendations.

(b) The CONTRACTOR shall test all sewers, service line connections and piping reconstructed under this Contract in accordance with the Standard Specifications.

(c) All testing shall be done by a certified independent testing firm approved by the ENGINEER. Cost of testing shall be borne by the DISTRICT.

6.04 References

(a) Codes, specifications, and standards, referred to by number or title, shall form a part of this Specification to the extent required by the reference thereto. Latest revision shall apply in all cases.

(1) FOLD AND FORMED PVC

Following is a partial list of American Society of Testing & Materials Standards which are applicable to this Specification for Fold and Formed PVC:

(a) **ASTM-F 1867-98** Standard Practice for Installation of Folded/Formed Poly Vinyl Chloride (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation

(b) **ASTM-F 1871-98** Standard Specification for Folded/Formed PVC Pipe Type A for Existing Sewer and Conduit Rehabilitation

(c) **ASTM-D-1784** Standard Specification for Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated PVC (CPVC) Compounds

(2) CURED IN PLACE PIPE

Following is a partial list of American Society of Testing & Materials Standards which are applicable to this Specification for Cured in Place.

(a) **ASTM-F1216-93** Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube

(b) **ASTM-F1743-96** Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-In-Place Thermo Setting Resin Pipe (CIPP)

(c) **ASTM-F-2019** Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cure-in-Place Thermosetting Resin Pipe (CIPP)

(d) **ASTM-D-5813-95** Standard Specification for Cured-In-Place Thermosetting Resin Sewer Pipe

(e) **ASTM-D-790-00** Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

(f) **ASTM-D-638-01** Standard Test Method for Tensile Properties of Plastics

(g) **ASTM-D-2412** Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

(h) **ASTM-D-3567** Standard Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings

(i) **ASTM-D-543** Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents

6.05 Submittals

(a) Shop Drawings

The CONTRACTOR shall submit at least 3 copies of shop drawings to the ENGINEER for approval. CONTRACTOR's dated stamp and signature verifying CONTRACTOR's approval must be on each stop drawing. Shop drawings shall not be approved without a CONTRACTOR's dated stamp and signature. The shop drawings shall include the items listed below:

(1) Fold and Formed PVC

(a) Liner data showing liner meets all requirements of ASTM F 1871-98 and ASTM D 1784.

(b) Complete catalog cuts and technical data and the manufacturer's recommendations as to method of installation.

(c) Liner design calculations.

(d) Curing process and recommended curing cycle.

(e) Factory quality control test reports for each liner reel.

(2) Cured In Place Pipe

(a) Complete shop drawings of CIPP liner which demonstrate compliance with these Specifications, show materials of construction (including resins, catalysts, etc.) and detail installation procedures (including recommended curing cycle). Certified material test results shall be included that confirm that all materials conform to these specifications. Testing procedures and quality control methods shall also be submitted. Materials not complying with these requirements will be rejected.

(b) Liner thickness calculations for the ENGINEER's review and approval. The CIPP shall be designed in accordance with the applicable provisions of ASTM F1216 and ASTM F2019 for "fully deteriorated gravity pipe conditions." The liner thickness shall be approved by the ENGINEER prior to liner manufacture or installation.

. (c) Wastewater capacity calculations for each size of CIPP liner to be installed.

(d) Documents certifying that the CIPP liner is manufactured in accordance with these specifications and the appropriate ASTM standards shall be submitted with each shipment. The certifications shall include a signed statement by the wet-out manager/supervisor that no fillers were added to the resin system during manufacture of

the CIPP liner. In addition, wet-out forms documenting the wet-out shall be submitted for each section of CIPP liner manufactured. The wet-out forms shall be submitted prior to requesting payment and shall be provided without delay or claim to any confidentiality. The wet-out forms shall document the date and time of wet-out, the wet-out supervisor, the wet-out facility address, the location where the CIPP liner will be installed (by manhole numbers), the CIPP liner diameter, the length of wet-tube and dry-tube, the thickness of the CIPP liner, the roller gap setting for establishing the liner thickness, the felt manufacturer, the resin used (by product name and batch/shipment number) and quantity, the catalyst(s) used (by product name) and quantity, any quality control samples taken, and all else pertinent to the wet-out process.

(b) Pre-construction Video

A CD or DVD of the video inspection performed no longer than 24 hours prior to the trenchless rehabilitation shall be provided. Video shall include voice description, as appropriate, with stationing of services indicated. Data and stationing shall be on videos and begin at Station 0.0 Ft.

(c) Post Construction Submittals

(1) Provide 1 CD or DVD containing MPEG files for each post TV inspection of the liner from manhole to manhole. The CD's or DVD's may be filled to capacity with as many MPEG files that will fit. Each MPEG file will be labeled with corresponding manhole numbers of the line segment inspected. For example, a file containing TV information of a liner inspected from manhole 28000 to manhole 28001 would be labeled "28000-28001.MPEG". MPEG 4 format shall be used and videos shall be scored per NASSCO PACP standards. Video shall include voice description as appropriate with stationing of services indicated and shall begin at Station 0.0 ft.

(2) For cured in place pipe, submit certified copies of all test reports indicating properties of the selected resin and liner. Test results on field liner samples, performed by an approved independent testing company, shall be submitted to the ENGINEER.

6.06 Product Handling

(a) The CONTRACTOR shall use all means necessary to protect lining materials before, during, and after installation. The installed work and materials of other trades shall also be properly protected. In the event of damage, the

CONTRACTOR shall immediately make all repairs or replacements deemed necessary by the ENGINEER, at no additional cost to the DISTRICT.

6.07 Site Conditions

(a) CONTRACTOR shall be responsible for verifying the size and condition of the existing sewer and his ability to insert the CIPP liner, prior to ordering materials. CONTRACTOR shall not receive compensation for excavations to remove obstructions due to conditions the CONTRACTOR should have seen by visual observation.

(b) Prior to entering confined spaces such as manholes or inspection hatches to perform inspections or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic gasses, flammable vapors or lack of oxygen must be performed by the CONTRACTOR in accordance with local, state and federal OSHA safety regulations.

(c) Television Inspection

(1) Within 24 hours prior to installation, all sewer sections to be lined shall be inspected by closed circuit television to confirm any changes that may have occurred from the date of the original inspection. All sewers or pipelines are to be cleaned as stated below prior to the television inspection.

(2) The television inspection shall be performed in order to provide a visual and audio record of the location of obstructions in the sewer that would interfere with or prohibit lining of the sewer and provide the location of service laterals that are to be reconnected to the new liner. A color television inspection camera with pan and tilt capability is required for all inspections.

(3) Any grade or alignment issue observed by CONTRACTOR in video review, which reduces the pipe's flow area by 10% or greater, shall be reported to ENGINEER in a timely manner. The ENGINEER shall review subject pipe video in a timely manner and make a determination as to any point repair or other improvement that is to occur before lining proceeds. CONTRACTOR shall not be compensated for repairs required after lining if this requirement was not followed.

(4) CD's or DVD's and hard copy reports shall be made for each line inspected. The quality of the video shall be such that obstructions and service lateral locations are clearly identified and can be located. The CONTRACTOR shall make the CD's or DVD's, and reports available to the ENGINEER for review. Areas in the pipe where camera is underwater

shall be cleared of debris prior to or during inspection to allow complete survey of pipe. Post construction video with "camera underwater" conditions due to debris will not be accepted.

(5) If there is an obstruction in the sewer line that will not allow the television camera to pass, then the camera shall be backed out of the line and an attempt shall be made to televise the line from the manhole at the other end. If the entire length of the sewer line cannot be televised because of two or more obstructions, then the ENGINEER shall be notified and a determination of how to proceed shall be made by the ENGINEER.

(6) The CONTRACTOR shall provide CD's or DVD's of the finished liner including all service reconnections and reinstatements of drops at drop manholes prior to acceptance by the ENGINEER.

(7) The cost of the television inspection, CD's or DVD's, and reports shall be included in the unit cost of the liner.

6.08 Warranty

(a) The Manufacturer shall warrant all materials to be free from defects in workmanship and materials for a period of one (1) year after final acceptance.

6.09 Materials

(a) Fold And Formed

(1) Poly Vinyl Chloride Liner

(a) The liner shall be fabricated to a size that, when installed, will neatly fit the internal circumference of the pipeline to be rehabilitated. Allowance for circumference stretching during insertion shall be made. The liner material shall be made from a poly vinyl chloride (PVC) compound.

(b) The minimum length shall be the distance from inlet to the outlet of the respective pipe to be lined. The CONTRACTOR shall verify the lengths in the field before forming.

(c) The minimum thickness shall be SDR 32.5, which is verified by design calculations by a Professional Engineer. The existing host pipe shall be considered **fully deteriorated** for design calculations. CONTRACTOR shall confirm loadings on buried pipe based on depths, soil conditions and water table. The height of water table shall be the same as the depth of soil above the pipe. The design soil unit

weight shall be 120 pounds per cubic foot. The pipe shall also be designed for an additional AASHTO HS-20 highway live load condition. All pipes shall have a minimum of 2% ovality in the circumference. Any deviation must be approved by the ENGINEER.

(d) Unless otherwise specified, the CONTRACTOR shall furnish a poly vinyl chloride compound liner pipe meeting all the requirements for cell classification 12111-C, as defined in Specification D 1784, and with minimum physical properties as listed below:

Physical Characteristics	Test Procedure	Rating
Tensile Strength	ASTM D-638	3,600 psi
Tensile Modulus	ASTM D-638	155,000 psi
Flexural Strength	ASTM D-790	4,100 psi
Flexural Modulus	ASTM D-790	145,000 psi

(e) The CONTRACTOR shall furnish, prior to installation of the materials, satisfactory written certification of compliance with the manufacturer's standards for all materials and conformance with the methods of the manufacturer.

(b) Cured In Place

(1) Liner

(a) The liner shall consist of one or more layers of flexible needled felt or an equivalent non-woven material capable of: carrying resin, withstanding installation pressure, installation tension (if pulled in place) curing temperatures, and should be compatible with the resin system recommended by the manufacturer.

(b) The liner shall be specifically fabricated and manufactured to fit the host pipe that is to be lined. It shall be the CONTRACTOR's responsibility to measure each host pipe section and to ensure that the liner shall be of sufficient size and diameter to produce a final product which meets or exceeds all requirements of these specifications. "Prefabricated or "Off-the-shelf" liners will only be permitted if they are an exact fit to the specific host pipe section. Liners which, in the opinion of the ENGINEER, have wrinkles, improperly cured sections or other abnormalities which do not meet or exceed the tolerances permitted in these specifications, will be rejected and it shall be the CONTRACTOR's responsibility to make appropriate corrections, up to and including full replacement of the pipe section by whatever means deemed necessary and appropriate by the DISTRICT.

(c) The liner shall be able to stretch to fit irregular pipe sections and negotiate bends.

(d) The liner shall be fabricated to a size that, when installed, will be water tight and tightly fit the internal circumference and the length of the original sewer pipe.

(e) Allowance shall be made for circumferential stretching during installation.

(f) The fabric liner and seam (if applicable) shall be tested in accordance with Test Method D1682. The liner shall have a minimum tensile strength of 750 psi in both the longitudinal and transverse directions.

(2) Resin

(a) The resin system shall be a corrosion resistant polyester, vinyl ester, or epoxy and catalyst system that meets the requirements of ASTM F1216 and ASTM F2019 and the physical properties herein. No fillers are to be added to resin without prior approval from the ENGINEER.

(b) The application of resin to the felt liner (wet-out) shall be conducted under factory conditions and the materials shall be fully protected against UV light, excessive heat and contamination at all times.

6.10 Surface Preparation

(a) All affected sewer sections are to be thoroughly cleaned and all debris, roots and other obstructions removed. All material removed from the existing sewer sections shall be properly transported on a daily basis to an approved disposal site obtained by the CONTRACTOR. Under no circumstances will the CONTRACTOR be allowed to accumulate debris or to create a public nuisance.

(b) The method used to clean the sewer sections shall be at the option of the CONTRACTOR and may include high pressure water jet cleaning, brushes, balls, swabs, bucket machine or other methods. The CONTRACTOR shall be responsible for damage to the sewer sections due to improper cleaning methods.

(c) The cost of preparatory cleaning shall be included in the unit price of liner.

(d) Removal Of Obstructions In Sewer

(1) Obstructions in the sewer sections which cannot be dislodged or cleared by cleaning, bucketing, dragging a mandrel, or other internal methods shall be cleared by excavation. The CONTRACTOR shall notify the

ENGINEER prior to any proposed excavation work that is not indicated on the plans.

(2) The excavation shall conform to requirements of Section VI-1, "Excavation," and shall minimize the obstruction of traffic. The size of the excavation shall be kept to a minimum and shall be shored and sheeted as required.

(3) The existing sewers shall be repaired, after the obstruction is removed, in accordance with DISTRICT Standards.

(4) If more than two obstructions require excavation in any one sewer section, the CONTRACTOR shall notify the ENGINEER and a determination of how to proceed shall be made by the ENGINEER.

6.11 Field Measurements

(a) The CONTRACTOR shall make all necessary measurements in the field to ensure precise fit of items in accordance with the Plans. In the event of a discrepancy, the CONTRACTOR shall immediately notify the ENGINEER. The CONTRACTOR shall not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

6.12 Inspection of Pipe Liner

(a) Each pipe liner shall be subject to inspection by the ENGINEER immediately before it is installed. Defective liner or liner which is less than the minimum required thickness will be subject to rejection for use on the project.

6.13 INSTALLATION

(a) General

(1) The CONTRACTOR shall make every effort to maintain sewer service throughout the duration of the project. In the event that a service line will be temporarily out of service, the maximum time of disruption of service shall not exceed 8 hours for any property. The CONTRACTOR shall notify DISTRICT and all affected property owners whose service laterals will be disrupted and advise against water usage until the sewer main is back in service. Such notifications to property owners shall be made 48 hours in advance of disruption of service.

(2) The following installation procedures shall be adhered to unless otherwise approved by ENGINEER.

(a) Safety: The CONTRACTOR shall carry out his operations in strict accordance with all OSHA and manufacturer's safety requirements. Particular attention is drawn to, but not limited to, those safety requirements involving working with hazardous/combustible materials, scaffolding, and entering confined spaces.

(b) Cleaning of Sewer Line: It shall be the responsibility of the CONTRACTOR to remove all internal debris from the sewer line.

(c) Inspection of Pipelines: Inspection of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles and service connections by closed circuit television. The interior of the pipeline shall be carefully inspected to determine the location of any condition which may prevent proper installation of the liner into the pipelines and it shall be noted so that these conditions can be corrected. A video and suitable log shall be kept for later reference by the DISTRICT. Pre-installation video shall be no older than 24 hours.

(d) Bypassing Flow: The CONTRACTOR, when required, shall provide for the flow around the section of pipe designated for lining. The bypass shall be made by plugging the line at an existing upstream manhole and pumping the flow into a downstream manhole or adjacent system. The pump and bypass line shall be of adequate capacity and size to handle peak flow.

(e) Any costs incurred by overflowing in a home or business shall be the responsibility of the CONTRACTOR.

(f) Line Obstructions: It shall be the responsibility of the CONTRACTOR to clear the line of obstructions that cannot be removed by conventional sewer cleaning equipment. The CONTRACTOR shall remove the obstruction or repair the pipe by excavation. Such excavation shall be approved in writing by the ENGINEER prior to the commencement of the work and shall be considered as a separate pay item.

(b) Installation of Fold and Formed Pipe Liner

(1) The method of installation shall be compatible with the manufacturer's recommended practices and shall meet ASTM-F 1867-98. For the pipe liner, the installation shall be as follows:

(a) The liner pipe shall be inserted into the existing sewer through existing manholes. The existing inverts shall be removed to a point no less than 2 inches below the invert of the pipe. This will

provide an area of expansion at the point where the liner exits the host pipe and also accommodates the invert rebuilding.

(b) After insertion of the liner pipe is completed, the CONTRACTOR shall apply steam of sufficient volume and pressure to "cure" the pipe liner. The equipment used shall be capable of delivering steam throughout the liner section to uniformly raise the pressure to form the PVC liner. The temperature shall be determined by the system employed.

(c) The heat source shall be fitted with suitable monitors to gauge the pressure of the steam supply. Another such gauge shall be placed at the remote manhole to determine the pressure during forming. Monitoring methods and forming time shall conform to manufacturer's recommendations.

(d) The liner pipe shall be expanded until it is pressed tightly against the existing pipe walls.

(e) If the liner fails to form, the CONTRACTOR shall remove the failed liner and replace it with a new liner. This work shall be performed without additional cost to the DISTRICT.

(f) After the liner has been formed, the ends of the liner shall be cut away at both manholes, leaving 4 inches inside of manhole. Ponding in the invert shall not be permitted. Existing invert may require chipping prior to pipe installation. See Technical Specification Section VI-II for additional information on manhole inverts.

(g) The finished liner pipe shall be continuous over the entire length of run between 2 manholes and shall be free from visual defects such as foreign inclusions and pin holes. It shall also meet the leakage requirements and pressure test as specified.

(h) Any defects which will affect the integrity or strength of the liner pipe shall be repaired at the CONTRACTOR's expense. Allowance shall be given for excess pipe (rib) when the cross-sectional area has been reduced due to offset joints, out of round sections, etc.

(c) Installation Of Cured-In-Place Pipe

(1) CONTRACTOR shall provide for continuous sewage flow around the sections(s) of pipe designated for insertion of liners, when required for acceptable completion of an insertion process. The pump and bypass line shall be of adequate capacity and size to handle the flow.

(2) The CONTRACTOR shall designate a location where the felt tube will be impregnated ("wetted out') with resin. The CONTRACTOR shall inform the ENGINEER in advance to inspect the materials and the wet out procedure. The process shall use distribution rollers and vacuum, to thoroughly saturate the felt tube prior to its dispatch for installation. A catalyst system or additive(s) compatible with the resin and tube may be used as per the manufacturer's recommendation. They shall, however, not impair or reduce the resin's quality to withstand the minimum chemical resistance criteria.

(3) The wetted out tube shall be transported and kept in a refrigerated truck until it is inserted through an existing manhole by approved techniques/process. The insertion area, equipment platform, etc., shall be securely protected, and all damaged yards, driveways, walks, etc., shall be repaired at no cost to the DISTRICT.

(4) The liner may be installed by inversion method per ASTM F1216 or by the pulled-in-place method per ASTM F1743 and ASTM F219. The methods used to install and cure the liner are at the option of the CONTRACTOR but a method statement (and detail information) must be submitted to the ENGINEER for approval at least 3 weeks prior to mobilizing to the work site.

(5) When the liner is to be installed using the inversion process, this process shall use either water column inversion or pressurized inversion (water or air). The heads or pressures used shall be in accordance with the head/pressure limits for the carrier tube. For water column/pressure inversion, the effect of pipeline fall of rise shall be taken into account when applying head/pressure at the inversion location so that the head/pressure anywhere along the run does not exceed allowances for the carrier tube.

(6) All water used shall be from a metered supply, the costs of which shall be paid to the Water System owner through its regular billing system.

(7) The inversion shall proceed in a uniform controlled method, and during inversion the head/pressure shall be maintained within a range that facilitates steady and controlled inversion. Unless special circumstances warrant, the head/pressure shall be maintained in the liner at all times during the inversion.

(8) In installations where a pull-in type liner may be used instead of an inversion type liner, pull forces shall be maintained below the rating of the liner carrier tube.

(9) Curing with Hot Water

(a) Hot water circulated within the liner shall be used to elevate the temperature of the resin to effect a cure. During the cure, the water in the liner shall be maintained at a head/pressure in accordance with the manufacturer's requirements for the specific size and thickness of the liner. A boiler of sufficient rating shall be used to add heat to the circulating water. Circulating pump(s) and internal hoses shall be sized to provide sufficient circulation of the hot water to uniformly heat the liner.

(b) The temperature of the circulating hot water shall be per manufacturer recommendations and shall be monitored at the supply from and return to the boiler. The temperature of the liner outer surface shall be monitored at each end using thermocouples or other suitable measuring devices.

(c) After the CIPP liner has changed to its hardened state, the cure heating shall be continued maintaining the liner at an elevated temperature for a period of time dependent on the size, thickness and ongoing temperature measurements to ensure the full level of cure has been achieved in accordance with manufacturing recommendations.

(d) On completion of the heat cure, the liner shall be cooled down either naturally or by adding cold water to the circulating water. During cool down the head/pressure in the liner shall be maintained at the cure head. The rate of cool down shall be commensurate with the liner size and thickness to minimize shrinkage and internal stresses.

(10) Curing with Steam

(a) Steam flowed through the interior of the liner shall be used to elevate temperature of the resin to effect a cure per manufacturer's recommendations. Compressed air shall be mixed with the steam as required to moderate the steam temperature to produce a controlled heating of the liner, avoid hot spotting and prevent blistering of the polyurethane coating.

(b) The pressure of the steam/air mixture shall be controlled at the injection and venting manifold locations to maintain the required internal pressure on the liner in accordance with the manufacturer's requirements for the carrier tube internal pressure

ratings. The temperature of the steam/air mixture shall be controlled and monitored at the mixing manifold. The temperature of the liner outer surfaces shall be monitored at each end using thermocouples or other suitable measuring devices.

(c) After the CIPP liner has changed to its hardened state, the cure heating shall be continued maintaining the liner at an elevated temperature for a period of time dependent on the size, thickness and ongoing temperature measurements to ensure the full level of cure has been achieved in accordance with manufacturing recommendations.

(d) On completion of the heat cure, the liner shall be cooled down either naturally or by gradually reducing the amount of heating steam in the steam/air mixture to all air. During cool down the pressure in the liner shall be maintained at the cure pressure. The rate of cool down shall be commensurate with the liner size and thickness to minimize shrinkage and internal stresses.

(11) Curing with Ultraviolet Light

(a) Compressed air shall expand the impregnated fabric tube of sufficient capacity to insert the ultraviolet multi-lamp curing assembly. The ultraviolet lamp shall operate in the 200 to 400 nm range.

(b) Air pressure shall be slowly adjusted to sufficient pressure to hold the impregnated fabric tube to the existing pipe. The desired pressure shall be maintained throughout the curing process. The ultraviolet lamp shall travel through the pipe at a pre-determined speed at which allows for curing of the CIPP resin.

(c) The ultraviolet lamp assembly shall make a first pass through the pipe for inspection of CIPP liner before the curing process begins. Defects in the pulled-in-place CIPP liner shall be corrected before curing.

(d) Documentation of time, rate of travel for ultraviolet lamp assembly, and pressure maintained shall be recorded during curing of the fabric tube.

(12) The finished CIPP shall be continuous over the entire length from manhole to manhole and be free from visual defects such as foreign inclusions, dry spots, keel, boat hull, pinholes, wrinkles and other deformities. The liner passing through or terminating in a manhole shall

be carefully cut out (also for samples) in a shape and manner approved by the ENGINEER. The invert and benches shall be streamlined and improved for smooth flow. The area/annular space between existing and the CIPP shall be sealed with approved materials in an approved manner described within the specifications. It shall also meet the leakage requirements of pressure test as specified. During the warranty period, which shall be defined as 12 calendar months after final acceptance by the DISTRICT, any defect which will affect the integrity or strength of the pipe or impede the flow through the pipe shall be repaired at the CONTRACTOR's expense, in a manner mutually agreed to by the ENGINEER and the CONTRACTOR.

(d) Sealing And Benches In Manhole

(1) The finished pipe shall make a tight fitting seal with the existing pipe(s) in the manhole. One-half inch diameter activated oakum band soaked in Scotch Seal 5600 or equal, shall be applied circumferentially near the annular space touching the end of existing pipe and encased with a cementitious mortar. The pipe shall be neatly cut off and not broken or sheared off, at least 3 inches away from the walls and a pipe collar built over pipe. The channel in the manhole shall be smooth continuation of the pipe(s) and shall be merged with other lines or channels, if any. Ponding in the upstream pipe or invert shall not be accepted if the condition could have been avoided by chipping out the existing invert prior to lining. Channel cross-section shall be U-shaped with a minimum depth of 6 inches for 8-inch pipe and full depth for greater sized pipes. The side of the channels shall be built up with mortar/concrete to provide benches at a minimum slope of 1 inch to 12 inches pitched toward the channel. All grout work including invert bench and pipe collars are to have a steel trowel finish.

(2) Payment for above work shall be incidental to sewer rehabilitation by the required method, since that payment is made from centerline to centerline of manhole.

(3) The liner and the existing pipe in the manhole must be sealed as specified above before proceeding to the next manhole section. All manholes will be individually inspected for liner cut-offs, benches and sealing works.

(e) Service / Outside Drop Reconnections

(1) After the pipe liner has been formed in place, the CONTRACTOR shall reconnect the existing active service connections as designated by the ENGINEER. This will be done by open trench excavation in order to provide a positive connection to the liner. If the CONTRACTOR

proposes to re-establish the connection by remote cut method, the ENGINEER shall approve the location prior to performing the work. In the event a service is to be re-established by remote cut, the finished penetration shall be brushed smooth and be no less than 90 percent of the original service size.

(2) The exact location and number of service connections shall be determined from pre-work video and/or in the field. It shall be the CONTRACTOR's responsibility to accurately field locate all existing service connections whether in service or not. The CONTRACTOR shall reconnect all live service connections to the liner pipe, unless directed otherwise by the ENGINEER. The CONTRACTOR shall be responsible for restoring/correcting without any delay, all missed or faulty reconnections, as well as for any damage caused to property owners for not reconnecting the services in a timely manner or for not giving adequate notice to the owners. All services which are reconnected to rehabilitated liner shall be shown on the "Record Drawings" with the exact distance from the nearest upstream/downstream manhole.

(3) In general, service connections shall be made by open cut excavation; however, if a remote cut method is allowed, and it does not meet the ENGINEER's approval with respect to quality and workmanship, the service connection shall be performed by excavation at no additional cost to the DISTRICT.

(4) Service laterals shall be reconnected as described in the paragraphs above. Additionally, the CONTRACTOR shall replace the service lateral from the main line to the clean-out assembly, when directed to do so by the ENGINEER.

(5) <u>Service Connection by Remote Cut</u>

(a) This operation shall be performed by experienced operators so that no blind attempt or holes are made in the liner pipe. Location shall be re-verified carefully with preconstruction videos for accuracy, especially where dimples are not defined or clearly ascertained. The ENGINEER reserves the right to require service connection by excavation at any or all locations at no additional cost to the DISTRICT, if the quality, workmanship and/or approval rating for remote cut is poor and unsatisfactory or is otherwise found not to meet project specifications.

(b) Where unsatisfactory remote cut reconnections are to be repaired by open cut method, the existing carrier or host pipe shall be carefully broken and removed so that only that amount of the liner which is absolutely necessary for the repair/re-connect is exposed. The liner

shall not be damaged and shall be allowed to normalize to ambient temperature, before a 4-inch or 6-inch diameter hole is cored out of the liner with a hole saw. This coupon shall be retrieved and handed to the ENGINEER for inspection of the liner thickness at that location, if so required.

(c) The remote cut shall be smooth and circular in nature as seen by a 360° TV camera. The hole shall be a maximum of 100% and a minimum of 90 percent of the service pipe diameter. It shall be properly aligned and be concentric to the existing connection. The locations of all remote cuts shall be verified carefully to match with pre-work videos for their exact locations. Excess, wrong holes and/or trial cuts shall not be made. However, in the event they do occur, they must be repaired at no cost to the DISTRICT to the full satisfaction of the ENGINEER. CONTRACTOR shall check the completed remote cut connections for the minimum 90% requirement when directed to do so by the ENGINEER, by excavating the site, in which case payment shall be made for the excavation at the location and for any special backfill, if necessary. Defective connections shall be repaired to the ENGINEER's satisfaction at no additional cost to the DISTRICT.

(d) Protruding taps that will deform the finished liner or otherwise obstruct or hinder the insertion of the liner, shall be removed to allow the liner to pass through. If these taps are to be reinstated at a later time by excavation, the initial removal will be incidental. If the camera equipment cannot pass, the trimming will be paid as a removal of protruding service by remote cut upon approval by ENGINEER.

(e) Outside drop pipes at drop manholes shall be reconnected by remote cut. Payment for this reconnection shall be the same as for a service connection by remote cut.

(6) Service Connection by Excavation

(a) Service reconnections shall be made by open cut method, unless otherwise stated in the Project Plans, Special Conditions or directed by the ENGINEER. In the event of poor quality or workmanship of a remote cut, the existing service connections shall be done by Excavation method. The existing sewer (now the carrier or host pipe for the liner) shall be carefully broken/removed to expose the liner to the extent necessary. The liner pipe shall not be damaged and shall be allowed to normalize to ambient temperature, before a 4-inch or 6-inch diameter hole is cored out with a hole saw. This coupon shall be retrieved and handed over to the ENGINEER for inspection of the

liner thickness at that location, if so required. The size of new service shall match the existing service size.

(b) A 3 piece service connection shall be installed consisting of an IPS/Schedule 40 PVC hub, rubber sleeve and 301 stainless steel band. The service connection shall be a compression fitting such as INSERTA TEE as manufactured by Inserta Fittings Company or equal for 8 inches and larger mains. The rubber sleeve shall meet ASTM C443. The PVC hub gasket shall meet ASTM F477.

(c) The rubber sleeve shall be lubricated as recommended by the manufacturer. The rubber sleeve shall be inserted into the pipe liner such that the entry lip forms a complete seal between the inside of the pipe liner and the sleeve entry lip. The PVC hub shall be inserted into the rubber sleeve to the mark shown on the outside of the hub. The hub shall not protrude into the pipe liner such that a TV camera cannot pass.

(d) Place the stainless band around the top of the rubber sleeve and tighten down. Install lateral service pipe in the normal manner.

(e) If directed by the ENGINEER, the CONTRACTOR shall replace the existing service line to the clean-out assembly.

(f) One or more homes discharging into a common connection shall be considered as one service connection. Damage repair to residences or properties due to delay or faulty connections shall be incidental.

(g) Compression fittings shall not be used on 6-inch main lines. Saddles shall be used for 6-inch lines as shown on the Plans, joined with two part epoxy and secured with stainless steel band.

(f) Testing

(1) Fold And Formed

(a) Gravity sewers rehabilitated using fold and formed pipe shall be tested in accordance with DISTRICT's Technical Specifications, with the exception that tests relating to grade and alignment are not required.

(b) All service line connections noted as leaking shall be repaired or replaced and then retested. If service line connection repair or replacement, testing or retesting, and backfilling of the excavation is not completed within the work day, the CONTRACTOR shall properly

cover each excavation with steel plates, plywood, or some other approved material, to make the area secure from accidents or hazard.

(2) Cured In Place

(a) A sample shall be cut from a section of cured CIPP liner at the installed liner termination point, that has been inverted through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags. Each sample shall be 6-8 inches in length. Sample shall be labeled with date and manhole to manhole numbers. Labeled samples shall be handed to Inspection staff at time of installation and preparation.

(b) Thickness measurements, flexural stress, flexural modulus of elasticity, and tensile tests shall be performed for each sample. The costs for these tests will be borne by the DISTRICT.

(c) Eight thickness measurements shall be made per ASTM D2122 and ASTM D3567 and the average thickness shall be the determined sample thickness. The minimum wall thickness at any point shall not be less than 87.5 percent of the specified thickness.

(d) Five specimens of each sample shall be tested for flexural stress and flexural modulus of elasticity per ASTM D790. The dimensions of each specimen including width, depth, and span shall be reported. Data items shall be reported for each of 5 specimens tested as follows:

- Specimen Number
- Displacement at Yield (in)
- Strain at Yield (in / in)
- Load at Yield (lbs.)
- Stress at Yield (psi)
- Modulus of Elasticity (psi)

(e) The mean, standard deviation, minimum value, and maximum value for the group of specimens shall be reported for each data item.

(f) Each report shall contain sample identification information for each sample including project name, sample number, date sample received, date sample tested, diameter of liner sample, upstream manhole number and downstream manhole number where sample was taken.

(g) Sample conditioning information such as humidity and temperature shall be provided on each report. Sample reports submitted to the ENGINEER without the specified data shall be rejected.

(h) Tensile tests shall be performed per ASTM D 638-01.

(3) Preliminary Acceptance of Cured In Place Pipe

(a) Following installation of the liner and re-establishment of all live service connections, the CONTRACTOR shall conduct a final digitally recorded color television inspection of the completed work as instructed in other sections of this Specification. Copies of these post-installation digital recordings, as well as the digital recordings made prior to the liner installation shall be submitted to the ENGINEER for approval and shall be retained by the DISTRICT. Payment will not be made for any CIPP lining until the ENGINEER has reviewed and approved these digital recordings. The CONTRACTOR shall submit the CD or DVD disks a minimum of 10 days in advance of any payment request to provide the ENGINEER ample time to review the recordings.

(b) There shall be no dry spots, lifts, wrinkles, ridges, splits, cracks, delaminations or other type defects in the CIPP lining. Defective lining will be removed and the pipe re-lined at no additional cost to the DISTRICT. If during the removal process, the host pipe is damaged, CONTRACTOR will perform a point repair at CONTRACTOR's own expense.

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(c) Groundwater infiltration through the liner shall be zero.

(d) All service connections shall be open, clear and watertight. The liner opening shall conform neatly with the opening in the host pipe and shall be free of burrs or debris.

(e) Preliminary acceptance of CIPP lining shall be based on the ENGINEER's evaluation of the installation and curing data, results of air testing where required, and review of the TV digital recordings.

(4) Final Acceptance Of Cured In Place Pipe

(a) Final acceptance of the liner shall be based on the preliminary acceptance of the liner by the ENGINEER and on the results of the certified laboratory tests on the liner specimens as specified in the Section entitled "Testing".

(b) Liners meeting or exceeding the specified thicknesses and strengths, as evidenced by the certified laboratory testing results, shall be paid for in full according to the contract unit rate for the finished diameter per linear foot.

(c) Where the laboratory analysis results indicate that the liner section does not comply with either the minimum thickness specified or the minimum flexural modules specified, payment for the section of liner represented by the specimen shall be modified, or the liner rejected, as follows:

(1) The minimum cured thickness required for the indicated liner section shall be recalculated using the actual liner cured flexural strength and tensile strength reported by the certified laboratory for the liner specimen taken from that section of liner. The values used shall be the average of the test values reported for that specimen. The minimum required thickness shall be calculated as described in the Section entitled "System Description".

(2) Calculate the value factor for the liner segment according to the following equation:

Value Factor = (Average thickness / calculated minimum required thickness)$^{1.5}$

In words, the Value Factor is equal to the ratio of the average of the actual reported thickness and the calculated minimum required thickness, all to the 1.5 power.

Ex: (0.162 inches (average) / 0.180 inches (min. req.)$^{1.5}$ = 0.85 Value Factor

(3) Where the Value Factor is calculated at 0.95 or greater, the payment for the liner shall be at the full unit price bid per linear foot for that diameter liner.

(4) Where the Value Factor is calculated at less than 0.95 but equal to or greater than 0.85, payment for the liner segment in question shall be based on the product of the Value Factor times the contractual unit price per linear foot for that diameter liner times the total length of the liner segment.

(5) Where the Value Factor is calculated at less than 0.85, the liner shall be rejected and the CONTRACTOR shall replace the non-conforming liner or shall propose an alternate method for

modifying the finished liner to conform to the specified strength and thickness, all at the CONTRACTOR's expense.

6.14 Service Lateral Rehabilitation

(a) CONTRACTOR shall install a clean-out assembly on the existing service lateral connections that do not currently have a clean-out assembly installed at the edge of the road right-of-way or easement right-of-way, and shall be approved by the ENGINEER prior to installation.

(b) Clean-out assemblies shall be installed in accordance with DISTRICT's Standard Details and Technical Specifications.

(c) In addition to the television inspection that will be required prior to installation of the pipe, all service laterals shall be inspected. The method of CCTV inspection of service laterals may be chosen by the CONTRACTOR, but must be coordinated and approved by the ENGINEER prior to inspection of the laterals.

(d) The CONTRACTOR shall coordinate each service lateral inspection with the ENGINEER. At the time of the inspection, the ENGINEER shall make a decision whether to replace the lateral or not. The ENGINEER may determine that replacement of the lateral is not required.

(e) If it is determined that the lateral needs to be replaced, the CONTRACTOR shall replace the existing service line from the clean-out to the main collection system line by means of open-cut excavation. Service laterals shall be constructed in accordance with DISTRICT's Standard Details of the Technical Specifications.

6.15 Field Quality Control

(a) The manufacturer of the liner material shall provide technical and installation advice to the CONTRACTOR's work force when first installing the liner. The service of an experienced installation representative shall be provided for a minimum of two days at no additional cost to the DISTRICT.

(b) CD's or DVD's shall be required after the liner has been installed in the existing sewer pipe, at no additional cost to the DISTRICT. The televising shall be done after all service connections have been made, unless required earlier by the ENGINEER.

(c) A dye test may be required to confirm reconnection of all services. Dye shall be introduced into all service lines and then flooded with water. The CONTRACTOR and the ENGINEER shall look to the downstream manhole to detect the dye coming out of the sewer main. This shall confirm a reconnection. If any more than one service connection is dye tested at a time, these dye tests

shall be done with enough time allowed between each test to allow the dye to be purged from the line. Otherwise, different colored dyes shall be used. Dye testing shall be performed by the CONTRACTOR at no additional cost to the DISTRICT.

6.16 Post Televising of Completed Sections

(a) The CONTRACTOR will provide to the ENGINEER color video CD's or DVD's taken by a 360° radial view camera for close up view, showing the completed work, including the condition of the restored pipes prior to requesting final payment.

(b) Television inspection, CD's or DVD's, reports, etc., shall be as specified elsewhere in this section. Upon completion of the installation work and testing, the CONTRACTOR shall restore/clear the project area affected by his operations.

6.17 Clean-Up

(a) The CONTRACTOR shall restore or replace all removed or damaged paving, curbing, sidewalks, gutters, shrubbery, fences, sod or other disturbed surfaces or structures in a condition equal to that before the work began, to the satisfaction of the ENGINEER, and shall furnish all labor and material incidental thereto.

(b) Surplus liner material, tools and temporary structures shall be removed by the CONTRACTOR. All dirt, rubbish and excess earth from operation shall be legally disposed of by the CONTRACTOR, and the construction site shall be left clean, to the satisfaction of the ENGINEER, in accordance with all appropriate regulations.

6.18 PATENTS

The CONTRACTOR shall warrant and hold harmless the DISTRICT against claims for patent infringement and any loss thereof.