Item No. 302
Cured-In-Place Pipe

302.1 Description

This item shall govern the construction, labor, material and equipment necessary for the rehabilitation of sanitary sewer mains and service connections by the installation of a flexible tube saturated with a thermosetting resin which is either inverted or pulled into the existing wastewater main.

302.2 Standards

Comply with local governing regulations if more stringent than specified herein. Piping and fittings shall be in full compliance with the applicable standards and specifications for each type of pipe involved. Pipe may be rejected for failure to comply with any requirement of this Section.

A. ASTM International (ASTM) Standards:

ASTM F1216	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin Impregnated Tube
ASTM F1743	Standard Practice for Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)
ASTM D5813	Cured In Place Thermosetting Resin Sewer Piping Systems
ASTM D638	Standard Test Methods for Tensile Properties of Plastics
ASTM D790	Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

302.3 Submittals

The submittal requirements of this specification item must include:

A. Shop Drawings:

1. Flow control implementation plan.
2. Quality Control Plan that includes a checklist documenting each critical step in the tube's resin saturation, unhardened CIPP tube's insertion into the subject reach of pipe, hardening process of the CIPP and a list of personnel and defined responsibilities during the installation process.

B. Product Data:

1. Method of rehabilitation and restoration of existing service connections.
2. Diameter, length, wall thickness and all structural design calculations for each sewer main segment. All design calculations shall be sealed by a professional engineer licensed in the state where the Project is located.
3. Type of resin or pipe material.
4. Method and materials for sealing liner at manholes.

C. Other Documentation:

1. Pre and Post-Installation CCTV.
2. Documentation of any corrective actions taken to address any defects. This will include stationing.

302.4 Quality Assurance

A. For a product to be considered commercially proven, a minimum of ten successful wastewater collection system projects for host pipes equal to or greater than the diameter of the largest pipe in this Project and in excess of 250,000 linear feet total shall be performed in the U.S. and documented to the satisfaction of the Owner to assure commercial viability. All successful projects must be equal to or larger in host pipe diameter to that which is included within this Project. The manufacturing process shall operate under a quality management system which is third party certified to ISO 9000 or other recognized standards. Proof of certification shall be required for approval.

B. For an installing company to be considered as commercially proven, the installer must satisfy all insurance, financial, and bonding requirements of the Owner, and must have had at least 5 years active experience in the commercial installation. In addition, the installer must have successfully installed at least 250,000 linear feet of a cured-in-place product in wastewater collection systems in the U.S. for host pipe equal to or greater than the diameter of the largest pipe in this Project. Acceptable documentation of these minimum installations must be submitted to the Owner. Installer's project manager assigned to this Project must have a minimum of 5 years of CIPP installation experience with the exact product and installing company intended for use with this bid.

302.5 System Description

If the inversion method is used, the tube is installed by utilizing an inversion standpipe and a hydrostatic head or air pressure. The resin is cured by circulating hot water or introducing controlled steam within the tube. If the tube is pulled into the existing wastewater main, it is placed flat and pressed out against the old pipe by inverting a calibrating hose through the center of the liner using water pressure. The resin is cured by circulating hot water through the liner. When cured and complete, the installed pipe shall extend from one manhole to the next in a continuous, tight-fitting, corrosion resistant, watertight pipe within a pipe.

302.6 Materials

A. Cured In Place Pipe:

1. Liner Hose:
   a. Inversion Flexible Felt Tube: The tube shall consist of one or more layers of flexible needled felt material or an equivalent non-woven or woven material capable of carrying resin and withstanding installation pressures and curing temperatures. The felt tubular material shall be lined on one side with a translucent waterproof coating such as polyurethane or polyvinylchloride (PVC) and be fully impregnated with a liquid thermosetting polyester resin and catalyst system compatible with the inversion process. The resin must be able to cure in the presence of water and the initialization temperature for cure shall be less than 180 F (82.2 C). The tubing shall be properly sized to the diameter of the wastewater pipe and the length of the

wastewater main to be rehabilitated and be able to stretch to fit irregular pipe sections and bends.

2. Pulled-In Felt Hose Fabrication: The construction of the lining hose shall be as follows:

   a. Resin absorbing first inner layer of polyester felt.
   b. Impermeable second layer of thin film polyester.
   c. Resin absorbing outer layer or layers of polyester felt.

3. The lining hose shall be capable of carrying resin, withstanding installation pressures, and curing temperatures, and be able to stretch to fit irregular pipe sections and bends. The lining hose shall be prefabricated to the appropriate diameter and thickness and shall be cut to the length necessary for the line being rehabilitated.

B. Properties: The cured pipe material shall meet the minimum chemical resistance requirements of ASTM F1216, Appendix 2, and shall conform to the minimum structural standards listed below:

Note to Specifier: 250,000 is acceptable for =<24-inch pipe, use 400,000 for > 24 inches.

Cured Pipe Material Test	Test Method Standard	Results
Flexural Stress	ASTM D790	4500 psi
Flexural Modulus of Elasticity	ASTM D790	**[250,000] [400,000]** psi

C. Tube Design: The tube shall be designed in accordance with ASTM F1216 Appendix 1. The design shall be based on a **[fully deteriorated, partial or non-deteriorated gravity pipe condition]** and shall withstand the following service requirements:

Notes to Specifier:
Engineer to determine deterioration level as it will have an effect on the thickness of the liner.

The Modulus of Passive Soil Reaction value 1500 is a conservative value. This value ranges from 600-4000 depending on soil classification, compaction level and depth of cover. May be refined through geotechnical investigation.

Tube Design - Service Requirements	
Soil Density	120 lb./cu. ft.
Live Loading	HS-20
Maximum Depth of Soil Cover	**[XX]** feet
Maximum Ground Water Level	**[XX]** feet
Ovality	2%
Modulus of Passive Soil Reaction	**[1500]** psi
Minimum Safety Factor	2

Notes to Specifier:
Provide explanation of expected condition for ground cover and water level.

Delete the subparagraph below if you have stated the pipe is fully deteriorated.

D. Allowable Hydrostatic Head: The liner shall have an allowable hydrostatic head which is greater than the depth of the host pipe invert. The allowable hydrostatic head shall be determined for each size of liner as follows:

1. The instantaneous critical buckling pressure of typical installed liner (having the physical properties specified herein) shall be measured by actual hydrostatic tests performed under the supervision of a licensed professional engineer. Engineer shall determine the allowable hydrostatic head by reducing the instantaneous buckling pressure with respect to the predicted installation affects, ovality factor, maximum dimension ratio and long-term (50-year) physical properties.

2. A sealed engineer's report showing the analysis and determination of allowable hydrostatic head shall be provided to the Owner for each size of liner used.

Note to Specifier: Delete the "Source Quality Control" Article below for 24-inch and greater pipe sizes.

302.7 Construction Methods

Preparation

A. Contractor shall plan its Work after review of previous television inspection tape and reports prior to commencement of the actual liner inversion process. All point repairs must be satisfactorily completed, equipment and material mobilized, and the Owner's Representative shall be informed of the work schedules for liner installations.

1. Safety: Carry out operations in strict accordance with all OSHA and manufacturer's safety requirements, including scaffolding provisions and proper entry into confined spaces.

2. Cleaning: Clean the existing wastewater pipe and remove all internal debris out of the wastewater main immediately before the television inspection at a cost incidental to the insertion of the liner per Specification Item No. 315 "CCTV Inspection". Utilize a method of material removal and disposal which meets regulatory requirements and is acceptable to the Owner.

3. TV Inspection: Provide inspection of wastewater mains by NASSCO / PACP certified personnel specially trained in locating breaks, obstacles, and service connections by closed circuit television. Inspect the interior of the wastewater main to determine the location and extent of any structural failures. The location of any condition which may prevent proper installation shall be noted and corrected. A video tape and detailed log shall be supplied by the Contractor to the Owner. TV inspection shall meet requirements found in Standard Specification Item No. 315 "CCTV Inspection".

4. Flow Control: Make provision for the flow of wastewater around the section or sections of pipe designated for inversion and effective TV inspection at a cost incidental to the

insertion of the liner. Submit a flow control implementation plan for the Owner's approval prior to construction. At no time shall wastewater be pumped into the streets, alleys or storm drain systems. The pump and bypass lines shall be of adequate capacity and size to handle the flow. Bypass pumping shall meet standards outlined in Specification Item No. 330 "Wastewater By-pass Pumping". Take all necessary steps to prevent flooding of any residence or business. Contractor shall be liable for any damages incurred as a result of this Work.

5. Line Obstructions: Identify point repairs required such as heavy solids, dropped joints, intruding service connections, collapsed pipe, or obstructions that must be removed to permit the inversion or lining process to be completed. This Work must be identified and approved in writing by the Owner's Representative prior to the Work being completed by the Contractor. Point repairs and removal of obstructions that require excavation of the pipe and removal of existing pipe sections shall be considered a separate pay item.

Note to Specifier: Coordinate with measurement and payment section.

6. Water: Water for the rehabilitation work will be made available to the Contractor by the City from the nearest fire hydrant. Hauling, if required, will be at the Contractor's expense. Contractor shall use a double-check valve assembly to prevent backflow in the event of pressure failure. The backflow prevention device must be approved by the Owner's Representative.

7. Public Notification: Contractor shall make every effort to maintain service usage throughout the duration of the Project. In the event that an individual sanitary sewer connection or group of connections must be out of service to complete the Work, the maximum amount of time out of service for any property served by the sanitary sewer shall not exceed 8 hours. A public notification program shall be implemented by the Contractor. Contractor shall, at a minimum, contact each home or business connected to the sanitary sewer and inform them of the Work to be conducted and when the sewer will be off-line. Contractor shall also provide the following: parathion

    a. Written notice delivered to each home or business the day prior to the beginning of work being conducted on the section, with a local telephone contact number for the Contractor that the citizens can call to discuss the Project or any problems which could arise.

    b. Contact, in person, any home or business owner that cannot be reconnected within the time stated in the written notice.

Construction

A. Cured In Place Pipe Insertion:

1. Inversion Method:

    a. Wet-Out: Designate a location where the uncured resin in original containers and the fiber felt tube will be vacuum impregnated prior to installation. A resin/catalyst system compatible with the requirements of this method shall be used. The quantities of the liquid thermosetting material shall be sufficient to provide the thickness specified herein and to fill the volume of air voids in the tube with

additional allowances for polymerization shrinkage and the loss of resin through cracks and irregularities in the original pipe wall.

b. Inversion using Hydrostatic Head: The resin-impregnated felt tube shall be inserted through an existing manhole by means of an inversion standpipe capable of applying the hydrostatic head required to fully extend the tube to the next designated manhole or termination point. The tube shall be inserted into the inversion standpipe with the impermeable plastic membrane side out. At the lower end of the inversion standpipe, the tube shall be turned inside out and attached to the inversion standpipe so that a leak-proof seal is created. The inversion head shall be adjusted to be of sufficient height to invert the tube from manhole to manhole and to hold it tight against the existing pipe wall, producing dimples at side connections and flared ends at the manhole. Care shall be taken to prevent damage or failure of the felt tube as a result of overstressing due to the elevated curing temperatures prior to completion of the final cure.

c. Inversion using Air Pressure: The resin impregnated tube shall be inserted thru an existing manhole by means of an inversion process utilizing air pressure sufficient to fully extend the tube to the next designated manhole or termination point. The tube end shall be connected by an attachment so that a leak-proof seal is created with the impermeable plastic membrane side out. The inversion pressure shall be adjusted to cause the impregnated tube to invert from manhole to manhole and hold the tube tight against the existing pipe wall, producing dimples at side connections and flared ends at the manhole. Care shall be taken to prevent damage or failure of the felt tube as a result of overstressing due to the elevated curing temperatures prior to completion of the final cure.

d. Curing using Circulating Heated Water:

    i. After the inversion is completed, Contractor shall supply approved heat source and water recirculation equipment capable of delivering heated water throughout the section to uniformly raise the water temperature above the temperature required to achieve a final cure of the resin. This temperature 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 water supply. An additional gauge shall be placed between the impregnated felt tube and the host pipe in the downstream manhole at or near the bottom to determine the temperatures during cure. Water temperature in the line during the cure period shall not be less than 150 F nor more than 200 F as measured at the heat source return line. Initial cure shall be completed when inspection indicates the exposed portions of the pipe to be hard and sound and the remote temperature sensor indicates that an exotherm has occurred. The recirculation of the water and cycling of the heat exchanger to maintain the water temperature shall continue for the duration of cure recommended by the resin manufacturer, modified for the specific installation process chosen.

    ii. After completion of the heated water cure, cool the hardened pipe to a temperature below 100 F before relieving the static head in the inversion standpipe. Cool-down shall be accomplished by the introduction of cool water into the inversion standpipe to replace water being drained from a small hole

made in the downstream end. Care shall be taken in the release of the static head so that a vacuum will not be developed that could damage the newly installed pipe.

e. Curing using Steam

i. After the inversion is completed, Contractor shall provide steam generating equipment to distribute steam throughout the section and uniformly raise the temperature within the pipe above the temperature required to achieve a final cure of the resin. This temperature shall be as recommended by the resin/catalyst system manufacturer. The steam generating equipment shall be fitted with a suitable monitor to gauge the temperature of the outgoing stream. The temperature of the resin being cured shall be monitored by placing gauges between the impregnated tube and the existing pipe at both ends. Initial cure shall be completed when inspection indicates the exposed portions of the pipe to be hard and sound and the remote temperature sensor indicates that an exotherm has occurred. The steam generating equipment shall continue in operation for the duration of cure recommended by the resin manufacturer, modified for the specific installation process chosen.

ii. After completion of the steam cure, cool the hardened cured-in-place liner down to a temperature below 100 F before relieving the internal pressure. Cool-down may be accomplished by the introduction of cool water into the section to replace the mixture of air and steam being drained from a small hole at the opposite end of the cured in place pipe, maintaining a constant internal pressure until cool-down is completed. Care shall be taken in the release of the internal pressure so that a vacuum will not develop that could damage the newly installed pipe.

Note to Specifier: The pull-in method is not as applicable with larger diameter applications as it can cause the liner to be thicker due to the stresses during the pulling.

2. Pulled-In Method:

a. Resin Impregnation: In an air-conditioned facility a vacuum system shall be connected to the felt hose to remove the air from the felt and the inner layer impregnated with an amount of resin that exceeds saturation. By means of a conveying system the lining hose shall be run through a pair of rollers that have been preset so the hose will have the desired thickness. After this impregnation (wet out) is complete the felt hose shall be transported to the Site in a refrigeration truck. Just prior to insertion the impermeable second layer shall be perforated to form a plurality of flow through openings for the resin.

b. Insertion of the Liner: Erect an inversion tower over the manhole and place the down pipe in the manhole with a 90-degree bend connected at the bottom. Run a cable from the manhole through the line to the termination point and the beginning of an auxiliary (calibration) hose inserted into the down pipe, turned over and affixed to the outside of the 90-degree bend. One end of the lining hose shall be put into the manhole at the termination point and tied to the cable. Winch the impregnated tube

through the line and fitted around the turned over region of the auxiliary hose on the 90-degree bend. Introduce water into the down pipe to provide lubrication. The pressure shall cause the turned over region of the auxiliary hose to gradually advance through the lining hose. Connect a 3-inch water hose on a nylon rope to the opposite end of the auxiliary hose. As the inversion of the auxiliary hose continues, pull the 3-inch hose and rope through the line. Shape the lining hose to conform to the line of the pipe by using the pressure head of the water. The pressure exerted on the lining hose shall cause the escape of the excess resin from the inner layer through the flow-through openings of the second layer so that the resin is absorbed by the outer layer which contacts the interior surface of the pipe.

c. Curing:

i. Pump water from the down pipe through a heater and return it to the auxiliary hose by means of the 3-inch hose that was pulled to the termination point during the inversion process. Through this cycling process the water inside the auxiliary hose shall be uniformly heated to achieve curing of the resin, bonding the lining hose to the pipe. To monitor the curing process the heater shall be fitted with gauges for both the incoming and outgoing water, and a gauge shall be placed between the impregnated tube and the pipe invert at the termination point. Initial cure will occur during temperature heat-up and is completed when exposed portions of the new pipe are found to be hard and sound and the remote temperature sensor indicates that the temperature is of a magnitude to achieve an exotherm or cure in the resin. After initial cure is reached, the temperature shall be raised to the post cure temperature. The cure temperatures and durations shall be as recommended by the resin manufacturer, as modified for the specific installation process. During this time, the recirculation of the water and cycling of the heat exchanger to maintain the temperature shall continue.

ii. The new pipe shall then be cooled to a temperature below 100 F before relieving the static head in the inversion standpipe. Care shall be taken while releasing the static head to avoid creating a vacuum. After the process is complete, the 3-inch hose and auxiliary hose shall be removed from the line by retracting the nylon rope.

Field Quality Control

Note to Specifier: Exclude low pressure air test for 20-inch and larger pipe sizes.

A. Testing: Check the water tightness of the liner after curing. Hold the water pressure inside the pipe at 4.3 psi for at least 4 hours prior to service line connections.

B. Inspection:

1. CIPP samples shall be prepared for each installation designated by the Owner/Engineer or approximately 20 percent of the Project's installations. Pipe physical properties will be tested in accordance with ASTM F1216 (or ASTM F1743, Section 8,) using (either method, if pipe is larger than 24 inches on the plate method is applicable. Delete previous bolded reference to ASTM F1743 if only plate method is to be utilized). The flexural properties must meet or exceed the values listed in Paragraph [2.01.A.2], Table

1 of ASTM F1216 or the values submitted to the Owner/Engineer by the Contractor for this Project's CIPP wall design, whichever is greater.

Note to Specifier: Delete reference to ASTM F1743 in the subparagraph below if pipe is larger than 24 inches.

C. Wall thickness of samples shall be determined as described in **[ASTM F1743 or ASTM F1216]**. The minimum wall thickness at any point shall not be less than 87.5 percent of the submitted minimum design wall thickness as calculated in Paragraph 5.6 of this document.

D. Contractor shall provide continuous thermal monitoring to ensure proper curing conditions are achieved. This shall be accomplished by Vericure or approved equal. The approved equal requirement is as defined in Division 01 of the Specifications.

Note to Specifier: Delete reference to ASTM F1743 in the subparagraph below if pipe is larger than 24 inches.

E. Visual inspection of the CIPP shall be in accordance with **[ASTM F1743 or ASTM F1216]**, Section 8.6.

F. After the Work is completed, the Contractor shall provide the Owner with a videotape showing both the before and after condition, including the re-installed building lateral connections. The finished pipe shall be continuous over the entire length of an inversion run between two manholes and shall be free from significant defects. Any defects which, in the opinion of the Engineer or Owner, will affect the integrity or strength of the pipe in the foreseeable future or warranty period shall be repaired at the Contractor's expense, in a manner acceptable to the Owner.

Adjusting

A. Sealing Pipe in Manholes: After installation, the liner shall be cut flush with the existing pipe at the manhole walls. The invert of the manhole shall be reworked (smoothed and built up) to match the flow line of the new liner pipe. Both ends of the new liner shall be sealed to the existing pipeline structure with LMK seals or approved equal in order to lock the liner in place and to prevent water movement between the two systems. If the installed pipe fails to make a tight seal due to a broken or misaligned wastewater pipe at the manhole, apply an approved sealant or use some other method approved by the Owner to seal the connection. The sealant shall be compatible with materials used in the lining process.

B. Service Connections:

1. Identify, locate, and excavate all sanitary sewer service connections prior to the pipe insertion to expedite reconnection unless approved otherwise by the Engineer or Owner's Representative. Once installation is started, pipe insertion shall be continuous and without interruption from one manhole to another except as approved by the Owner. Upon completion of insertion of the new pipe, the Contractor shall expedite the reconnection of services to minimize any inconvenience to the customers.

Note to Specifier: The subparagraph below is for externally excavated taps, delete if not used.

C. Mechanical saddles for polyethylene pipe shall be made of polyethylene pipe compound that meets the requirements of ASTM D1248, Class C, and they shall have stainless steel straps and fasteners, neoprene gaskets and backup plates. Mechanical saddles shall be heat fusion saddles, such as Strap-On-Saddle Type as manufactured by Driscopipe, Tapping Saddle manufactured by Fernco Joint Sealer Company, DFW Plastics, Inc., or approved equal. Once the saddle is secured in place, drill a hole equal to the full inside diameter of the saddle outlet in the pipe liner.

D. At all points where the new pipe has been exposed, as in starter excavations, at service connection fittings, outside of manholes, etc., encase the pipe and fittings with a minimum thickness of 6 inches of concrete, sand cement backfill, or flowable fill as specified in Specification Item No. 120 “Utility Trenching and Backfill”. If sand cement backfill or flowable fill is used, remove all debris and create a void space along each side of the pipe at the spring line to undisturbed soil in preparation for the backfill or flowable fill. The width of the void shall not exceed the outside diameter of the main or service line plus 2 feet.

Note to Specifier: The subparagraph below is for internal cutting of service connections. This is only to be used where excavations are impractical, otherwise delete.

E. **[Certain]** Branch connections or laterals to buildings are to be reopened without excavation, utilizing a remote-controlled cutting device, monitored by a video TV camera. Contractor shall furnish certification that he has a minimum of two complete working cutters plus spare key components on the Site before each inversion. Unless otherwise directed by the Owner or its authorized representative, all service connections shall be reinstalled. No additional payment will be made for excavations for the purpose of reopening connections, and the Contractor shall be responsible for all costs and liability associated with such excavation and restoration Work.

302.8 Measurement

Cured-In-Place pipe will be measured by the linear foot of pipe complete in place. Such measurement will be made between the ends of the pipe along the central axis as installed.

302.9 Payment

The work performed and materials furnished as prescribed by this item and measured as provided under "Measurement" will be paid for at the unit bid price per linear foot for "Cured-in-Place Pipe”, of type, size and class of encasement pipe indicated on the Drawings. The price shall include full compensation for furnishing, preparing, hauling and installing required materials, Cured-in-Place Pipe and for labor, tools, equipment and incidentals necessary to complete work, including pre and post construction CCTV, excavation, backfilling and disposal of surplus material.

Payment when included as a contract pay item, will be made under one of the following:

Pay Item: Cured-In-Place __ in. Pipe, Class ___ Per Linear Foot.

End