SPECIAL SPECIFICATION

7654

Cured-In-Place Pipe (CIPP)

1. **Description.** It is the intent of this specification to provide for the reconstruction of existing structurally sound storm sewer pressure pipelines by the installation of a cured-in-place (CIPP) pressure pipe lining system. The cured-in-place pipe (CIPP) shall provide flow capacity equal to or greater than the original pipes’ flow capacity when new. The pipe lining is designed to span and seal pinholes, eliminate leakage through joints and prevent internal corrosion and/or erosion in structurally sound pressure pipe.

The installation of the “CIPP” shall be accomplished by the inversion and curing of a resin-impregnated tube or approved equal process. The process is defined as the reconstruction of sewer lines by installation of a thermosetting resin impregnated flexible fiber reinforced felt tube coated on one side with an impermeable flexible membrane such as polyethylene or polyurethane which is inverted into the existing sewer line utilizing a water column. Curing is accomplished by circulating hot water (or other approved fluid) throughout the length of the inverted tube to cure the thermosetting resin into a hard impermeable pipe with flexible membrane coating on the inside surface of the new pipe. The formed pipe shall extend the full length of the original pipe and shall provide a structurally sound, jointless, close-fitting, cured-in-place pipe. The tube wall thickness shall be designed by the Contractor based on the existing host pipes’ size and pressure requirements.

The contractor may propose a proven alternate method of “CIPP” instead of the procedure described in this specification. Such a proposal shall be submitted to the engineer for review and approval prior to its use on this project. The alternate method must meet all the requirements of this specification.

The following information shall be submitted to the engineer for approval of alternate methods:

- Product data including physical properties and material specifications.
- Installation method and specifications.
- Testing methods and third party test data.
- Design criteria and limitation of process
- List and size of completed projects in USA
- List and size of current projects in USA
- References (name & telephone numbers)
The Engineer will not consider an alternate method which does not have a proven track record of the successful installation of the material in the quantities and sizes of pipe specified in the plans or as directed by the Engineer.

The inversion process is patented and shall be installed only by licensed contractors. The contractor shall warrant to the state that the methods, materials and equipment used herein, where covered by license are furnished in accordance with such license and the prices included in this proposal include applicable royalties and fees in accordance with such license. The contractor shall warrant and save harmless the state and his engineer against all claims for patent infringement and loss thereof.

2. **Submittal.** The following items shall be submitted to the engineer for approval prior to their use on this project

   A. **Resin.**
      
      1. Submit technical data sheet showing physical and chemical properties.
      
      2. Submit test results to show compliance with ASTM C581.

   B. **Flexible Tube.** Submit technical data sheet showing physical properties

3. **Materials.**

   A. **General.** The flexible fiber reinforced felt tube shall be fabricated to a size that when installed will neatly fit the internal circumference of the conduit specified in the plans. An allowance shall be made for some circumferential stretching during inversion. The Contractor is responsible for determining the tube materials and layers necessary for the specified conditions.

   The minimum length shall be that deemed necessary by the contractor to effectively span the distance from the inlet to the outlet of the respective manholes unless otherwise specified in the plans. The contractor shall verify the lengths in the field before impregnation of the tube with resin. Individual inversion runs can be made over one or more manhole sections as determined in the field by the contractor and approved by the Engineer.

   The outside of the tube, before installation shall have an impermeable plastic coating. This coating will form the inner layer of the finished pipe and is required for enhancement of corrosion, flow, and abrasion properties. It shall be a translucent flexible material that clearly allows inspection of the resin impregnation (wet-out) procedure.

   The layers, which constitute the pipe wall, must be such that when the thermosetting resin cures, the total wall thickness must be homogeneous with no internal layer of plastic which might weaken the pipe wall and allow internal shear. When cured the “CIPP” must form a mechanical bond with the conduit.

   The Contractor shall furnish to the Engineer, prior to use of the lining material, satisfactory certification from an approved testing laboratory as to the results of testing the proposed lining material.
In addition to the above structural requirements, satisfactory evidence shall be provided by the Contractor to the Engineer that the proposed lining material will incorporate a pre-approved resin that is suitable for chemical resistance.

The finished “CIPP” shall be continuous over the entire length of inversion run and be as free as commercially practicable from visual defects such as foreign inclusions, dry spots, pinholes and delamination. It shall also meet the leakage requirements or pressure test specified. Any defects which will affect the integrity or strength of the “CIPP” shall be repaired at the contractor’s expense.

B. **General Corrosion Requirements.** The CIPP shall be fabricated from materials which when cured will be chemically resistant to withstand internal exposure to domestic sewage and hydrocarbons.

C. **Physical Strength.** Unless otherwise specified, the Contractor shall furnish a vinyl ester resin and catalyst system compatible with the inversion process that provides cured physical strengths specified herein.

1. **Design.** Detailed design calculations for both internal and external loading conditions shall be submitted for review and approval. The design working pressure of the force main is 15 psi. The CIPP shall be designed as per ASTM F1216, Appendix X1.3.1 for the Partially Deteriorated Pressure Pipe condition. These detailed calculations shall provide the input data as well as the actual calculations for Eqs X1.1, X1.5, and X1.6 of Appendix X1. of ASTM F1216. The design submittal shall also clearly identify the physical properties used for design.

The physical properties used in the design submittal shall be clearly identified. These physical properties shall be the basis for the acceptance of submittals of field samples and the acceptance of the final product. At a minimum, the pipe lining shall have the following physical properties:

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>ASTM TEST METHOD</th>
<th>MINIMUM VALUE*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Flexural Modulus of Elasticity</td>
<td>D790</td>
<td>300,000 PSI</td>
</tr>
<tr>
<td>Initial Flexural Strength</td>
<td>D790</td>
<td>7,000 PSI</td>
</tr>
<tr>
<td>Initial Tensile Strength</td>
<td>D638</td>
<td>6,000 PSI</td>
</tr>
</tbody>
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*Value are for design conditions @ 75°F (25°C)

The external hydrostatic load design (as per Eq. X1.1 of ASTM F1216) shall be based on an enhancement factor (K) of 7.0, an ovality (q) of 0%, a Poisson’s ratio of 0.3, and a factor of safety of 2.0. The long-term (time-corrected) flexural modulus of elasticity shall be determined by multiplying the design initial flexural modulus of elasticity by a creep retention factor (C_\text{f}) . At a minimum, a creep retention factor of 50% shall be applied.

The pipe lining shall also be capable of withstanding instantaneous transient vacuum occurrences. For the instantaneous transient vacuum load condition, the design shall also be based on Eq. X1.1 of ASTM F1216. It is assumed that the
internal vacuum effect is similar to the external loading of groundwater. The design shall be based on an enhancement factor (K) of 7.0, an ovality (q) of 0%, a Poisson’s ratio of 3.0, the initial flexural modulus of elasticity, and a total design factor of safety of 3.0, which consists of a cyclic vacuum loading design factor of 2.0 and a additional factor of safety of 1.5.

The pipe lining shall be designed to span over any small holes that exist in the pipeline (as per Eq. X1.6 of ASTM F1216), under the normal internal pressure design conditions. For the hole spanning condition, the design shall be based on a factor of safety of 2.0 and a flexural strength, reduced to account for long-term effects, equal to 1/3 of the initial design flexural strength.


A. Reference Specifications. This specification references ASTM F1216 (Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube), ASTM F1743 [Rehabilitation of Existing Pipelines and Conduits by Pulled-in-Place Installation of a Cured-in-place Thermosetting Resin Pipe (CIPP)] and ASTM D790 (Test Methods for Flexural Properties of Unreinforced Plastics) which are made a part hereof by such reference and shall be the latest edition and revision thereof. In case of conflicting requirements between this specification and these referenced documents, this specification will govern.

B. Material on Hand. The contractor shall have on hand sufficient material to perform the work he/she is assigned within (10) days of notice to proceed.

The existing sewers, where designated or required, shall be lined using materials and workmanship which can be adapted to the restrictions of the work site. The Contractor shall not begin this phase of the work until there is sufficient materials on hand to complete the job.

C. Pre-Installation. The following installation procedures shall be adhered to unless otherwise approved by the Engineer.

1. Safety. The Contractor shall carry out his operations in strict accordance with all applicable OSHA standards. Particular attention is drawn to those safety requirements involving work on an elevated platform and entry into a confined space or the use of steam.

Prior to entering access areas (such as manholes) and performing inspection or cleaning operations, the Contractor shall make an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen. This shall be undertaken in accordance with local, state, and federal safety regulations.

2. Pre-Inversion Cleaning. It shall be the responsibility of the Contractor to remove all loose debris which is located within the sewer pipe. Pipes shall be cleaned by the Contractor, as needed, with high-velocity jet cleaners, mechanically powered equipment, cable-attached devices, fluid-propelled devices (e.g., pipe pigs), or other methods acceptable to the Engineer.
3. **Pre-Inversion Inspection.** Inspection of sewer pipe shall be performed by experienced personnel trained in locating breaks, obstacles and service connections by closed circuit television inspection. The interior of the pipe shall be carefully inspected to determine the location of any conditions which may prevent proper installation of the “CIPP”, 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 Engineer.

4. **By-Passing Runoff.** The contractor shall provide for the flow of water around the section or sections of pipe that are to be lined. The by-pass 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 by-pass lines shall be of adequate capacity to handle the flow.

5. **Line Obstructions.** If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, such as heavy solids, dropped joints, protruding service connections or collapsed pipe that will prevent completion of the inversion process, then a point repair excavation shall be made by the Contractor as approved by the Engineer to uncover and remove or repair the obstruction. Known obstructions to be repaired will be shown on the plans.

6. **Coordination.** The general contractor is responsible for coordination between the CIPP installation and other work being done in this project.

5. **Installation Procedures.**

   A. **Wet Out.** The tube shall be vacuum-impregnated (wet-out) with resin under controlled conditions. The quantity of resin used for the tube impregnation shall be sufficient to fill the volume of air voids in the tube with additional allowances for polymerization shrinkage and loss of resin through cracks and irregularities in the original pipe wall.

   The Contractor shall designate a location where the tube will be vacuum impregnated prior to installation. To ensure a thorough wet out, the point of vacuum shall be no further than 25 feet from the point of initial resin introduction. After vacuum in the tube is established, the vacuum points shall be no further than 75 feet from the leading edge of the resin. The leading edge of the resin slug shall be as near to perpendicular as possible. Vacuum points shall be sealed as they are vacated. A roller system shall be used to uniformly distribute the resin throughout the tube. The Contractor shall allow the Engineer to inspect the materials and procedures used to vacuum impregnate the tube.

   B. **Insertion.** The existing pipeline shall be dewatered and free of incoming water. If water is present, measures shall be taken to minimize contact of the water with the inverting tube.

   The wet out tube shall be inserted through an existing manhole or approved access point by means of an inversion process and the application of a hydrostatic head sufficient to extend it to the next designated manhole or termination point.

   Before the installation begins, the Contractor shall determine the minimum pressure required to hold the tube tight against the existing pipeline, and the maximum allowable
pressure so as not to damage the tube. Once the installation has started, the pressure
shall be maintained between the minimum and maximum pressures until the installation
has been completed. Tube installation forces or pressures shall be limited so as not to
stretch the tube longitudinally by more than 5% of the original length.

The use of a lubricant during inversion may be needed to reduce friction. The lubricant
used shall be a nontoxic product that has no detrimental effects on the tube or boiler and
pump system, shall not support the growth of bacteria, and shall not adversely affect the
fluid to be transported.

C. Curing. After installation is completed, suitable heat source and water recirculation
equipment shall be used to circulate heated water throughout the pipeline. The
equipment shall be capable of delivering hot water throughout the pipeline to uniformly
raise the water temperature required to effect a cure of resin. Water temperature in the
line during the cure period shall be determined by the Contractor.

The heat source shall be fitted with suitable monitors to gauge the temperature of the
incoming and outgoing water or steam supply. To determine the temperatures during
the cure cycle, a gauge shall be placed at the beginning and termination points between
the impregnated tube and the invert of the existing pipe. The temperature of the cure
water shall be monitored at the termination end by placing a temperature probe through
a small hole in the tube, near the invert, into the cure water. The hole in the tube shall be
made such that the temperature probe fits tightly and minimizes cure water leakage.

Initial cure will occur during temperature heat-up and is completed when exposed
portions of the new pipe appear to be hard and sound and the remote temperature sensor
indicates that the temperature is of a magnitude to realize an exotherm or cure in the
resin. After initial cure is reached, the temperature shall be raised to the post-cure
temperature as determined by the Contractor. The post-cure temperature shall be held
for a period as determined by the Contractor, during which time the recirculation of the
water and cycling of the boiler to maintain the temperature continues. The curing
process shall take into account the existing pipe material, the resin system, and ground
conditions (temperature, moisture level, and thermal conductivity of soil).

D. Cool-Down. The Contractor shall cool the hardened “CIPP” to a temperature below
90º degrees Fahrenheit before relieving the hydrostatic head. Cool water may be added
to the water column while draining hot water from a small hole at the opposite end of
the “CIPP” 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 be developed that could damage the newly installed “CIPP”. In addition, the cure
water incoming temperature during cool-down shall not decrease at a rate greater than
20ºF (11ºC) per hour.

E. Sealing at Manholes and Inlets. The “CIPP” material shall be extended upward to the
top of manholes and inlets. It shall be joined to the pipe lining and sealed and bonded to
the highest point of concrete as determined by the Engineer according to the
manufacturer’s specifications. The seal shall be a material compatible with the “CIPP”
material as specified by the manufacturer.
The Contractor shall install end seals at each of the “CIPP” beginning and termination points. The ends seals shall be a mechanical, expansion type, constructed of stainless steel and elastomeric rubber seals. The end seals shall be rated by the manufacturer for the operating pressure and shall be compatible with the piped fluid. The existing pipeline at the end seal installation points shall be structurally sound and free of any significant pitting or heavy corrosion. This is required to ensure an adequate seal between the “CIPP” and the existing pipeline. Otherwise, replacement with a new steel or concrete spool piece at these ends may be required.

Where CIPP runs continuously through a manhole, the manhole shall be sealed with grout after curing and setting as recommended by the manufacturer to aid in support of the CIPP.

F. **Other Service Connections.** After the “CIPP” has been cured in place, the Contractor shall reopen the existing active service connections as designated by the Engineer. This shall generally be done without excavation, and in the case of non-man entry pipe, from the interior of the pipeline by means of a television camera and cutting device that reestablishes the service connection to not less than 90% capacity. Cutting devices that use high pressure water shall not be used since they may cause damage to laterals. When fiberglass or other reinforcing fibers are used that may cause wicking at lateral openings, the lateral opening edges must be sealed with a resin mixture compatible with the tube resin.

G. **Inspection and Testing.** The installation shall be inspected visually, if appropriate, or by closed-circuit television if visual inspection cannot be accomplished. Variations from true line and grade may be inherent because of the conditions of the original piping. No infiltration of groundwater shall be observed.

The finished “CIPP” shall be continuous over the entire length of an installation run and be free of dry spots, lifts, and delaminations.

For each inversion length designated by the Engineer, one sample shall be prepared for physical property testing. The sample shall be fabricated from material taken from the tube and the resin/hardener system used and cured in a clamped mold placed in the downtube during the curing process.

The “CIPP” samples shall be large enough to provide a minimum of three specimens and a recommended five specimens for flexural testing and tensile testing.

The “CIPP” samples shall be tested in accordance with ASTM D790 and D638 to confirm that the required physical properties specified in the design submittal of the proposed product have been achieved.

The “CIPP” shall meet the chemical resistance requirements of Section 9.

H. **Chemical Resistance.** The “CIPP” system shall meet the minimum chemical resistance requirements of ASTM F1216, Table X2.1. Samples used for testing shall be of the same resin system and similar tube materials as that proposed for the project. It is required that “CIPP” samples without plastic coating meet these chemical testing requirements.
Chemical resistance tests shall be completed in accordance with ASTM Test Method D 543 with the chemical solutions shown in ASTM F1216, Table X2.1. Exposure shall be for a minimum of one month at 73.4°F (23ºC). During this period, the “CIPP” test specimens shall lose no more than 20% of their initial flexural strength and initial flexural modulus of elasticity.

I. **Clean-up.** Upon acceptance of the installation work and testing, the Contractor shall restore the project area affected by his operations.

6. **Measurement.** “Cured-in-Place-Pipe” will be measured by the actual linear foot. Such measurement will be made between the center-of-manhole to center-of-manhole on a reconstructed sewer pipe section.

These are plan quantity measurement items and the quantity to be paid for will be that quantity shown in the proposal and on the “Estimate and Quantity” sheets of the contract plans, except as may be modified by article 9.8. If no adjustment of quantities is required, additional measurements or calculations will not be required.

7. **Payment.** The work performed and materials furnished in accordance with this item including pre-inversion cleaning, point repairs, pre-inversion inspection, wet out of tube, insertion of tube, curing of tube, sealing “CIPP” in manholes, testing and cleanup, and measured as provided under “Measurement” will be paid for at the unit price bid for the various bid sizes as stipulated by the outside diameters of the existing pipe to be lined as “Cured-in-Place-Pipe”. This price shall be full compensation for furnishing, hauling, placing and reinstating the project area affected by the Contractor’s operations, and for reopening the existing service connections from the interior of the pipe and all material, labor and equipment, tools, and incidentals necessary to complete the work.

The initial (first time) cleaning, point repairs, and television inspection work, if required, will be considered incidental to the work performed and subsidiary to this item.

Payment for bypassing the storm sewer during the construction operation by measures as approved by the Engineer will not be paid for directly but will be considered subsidiary to this item.