SPECIAL SPECIFICATION

5256

Cured-In-Place Pipe (Sanitary Sewer)

1. **Description.** Furnish and install cured-in-place pipe.
   
   A. Resin-impregnated flexible tubes inserted into existing sewers, expanded against the existing sewer interior surfaces, and cured by circulating heated water, steam, or ambient temperature water or air, throughout the tube from manhole to manhole.
   
   B. CIPP cures into a hard, impermeable, corrosion-resistant liner of specified thickness and physical properties, with a uniformly smooth interior surface.
   
   C. CIPP Material and Installation: Comply with ASTM D 5813, ASTM F 1216, and ASTM F 1743, as modified by this specification. The Department reserves the right to approve materials or installation practices which differ from these standards.

2. **References.** Approved methods and materials for the rehabilitation of deteriorated gravity sewer lines by the Cured-In-Place Pipe (CIPP) method. The following references will apply:
   
   
   
   
   
   E. ASTM D 3567 - Standard Practice for Determining Dimensions of Reinforced Thermosetting Resin Pipe (RTRP) and Fittings.
   
   
   G. ASTM D 5035 - Test Method for Breaking and Elongation of Textile Fabrics (Strip Method).
   
   
   I. ASTM D 5813- Standard Specification for Cured-In-Place Thermosetting Resin Sewer Pipe.
J. ASTM E 1252 - Standard Practice for General Techniques for Qualitative Infrared Analysis.

K. ASTM F 1216 - Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube.

L. ASTM F 1743 - Standard Practice for the Rehabilitation of Existing Pipelines and Conduits by the Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP).


A. Resin.

1. Submit product data stating physical and chemical properties.
2. Submit results of testing performed by resin manufacturer demonstrating compliance with specified chemical resistance requirements.
3. Submit manufacturer-certified infrared spectrum analysis (chemical fingerprint) of proposed resin system in accordance with ASTM E 1252.

B. Flexible Tube.

1. Submit product data stating physical properties meeting ASTM D 5035.
2. Submit tabular summary by sewer segment noting required CIPP thickness specified. Provide certification that liner’s “dry” thickness meets or exceeds the required cured laminate thickness(es). Measure thickness in accordance with ASTM D 5199.

C. Cured-In-Place Pipe.

1. Submit field measurements of cured liner thickness for determining payment.
2. Submit representative sample(s) of the cured liner required for testing in accordance with ASTM D 790.
3. Submit post-installation television inspection tapes as specified in “Sanitary Sewer (Television Inspection)”.

4. Products.

A. Quality Assurance. During the course of the Work, make no substitutions of materials, design values or procedures for those specified without the prior written approval of the Engineer.

B. Approved Manufacturers. Refer to Table 1 for City of Houston Approved Products List for acceptable product manufacturers.
Table 1
City Of Houston Approved Products List

<table>
<thead>
<tr>
<th>Product Description</th>
<th>Manufacturer Trade Name</th>
<th>Spec. No. ASTM</th>
<th>Size Range Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cured In Place Pipe</td>
<td>First Inliner USA</td>
<td></td>
<td>72 and smaller</td>
</tr>
<tr>
<td></td>
<td>Inliner Technologies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Insituform</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>National Liner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cured In Place Pipe</td>
<td>Novapipe</td>
<td>ASTM F-1216, F-1743</td>
<td>3 - 96</td>
</tr>
</tbody>
</table>

1. Do not use products of manufacturers not noted on this list
2. Use current list in effect as of the specified bid date and time for this project.

C. Materials, Flexible Tube.

1. Provide flexible tube manufactured and fabricated under manufacturer’s quality-controlled conditions. Use tube sized so as to snugly fit the internal circumference of the existing sewer and produce specified cured thickness and physical properties.
2. Tube Length: Fully and continuously span the distance between manholes, including sufficient material for sealing at manholes and product sampling (when required).
3. Fabric tube minimum tensile strength in both longitudinal and transverse directions, when tested in accordance with ASTM D 5035: 750 psi.
4. Identify all tubes with manufactured thickness when tested in accordance with ASTM D 5199.
5. Resin for Tube Saturation: Liquid thermosetting polyester, vinyl ester, or epoxy resin meeting specified requirements.

5. Testing Requirements.

A. Manufacturer’s Chemical Resistance Testing. Perform chemical resistance testing of resin in accordance with ASTM C 581, as modified herein. Perform testing to demonstrate chemical resistance to a solution with a pH of 0.5 and a solution with a pH of 10. Use reagents or solutions as required to establish and maintain the minimum and maximum pH values specified for the duration of the testing. Exposure to the minimum and maximum pH values will produce an average loss of not more than 20 percent in the initial flexural properties for each test interval, and an average loss of not more than 15 percent for a period of one year, as determined according to ASTM D 790. Perform testing at a temperature of 73.4 F (plus or minus 3.6 F). Test specimens will not have more than 1.5 percent gain or loss in weight over a period of one year. Test frequency and sample preparation: Follow ASTM C 581.

B. Test Results. Submit test results including at least the following.

1. Raw data for each test specimen for each test interval performed.
2. Calculated average test results for each test interval.
3. Using calculated averages for each test interval, calculate the average test result for the duration of testing.


A. **Minimum CIPP Thickness after Curing.** Refer to Table 2 for minimum CIPP thickness after curing based on the maximum sewer invert depth for the segment being rehabilitated.

<table>
<thead>
<tr>
<th>Nominal Sewer Diameter (Inches)</th>
<th>Maximum Pipe Segment Invert Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up to 10 Feet</td>
</tr>
<tr>
<td>6</td>
<td>4.5</td>
</tr>
<tr>
<td>8</td>
<td>6.0</td>
</tr>
<tr>
<td>10</td>
<td>6.0</td>
</tr>
<tr>
<td>12</td>
<td>6.0</td>
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<tr>
<td>15</td>
<td>7.5</td>
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<tr>
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<td>48</td>
<td>22.5</td>
</tr>
<tr>
<td>54</td>
<td>25.5</td>
</tr>
<tr>
<td>60</td>
<td>28.5</td>
</tr>
</tbody>
</table>

B. **CIPP Minimum Flexural Properties, after Curing.** Refer to Table 3.

<table>
<thead>
<tr>
<th>Property</th>
<th>Reference</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural Strength (Modulus of Rupture)</td>
<td>ASTM D 790</td>
<td>4,500 psi</td>
</tr>
<tr>
<td>Tangent Modulus of Elasticity</td>
<td>ASTM D 790</td>
<td>250,000 psi</td>
</tr>
</tbody>
</table>

7. Field Testing.

A. **Flexible Tube Thickness.** Prior to wet-out; provide access to all flexible tubes intended for the use on the project. Clearly identify flexible tubes with their manufactured thickness. Do not use flexible tubes which fail to meet the specified thickness. Testing will be performed in accordance with ASTM D 5199.

B. **Infrared Spectrum Analysis (Chemical Fingerprinting).** Provide access to the resin intended for the use on the project for sampling and chemical fingerprint testing. All testing will be performed in accordance with ASTM E 1252. If sample fails test, work is non-conforming. See Article 13. Non-Conforming Work.

C. **Physical Property Testing.** Post installation physical property testing of the cured composite tube will be performed in accordance with ASTM D 790. Provide sufficient
samples for conducting the testing required under ASTM D 790. If sample fails test, work is non-conforming. See Article 13. Non-Conforming Work.

D. **Cured-in-Place Pipe Thickness.** Caliper or other suitable measuring device will be used to test liner thickness. Perform testing for thickness on the samples prepared for physical property testing. All calibration tubes or other non-structural linings and coatings will be removed prior to the testing for thickness. Test the sample at three locations and the average thickness measured will be taken as the actual thickness of the cured-in-place pipe for the impacted segment. If sample fails test, work is non-conforming. See Article 13. Non-Conforming Work.

8. **Execution.**

   A. **Pre-installation Cleaning and Television Inspection.** Perform a pre-installation television inspection as specified in “Sanitary Sewer (Television Inspection)”. Verify that sewer is clean and pipe conditions are suitable for installation of the CIPP. Notify Engineer if conditions exist which will impact the installation.

   B. **Obstruction Removal, Point Repair and Sag Elimination.**

      1. If pre-installation video inspection reveals an obstruction in the line segment (such as heavy solids, dropped joints, protruding service connections or collapsed pipe) that cannot be removed by conventional sewer cleaning equipment and the obstruction will prevent completion of the insertion process, perform point repairs or obstruction removal prior to CIPP installation. Obtain approval of the Engineer before performing work. Perform the following sequence:

         a. After the location of a point repair, excavate the required length for the point repair.

         b. Prior to replacing pipe, determine condition of the existing line on both sides of the point repair by lamping the line at least 10 feet in each direction. Determine whether additional lengths of line (beyond "minimum length" criteria) need replacement. Report need for additional replacement to the Engineer and obtain authorization before proceeding.

         c. Remove the damaged pipe and replace with new pipe, shaping the bottom of the trench and placing the required pipe bedding so that the grade of the replaced pipe matches the grade of the existing line. Establish proper grade for the pipe being replaced using methods acceptable to the Engineer.

         d. Connect the new pipe to existing pipe using flexible adapters. If joints cannot be made watertight using flexible adapters, place waterstop gaskets on each joint and encase in a reinforced concrete collar as indicated on Detail “Sanitary Sewer Pipe Transition for 36" Sewer and Smaller”. Place concrete as specified in Item 420 “Concrete Structures”. Reconnect affected service connections or stacks using full-bodied fittings. No field fabrication of fittings allowed.

         e. After completion of point repair, but prior to backfill, perform a low pressure air test to demonstrate the integrity of the repair, in the presence of the
Engineer. Test as specified in Item 5244, “Sanitary Sewers”. Repair and retest sections that fail until repair passes test.

f. Encase exposed pipe in cement stabilized sand complying with Item 400 “Excavation and Backfill for Structures”.

g. Backfill the excavation as specified in Item 400, “Excavation and Backfill for Structures”.

2. If pre-installation video inspection reveals a sag in the sewer that has a vertical displacement greater than one-half the pipe diameter, eliminate the sag by performing a point repair or by removal and replacement of the sewer segment. Obtain approval of the Engineer before performing work.

3. Remove obstructions identified on videotape of a sanitary sewer line segment which could cause a non-uniform liner pipe installation or obstruction of the liner during installation. Obtain authorization from the Engineer for obstruction removal with a remote device before proceeding.

   a. Use a power-driven cutting device (robotic cutter) to remove protruding taps. Cut protruding taps so that protrusions are no greater than 3/4 in. If a protruding tap cannot be removed by the cutting device, then a point repair may be performed. Obtain authorization from the Engineer before proceeding.

   b. To remove other obstructions, use a remote device. Pull or drive the device from manhole to manhole up to a continuous length of 500 ft. using a solid steel mandrel, porcupine, root saw, bucket, robotic cutter or similar device to remove the obstruction. Select a device that is adequately sized to remove the obstruction.

4. **Excavation.** Use excavation as the method of obstruction removal when installation of the liner in the sanitary sewer is in progress. If during the liner insertion operation, a collapsed sewer, off-set joint or other obstruction is encountered which prevents or blocks the passage or insertion of the liner, notify the Engineer for authorization to excavate. Uncover and remove the obstruction as follows:

   a. Excavate at the point where there is an obstruction. Use a trench safety system as required.

   b. Break out the existing sanitary sewer pipe (carrier pipe) as directed by the Engineer. Remove only that amount of material which is causing the obstruction. Remove the minimum amount of carrier pipe. Under such conditions, replacement of the carrier pipe is not required. Do not disturb the existing sewer bedding during excavation. However, if embedment is disturbed during the obstruction removal procedure, place cement-stabilized sand or crushed stone beneath the liner.
c. When the liner is completely in place, encase it with crushed stone or cement-stabilized sand as shown on Detail “Sanitary Sewer Embedment and Trench Zone Backfill for dry or wet stable trench”.

C. Diversion Pumping.

1. Maintain commercial and residential sanitary sewer service during the installation process.

2. Install and operate diversion pumping equipment to maintain sewage flow around the segment of pipe being rehabilitated, and to prevent backup or overflow, as specified in Special Specification, “By-Pass Pumping (Sanitary Sewer).

D. Installation Procedures.

1. Notification. Inform the Engineer of work schedules for CIPP installation. Provide 24-hour notice so that the Engineer may witness the “wet-out” procedure. Provide 24-hour notice so that the Engineer may witness inversion and curing of liner.

2. Conduct operations in accordance with applicable OSHA standards, including safety requirements involving work on elevated platforms and entry into confined spaces. Take suitable precautions to eliminate hazards to personnel near construction activities when pressurized air is being used.

3. Wet-out. Designate a location where the flexible tube will be impregnated with resin. Thoroughly saturate flexible tube prior to installation. Use catalyst systems or additives compatible with resins and flexible tubes complying with manufacturer’s recommendations. Handle resin-impregnated flexible tubes to retard or prevent resin setting until ready for curing.

4. Insertion. Insert flexible tubes through existing manholes or access structures by inversion, pull-in or other approved procedure.

5. Curing.

a. Follow manufacturer’s recommended cure schedule in curing of liner.

b. After insertion is completed, apply a suitable recirculation system capable of delivering steam, hot water or ambient temperature water or air, uniformly throughout the section to achieve consistent cure of the resin. Maintain curing temperature as recommended by the resin/catalyst system manufacturer.

c. Provide suitable monitors near the heat source to gauge temperatures of incoming and outgoing water or steam supply. Place additional temperature sensors between the impregnated tube and invert of the original pipe at each manhole to monitor the outside temperature of the liner while curing.

d. Continue uninterrupted heating until the required curing temperature is achieved. Accurately measure temperatures at both ends of the CIPP. Initial cure is considered complete when exposed portions of the flexible tube pipe
appear to be cured and the remote temperature sensors have achieved the external temperature recommended by the resin/catalyst system manufacturer.

6. **Cool Down.** Initiate controlled cool-down of the hardened pipe to a temperature below 110°F, in accordance with the manufacturer’s recommended cure schedule. Take care in releasing the water column so that a vacuum does not develop that could damage newly installed pipe. Do not discharge water hotter than 110°F into the sanitary sewer system.

7. **Finished Pipe.** Provide a finished CIPP which is continuous and as free as commercially practicable from visual defects such as foreign inclusions, dry spots, pinholes, lifts, delaminations, and areas which have not cured sufficiently.

8. If point repair is required after the liner has cured, use a tube segment to splice across the point repair. Overlap on each end will be twice the diameter or 12 inches, whichever is greater. Cure the segment using the same process specified for the original liner.

9. **Service Reconnections.**
   
   A. Complete service reconnections within 24 hours after completion of the cured-in-place process.

   B. Reconnect services by excavation, man-entry or remote-operated cutting tool. Follow procedures for reconnecting sewer service specified in Item 5244, “Sanitary Sewers”. Perform smoke testing on services reconnected by excavation before backfilling.

10. **Sealing Manholes.**

    A. Form tight seals between the CIPP and the manhole walls at pipe penetrations. Do not leave annular gaps. Seal annular spaces with 1/2-in. diameter activated Oakum bands soaked in chemical sealant. Seal annular spaces greater than 1/2-inch with manhole wall repair material. Finish off seals with non-shrink grout or cementitious liner materials placed around the pipe opening from inside the manhole in a band at least 4 inches wide. Complete sealing procedures for each liner segment immediately after the liner is cured.

    B. Reshape and smooth the manhole invert as specified in Special Specification, “Manhole Rehabilitation”.

11. **Post-Installation Television Inspection.** Make and submit video tape(s) showing completed work, including condition of restored connections as specified in Special Specification, “Sanitary Sewer (Television Inspection)”.

12. **Final Cleanup.** Upon completion of rehabilitation work and testing, clean and restore project area affected by the Work in accordance with the following:

    A. Clean up construction debris and level the area with bank sand so that the resulting surface of the new grass matches the level of the existing grass and maintains pre-construction drainage patterns. Level minor ruts or depressions caused by construction operations where grass is still viable by filling with bank sand.
B. Restore grass areas disturbed or damaged by construction with grass comparable with that previously existing.

C. Restore established lawn areas, including easements and esplanades disturbed or damaged by construction, by sodding and fertilizing in accordance with Item 162, “Sodding for Erosion Control” and Item 166, “Fertilizer”.

D. Restore grass areas not requiring sodding using Drill Seed in accordance with Item 164, “Seeding for Erosion Control”.


A. If the thickness, flexural strength or flexural modulus of elasticity of the installed CIPP are less than 90% of the specified values, the product is considered unacceptable. Submit a proposed method of repair or replacement for review and approval by the Engineer. Work required to remedy non-conforming work will be at no additional cost to the Department.

B. If it is determined that the resin utilized did not match the submitted and approved resin via the Infrared Spectrum Analysis, the product is considered unacceptable and non-conforming. Submit proof that the resin actually utilized meets the requirements of the specification or submit a method for replacement of the sewer segment liner for review and approval by the Engineer. Work required to remedy non-conforming work will be at no additional cost to the Department.

C. For all instances, where CIPP is deemed unacceptable, other than thickness, flexural strength, and flexural modulus of elasticity, as described in this specification section, submit a proposed method of repair or replacement for review and approval by the Engineer. Work required to remedy non-conforming work will be at no additional cost to the Department.

14. Measurement. Measurement for cured-in-place pipe is by the foot, measured along centerline of pipe from centerline to centerline of manholes, and will be considered full compensation for all labor and materials required to install the liner to specified requirements. Depth range for payment is based on greatest depth measured at manholes from natural ground level to flow line of sanitary sewer for each pipeline segment.

Measurement for sewer line point repair is on a unit price basis for each repair performed. Minimum length of pipe to be replaced for each repair, determined by depth of sewer line measured from natural ground to flow line at point of repair:

1. Up to 10-ft. depth: 6 ft. minimum length.
2. 10 to 15-ft. depth: 9 ft. minimum length.

The cost of the excavation, embankment, backfill hauling and lawful disposal of excavated material, pipe, pipe fittings, adapters, concrete, smoke testing and restoration of site are included in the unit prices for point repairs.
Obstruction removal by excavation will be paid on a unit price basis according to depth for each removal. Obstruction removal can be submitted for payment when the obstruction has been cleared from the sewer line to be lined. Liner work must proceed at least 6 ft. before payment for removal of another obstruction will be considered (i.e., all obstruction within a distance of 6 ft. is considered to be part of the same obstruction.).

A. Obstruction removal by remote device will be paid on a unit price basis, per manhole section, and includes all obstruction removals within a manhole section.

B. Depth will be measured from natural ground level to the flow line at the point of obstruction removal.

C. The cost of the following items of work is included in the unit prices for obstruction removal by remote device or excavation:
   
   (1) Cleaning of sanitary sewers due to broken pipe, roots, dirt, loose deposits, etc.

   (2) Television inspection.

   (3) Excavation, embedment and backfill.

   (4) Hauling away and lawful disposal of excess excavated material and debris.

   (5) Restoration of site improvements, including sodding.

D. Payment will not be made for obstruction removal if the existing sewer line, service line or tap is damaged and a point repair is required. Payment will not be made for removal of a protruding tap if the service reconnection is performed by excavation.

Removal of hard deposits, concrete, debris, pipes or any other material in a manhole, or that is accessible from the manhole wall, will be cleared under work items for rehabilitation of sanitary sewer pipes and manholes.

15. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Cured-In-Place Pipe” of the size specified.

No separate payment will be made for the following items of work. Include cost in the unit price for installing cured-in-place pipe.

   1. Temporary meter and municipal water obtained from a City fire hydrant.

   2. Sealing the liner in manholes.

   3. Reworking inverts and benches for manholes.

B. Where post-installation thickness measurements or physical property testing is performed, payment for installed cured-in-place pipe will be made as follows:
1. **Full payment.** If thickness, flexural strength and flexural modulus of elasticity of installed CIPP are all 95 % or better of specified values, full payment will be made.

2. **Adjusted payment.** If thickness, flexural strength or flexural modulus of elasticity are between 90 % and 95 % of specified values, payment will be made based on an Adjusted Unit Price, which will equal the Unit Price bid, multiplied by a Value Factor calculated as follows:

\[
\text{Value Factor} = \frac{\text{actual thickness}}{\text{specified thickness}} \times \frac{\text{actual flexural strength}}{\text{specified flexural strength}} \times \frac{\text{actual flexural modulus of elasticity}}{\text{specified flexural modulus of elasticity}}
\]

"Value Factor" will not exceed 100 percent.