

## SECTION 33 31 40

### CURED-IN-PLACE PIPE (CIPP)

#### PART 1 – GENERAL

##### 1.01 SUMMARY

- A. Section Includes: Rehabilitation of pipe by the cured-in-place (CIPP) method.
- B. System Description: Rehabilitate existing pipes by inserting a resin-impregnated flexible tube through the host pipe, inflating it to the inside diameter of the host pipe using low-head hydrostatic pressure, and curing the tube using heated water or steam.
- C. This section provides general guidelines. Nothing contained herein shall relieve the Contractor from completing the CIPP pipe rehabilitation in the most feasible, efficient, highest quality, and safe manner, using required materials to the lines and grades of the sewers to be rehabilitated and to the requirements of this specification.
- D. Contractor shall supply all labor, materials, equipment and apparatus not specifically mentioned herewith or noted on the Plans, but which are incidental and necessary to complete the specified work.

##### 1.02 SUBMITTALS

- A. Prepare and submit in accordance with Section 01 33 00.
- B. Experience: Submit documentation demonstrating compliance with specified experience requirements as detailed herein.
- C. Product Data:
  - 1. Information on CIPP materials, including lining material and resins.
- D. Construction Details:
  - 1. CIPP Manufacturer's recommended storage procedures, resin application, curing process details and cure schedules (including heat up, hold and cool down cycles and temperature control for each diameter and CIPP thickness).
  - 2. Trimming and finishing at manhole walls.
  - 3. Lateral reinstatement methods.
  - 4. Safety systems associated with the proposed heating equipment and boiler management operational safety systems for use with the cure process.
  - 5. Methods, materials, equipment and procedures used for point repairs identified on the Drawings.
  - 6. Methods, materials, equipment, and procedures employed to seal annular space between the CIPP and the host pipe at manholes and, if required, at all internally reinstated lateral connections.

7. Documentation describing methods, equipment and materials used to cut the liner for lateral reinstatement, seal the connection between the rehabilitated sewer main and the reinstated service lateral to prevent sewage from getting between the liner and the host pipe, and seal leaking lateral connections.
  8. Contingency Plan: Provide a plan for repair of defects that may expose the host pipe during removal of the defect. The plan shall include detailed information on removal of the defect and proposed method for defect repair.
- E. Engineering calculations for the design of the liner thickness
1. Design calculations shall be checked and approved by a Registered Civil Engineer in the State of California. Liner design calculations shall be supported by field analysis, technical assumptions, requirements of these Specifications and ASTM F1216.
  2. Calculations shall be submitted and reviewed prior to ordering liner.
- F. During the curing process, keep logs, charts and/or graphs of the liner temperatures at the specified locations to ensure that proper temperatures and cure times have been achieved. Copies of logs, charts and/or graphs shall be submitted to the City within 5 days of installation.
- G. Certifications and Testing:
1. Certification from the CIPP manufacturer that the resin/catalyst and tube material complies with the required application, meets the intended service condition and complies with the physical requirements.
  2. Literature and background information on the independent third party testing laboratory proposed for testing the physical properties of the installed pipe.
  3. Manufacturer's certification that lining material is manufactured, sampled, tested and inspected in accordance with ASTM F1216 and F1743. Include the manufacturing date of the lining materials in the certification.
  4. Verification of product conformance by third party testing for the chemical resistance and physical testing requirements along with a report of test results.
- H. For each diameter and thickness to be installed on the project, provide volume of resin required per unit length (gal/foot or liters/meter) to fill the volume of air voids in the tube plus the additional allowance for polymerization shrinkage and to meet the finished liner strength requirements.
- I. After each impregnation of a tube for an installation, submit a process record that verifies that the resin impregnation yield matches the required quantity for the diameters and thicknesses.
- J. Written notification of any crew changes. Notification shall be a minimum of one week prior to date of actual change.

## 1.03 EXPERIENCE REQUIREMENTS

- A. Required experience:
1. CIPP Manufacturer:
    - a. Minimum of 5,000 linear feet of CIPP successfully installed in sanitary sewers owned by public agencies or municipalities in the state of California, where the CIPP has been in successful service for a minimum of 3 years.
  2. Installation Contractor:
    - a. A minimum of three (3) years of active experience in the commercial installation of CIPP.
    - b. Minimum of 5,000 linear feet of CIPP successfully installed in sanitary sewers owned by public agencies or municipalities in the U.S.
    - c. Each of the referenced lining projects shall have been in service in the City's system for at least one year.
    - d. Referenced project experience must be specific experience of the Installation Contractor. The prior experience of individuals within the organization that was gained through employment with other companies will not be accepted.
    - e. Licensed by manufacturer.
  3. Field Superintendent: Superintendent shall have at least two (2) years cured-in-place pipe supervisory field experience on a minimum of three successfully completed projects. Qualifying experience for the three reference projects submitted shall include:
    - a. Length: At least 5,000 linear feet CIPP total length.
    - b. Minimum Pipe Diameter: 12-inches in diameter.
    - c. Sewage Flow Control: At least one year of sewage flow control supervisory field experience.
  4. Installation Crew: At least three persons from the CIPP installation crew shall have a minimum of two years of CIPP experience.
  5. Boiler Technician: Provide the name and information for the boiler technician who will perform the actual work. All boiler technicians shall be certified and approved as operators by the rehabilitation system manufacturer or an independent testing agency.
- B. The final decision to accept or reject the product, manufacturer, and/or installer lies solely with the City. The named Manufacturer, Field Superintendent, CIPP Installer, and Boiler Technician must be utilized to perform the work under this project, unless changes are specifically authorized by the Engineer in writing.

#### 1.04 WARRANTY

- A. Contractor shall provide a warranty to be in force and effect for a period of one year from the date of written final acceptance. The warranty shall require the repair or replacement of the liner due to failure resulting from faulty materials or installation as deemed necessary by the City. All required work incidental or required as part of the repair or replacement shall be provided by the Contractor at no additional cost to the City.

### **PART 2 – PRODUCTS**

#### 2.01 GENERAL

- A. Materials provided and process variables used in the CIPP installation process are the responsibility of the Contractor.
- B. Materials, installation procedures and the final product shall equal or exceed the requirements of ASTM F1216, ASTM F1216 Appendix X1, and F1743.

#### 2.02 COMPONENT PROPERTIES

- A. Liner Tube: One or more layers of flexible needle felt or an equivalent woven and/or non-woven material capable of carrying resin, withstanding installation pressures and curing temperatures, compatible with the resin system used, and having markings to determine elongated length during liner installation.
- B. Resin:
  - 1. Compatibility with Application: Liquid thermosetting resin that is compatible with the CIPP rehabilitation process used and designed for a wastewater environment.
  - 2. Type: Polyester, vinyl ester or epoxy meeting the service conditions specified for the tube system and the applicable sections of ASTM F1216 and F1743.
  - 3. Enhancers: Use of enhancers will not be allowed.
  - 4. Resin Characteristics: Sufficiently thixotropic to obtain non-draining characteristics when impregnated into the fiber fabric
- C. Catalyst: Compatible with the resin and other materials to be utilized in the rehabilitation process. Select quantity and type of catalyst based on the curing conditions and recommendations of the resin manufacturer.

#### 2.03 FINISHED AND CURED LINER PROPERTIES

- A. Design Parameters - The liner material and thickness shall be calculated and designed for use in gravity sanitary sewers and must be in strict conformance with all applicable sections of ASTM F1216, ASTM F1216 Appendix X1, F1743 and D5813.

- B. The design shall be based on the following pipe conditions, service requirements and physical conditions:
1. Deterioration design parameter: Fully Deteriorated.
  2. Assume groundwater is at ground surface.
  3. All pipes subject to soil load of 130 lb/cu.ft. and H-20 live load.
  4. Ovality of host pipe is 2 percent.
  5. Factor of safety (N) is 2.
  6. Modulus of passive soil reaction is 500 psi.
  7. External Buckling Design - Acceptable third party testing and verification of the design analysis techniques (ASTM F1216, Appendix X1).
  8. A minimum service life of 50 years.

- C. The liner shall be homogeneous throughout, white, uniform in color, free of cracks, holes, foreign materials, blisters, or deleterious faults. The physical properties of the cured liner shall meet the minimum chemical resistance requirements of ASTM F1216 and F1743 and shall conform to the minimum structural standards listed in the following table:

Structural Property	ASTM Standard	Minimum Value
Wall Thickness	D2122	As Calculated Min 6 mm
Flexural Strength	D790	4,500 psi
Flexural Mod. of Elasticity (short-term)	D790	250,000 psi
Flexural Mod. Of Elasticity (long-term)	D790	125,000 psi

- D. The CIPP wall thickness shall be a minimum of 0.24 inches (6.0 mm) or as calculated by Contractor, whichever is greater.

- E. Liner Tube Sizing:

1. Outside diameter of the liner tube being inserted shall be properly sized to allow for expansion so that the CIPP liner can fit tightly against the host pipe.
2. Shall be properly sized to the length to be rehabilitated and be able to stretch to fit irregular pipe sections and negotiate bends and curves with the minimum tube length necessary to effectively span the designated run between manholes, unless otherwise specified.
3. Contractor shall verify the lengths of the pipelines to be rehabilitated in the field prior to impregnation of the tube with resin, to ensure that the tube will have sufficient length to extend the entire length of the run.
4. Contractor shall measure the inside diameter of the existing pipelines in the field so that the liner can be installed in a tight-fitted condition.

## **PART 3 – EXECUTION**

### **3.01 LINER PIPE STORAGE AND HANDLING**

- A. Liner pipes shall be properly stored and handled to prevent damage in accordance with the manufacturer's recommendations and as approved by the Engineer.
- B. Damage includes, but is not limited to, gouging, abrasion, flattening, cutting, puncturing, or ultra-violet (UV) degradation.
- C. All damaged materials and pipe rejected by the Engineer shall be promptly removed from the project site at no additional cost to City and disposed of in accordance with current applicable regulations.

### **3.02 PREPARATORY WORK**

- A. Provide temporary sewage flow control of the sanitary mains in accordance with Section 33 31 50, Bypass Pumping.
- B. Thoroughly clean the host pipe in accordance with Section 33 31 70, Cleaning Sanitary Sewer System.
- C. Diameter and Length Verification: Verify internal diameter and length of existing sewer pipe prior to sizing and ordering liner.
- D. Preliminary CCTV Inspection of Sewer Lines: Perform internal CCTV inspection after cleaning of the sewer lines to document the condition of the host pipe, identify and locate any active service laterals, and verify the lines were cleaned in accordance with Section 33 30 00, Sanitary Sewerage Utilities and the liner manufacturer's requirements.
- E. Spot Repairs: Prior to wet-out contractor shall determine if spot repairs are required for proper installation of liner as required by lining manufacturer. It shall be the Contractor's responsibility to remove all debris, repair protruding laterals and control moderate infiltration at no additional cost to the City. Written notification shall be provided to the City a minimum of three days prior to all repairs that require excavation, such as collapsed pipe, or specialized equipment to stop heavy infiltration. The City will provide written approval prior to all work that requires excavation or specialty equipment.

### **3.03 WET-OUT PROCEDURE**

- A. Contractor shall utilize the resin and catalyst in sufficient quantities to ensure complete impregnation of the liner and provide the properties specified in this Specification.
- B. The fiber-felt liner tube shall be fully impregnated with resin by vacuum or other means prior to installation. The resin and catalyst systems that are compatible with the requirements of the method shall be used. The quantity of resin used for tube impregnation shall be sufficient to fill the volume of air voids in the tube with additional allowance for polymerization shrinkage and the loss of resin through cracks and irregularities in the original pipe wall. Unless otherwise

specified to provide for excess resin migration, the gap thickness of wet out equipment shall be sized to allow an excess of 5 to 10 percent resin to pass during impregnation.

- C. If resin impregnation/wet-out is to take place off-site, provide the City with 48 hours notice for each scheduled wet-out. The City reserves the right to check, verify, or inspect all phases of production and testing of materials, from manufacturing, shipping, wet-out, installation, and cure, to finished product.

### 3.04 FINAL CLEANING AND INSPECTIONS

- A. The existing host pipe shall be cleaned again after sewage has been bypassed and just prior to insertion of the liner.
- B. A maximum of one hour may elapse between this final cleaning pass and the insertion of the liner.
- C. After the cleaning is complete, a final camera pass shall be made to verify the cleanliness of the line.
- D. Bypass pumping: in accordance with Section 33 31 50, Bypass Pumping, and shall exclude any sewage or other flow from entering the line during the inspection.
- E. Pipe invert shall be cleared of any standing water and shall be continuously visible during the inspection.
- F. Prior to insertion of the liner, the sewer main must be accepted as 'clean' as defined in Section 33 31 70, Cleaning Sanitary Sewer System, by the Engineer.
- G. This final inspection does not need to be videotaped but the Engineer must be present in the TV truck during the inspection to verify the cleanliness of the line.

### 3.05 LINER INSTALLATION

- A. Install the liner tube through the existing manholes in accordance with the manufacturer's recommendations and procedures. Protect manholes to withstand forces generated by equipment, water, or air pressures used while installing the liner tube.
- B. Transport the impregnated liner tube to the site and store in such a manner that it will not be damaged, exposed to heat and/or direct sunlight, or result in any public safety hazard. Materials shall be subject to inspection and review prior to installation. The impregnated liner tube must be installed prior to exceeding the resin pot life or within two weeks whichever is less.
- C. The installed pipe liner shall be in strict accordance with the liner manufacturer's instructions and recommendations. The liner shall be inserted through an existing manhole or other access approved by the Engineer, by means of the installation process and the application of hydrostatic head, compressed air, or other means sufficient to fully expand and extend the liner to the next designated manhole or termination point. The liner shall be installed at a rate not to exceed that needed to remove water from the sewer during installation process.

- D. Contractor shall abide by all City requirements for water acquisition.

### 3.06 CURING

- A. The Contractor shall abide by all discharge requirements to meet the pollutant limits as required.

- B. Heating Source and Distribution Equipment:

1. After liner placement is completed.
2. A suitable heat source and distribution equipment shall be provided to distribute or recirculate hot water or steam throughout the pipe.
3. The equipment shall be capable of delivering hot water or other heating methods throughout the section to uniformly raise the temperature above the temperature required to cure the resin.
4. This temperature shall be determined by the manufacturer based upon the resin/catalyst system employed.
5. The curing of the CIPP must take into account the existing pipe material, the resin system, and ground conditions (temperature, moisture level, and thermal conductivity of the soil).
6. The heat source piping shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing water, steam, or air supply.
7. Another such gauge shall be placed between the impregnated tube and the pipe invert at a minimum of five feet from the termination to determine the temperature during cure.
8. Water temperature during the cure period shall meet the requirements of the resin manufacturer as measured at the heat source inflow and outflow return lines.
9. Provide standby equipment to maintain supply of the heat source.
10. Pipelines that connect the liner to the heat source shall be leak-free and no cure water is allowed to spill to the ground surface. Contractor shall take full responsibility for all required actions to prevent, contain and remediate, and pay all costs including fees and fines for any spilled or leaked cure water at no additional cost to the City.

- C. Cure Period

1. Shall be of duration recommended by the resin manufacturer during which time the recirculation of the water to maintain the temperature continuously takes place.
2. The initiation temperature for cure shall be as recommended by the resin manufacturer.
3. Temperature monitoring devices shall be installed at all exposed portions of the pipe (beginning and end of run) for each inversion or run of installed liner pipe between the host pipe and the CIPP liner.

### 3.07 COOL DOWN

- A. After the tube is cured, allow a cool-down period prior to opening the downstream plug and returning normal flow back into the system.

- B. The CIPP shall be cooled to a temperature below 90 degrees Fahrenheit, or to a temperature as required by the City or as specified on the discharge permit and held for one (1) hour before relieving the head in the inversion pipe.
- C. Cool-down may be accomplished by the introduction of cool water into the CIPP. Care shall be taken in the release of the static head so that a vacuum will not develop that could damage the newly installed liner.
- D. Abide by all requirements of any discharge permit for discharging any water from the cool-down process.
- E. Cure and cool down water shall be treated to remove styrene per discharge requirements.
- F. Cure and cool down water shall be contained and shall not be allowed to leak on the ground surface or be discharged to the storm drain system.

### 3.08 SAMPLING AND LABORATORY TESTING

- A. The physical properties of the installed CIPP:
  - 1. Shall be verified through field sampling and laboratory testing.
  - 2. Materials testing shall be performed at the Contractor's expense and by an independent third party laboratory recommended by the manufacturer and pre-approved by the City
  - 3. Testing shall be in accordance with applicable ASTM test methods to confirm compliance with the requirements for minimum wall thickness, flexural strength, and short-term flexural modulus of elasticity.
  - 4. Physical properties shall meet those specified in Section 2.03 or those used in design whichever is more stringent.
- B. Testing short term properties of the CIPP liner material from the actual installed liner:
  - 1. Certified results
  - 2. Tests shall be conducted at a minimum of one location per pipe size for each alignment, or
  - 3. Per each 1,000 linear feet of installed liner per each alignment (there is only one diameter in heat alignment)
  - 4. At a downstream manhole.
  - 5. Sample:
    - a. Cut from a section of cured CIPP that has been inverted through a like diameter pipe which has been held in place by a suitable heat sink, such as sandbags.
    - b. The sample cannot be fabricated from material taken from the tube and the resin system used and cured in a clamped mold placed in the downtube.
- C. If required by the Engineer, remove a sample from each pipe to be used to check the liner thickness, by core drilling 2-inch diameter test plugs at locations specified by the Engineer.
- D. The laboratory results shall identify the test sample location as referenced to the nearest manhole and station. Final payment for the project shall be

withheld pending receipt and approval of the test results. If properties tested do not meet minimum requirements, the CIPP shall be removed and replaced at no additional cost to the City.

### 3.09 FINISHED PIPE LINER

#### A. Finished Liner:

1. Shall be inner polyethylene layer and an outer polyester felt layer impregnated with a thermosetting resin to fit tightly against the existing inside pipe wall.
2. Shall be fabricated from materials that, when cured, shall be chemically resistant to withstand internal exposure to sewage gases containing quantities of hydrogen sulfide, carbon monoxide, methane, petroleum hydrocarbons, moisture saturation, and dilute sulfuric acid.
3. Shall be continuous over the length of pipe rehabilitated.
4. Shall be free from dry spots, delamination, lifts, fins and the like as identified by the Engineer. Contractor shall remove and replace the CIPP full circumference, from manhole to manhole or as directed by the Engineer if these conditions are present.

#### B. Interior Surface:

1. Interior surface liner within 10 feet of manholes shall be wrinkle free. All wrinkles within this limit shall be properly removed to allow proper installation of flow restricting plugs.
2. Wrinkles in the finished lined pipe which:
  - a. Cause a backwater greater than one (1) inch in depth,
  - b. Reduce the hydraulic capacity of the pipeline as determined by the Engineer,
  - c. Have a height equal to or greater than one (1) inch,
  - d. Cause a maintenance problem or inconvenience as determined by the Engineer,
  - e. Cause debris and solids to hang-up and accumulate, or Reduce the structural stability of the pipe are unacceptable and shall be removed or repaired by the contractor in a method that is approved by the Engineer at not additional cost to the City.
3. If a void, lift, blister, or delamination between the liner and the pipe exists, the Contractor shall repair or replace that section of pipe as approved by the Engineer and at no additional cost to the City. Repairs shall be made by removal and replacement of the liner around the full circumference of the pipe, in the vicinity of the defect, as approved by the Engineer. Removal of defect liner and patching shall not be allowed unless approved by the Engineer.
4. If wrinkles are detected in the installed liner, the Contractor shall provide photographs and dimensions of the wrinkle including height and direction.
5. Methods of repair shall be proposed by the Contractor and submitted to the Engineer for review. The Engineer will determine on a case by

case basis if removal of the wrinkle, or replacement or repair of CIPP liner is required.

- C. Liner terminations at manhole or rodding inlets:
1. The beginning and end of the CIPP shall be cut flush at the inlet and outlet points in the manhole.
  2. The ends shall be permanently sealed to the rehabilitated pipeline to prevent any infiltration between the CIPP and the host pipe.
  3. Ends shall be sealed with a resin mixture that is recommended by the liner manufacturer.
  4. Sealing:
    - a. Shall be compatible with the liner/resin system, provide a watertight seal and is approved by the Engineer prior to start of construction.
    - b. Hydraulic cements and quick-set cement products are not acceptable.
    - c. Acceptable materials shall be an approved epoxy type product that will bond, not crack, dry up, slough off, or shrink in time, and provide a good transition in the manholes.
    - d. Sealing shall be performed at no additional cost to the City.

### 3.10 REINSTATEMENT OF SERVICE LATERALS

- A. Contractor shall reinstate all laterals that are connected directly to the rehabilitated sewer main after the rehabilitation of each sewer is completed using robotic cutting equipment
- B. Reinstatement using open-cut excavation shall not be allowed.
- C. Reinstatement of laterals shall be as recommended by the liner manufacturer.
- D. The opening in the liner for the lateral connection shall be one hundred percent and of the same configuration as the existing opening.
- E. All cut edges at the reinstated laterals shall be smooth and free of jagged edges that can hang up solids and shall not be cut to expose host pipe.
- F. Any over-cut lateral openings that exposes the host pipe shall be sealed, as recommended by the liner manufacturer and approved by the Engineer, as deemed necessary by the Engineer.
- G. The connection between the lateral and the rehabilitated sewer main shall not restrict flow from the lateral into the rehabilitated lateral.
- H. Any lateral reinstatement that has jagged edges or impedes the flow from the lateral shall be considered defective and shall be re-cut until the Engineer approves.
- I. Reinstatement of the laterals shall be performed in the presence of the Engineer.
- J. Seal the connection between the lateral and the sewer main using "Top Hat" or approve alternate lateral liner. Lateral liner shall extend a minimum of 2 feet

into the lateral. The sealing shall be performed in the presence of the Engineer.

- K. Reinstatement of laterals shall be performed immediately (within 4 hours) after approval of lining by the Engineer.

### 3.11 QUALITY CONTROL

- A. The Contractor shall clean and perform a closed-circuit television inspection after installation of the CIPP liner.
- B. Prior to reconnection of all connected service laterals perform an exfiltration test on the liner. If liner requires repair, exfiltration test shall be performed after repair is complete.
- C. Exfiltration test:
  - 1. Plug the downstream end of the lined pipe segment and install a standpipe to the lined pipe's upstream end using appropriately sized 90-degree elbow fittings, plastic standpipe and flexible watertight couplings.
  - 2. Contractor shall remove all air from line to be tested.
  - 3. The standpipe shall be temporarily secured within the manhole.
  - 4. Contractor shall perform exfiltration test as specified in ASTM F1216.
  - 5. The allowable water exfiltration shall not exceed the limits stated in ASTM F1216 for the pipe to be accepted as watertight.
  - 6. If the lined pipe segment does not meet the requirements of the exfiltration test, repair or replace and retest the lined pipe segment so that it meets the requirements at no additional cost to the City.

### 3.12 REBUILD MANHOLE SECTIONS REMOVED FOR LINER INSTALLATION

- A. Manholes modified for construction including construction of bulkheads, removal of manhole frame and cover, manhole steps, and/or cone section during liner installation shall be returned to their original condition or better after construction. Existing materials removed for construction shall be replaced with all new materials.

-END OF SECTION -