

**CONSTRUCTION STANDARD SPECIFICATION**

**SECTION 02957**

**SEWER PIPE LINING**

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**SECTION 02957**

**SEWER PIPE LINING**

**PART 1 - GENERAL**

**1.01 SUMMARY**

- A. Section includes rehabilitation of sewer lines by manhole entry methods.
  - 1. Utilize trenchless methods.
  - 2. Excavations are not allowed.
  - 3. Reline finished, rehabilitated sewer line with continuous tight-fitting, watertight liner extending over entire length between manhole sections.
- B. Related Sections: Refer to the following sections for related work:
  - 1. Section 02200, "Earthwork"
  - 2. Section 02730, "Sanitary Sewer Systems"
  - 4. Section 02955, "Sewer Flow Control"
  - 5. Section 02956, "Sewer Cleaning"
  - 6. Section 02958, "Manhole Rehabilitation"
  - 7. Section 02959, "Television Inspection"

**1.02 REFERENCES**

- A. American Society of Testing and Materials (ASTM)
  - D543 Resistance of Plastics to Chemical Reagents
  - D638 Tensile Properties of Plastic
  - D790 Flexural Properties of Unreinforced and Reinforced Plastic and Insulating Materials

- D1693 Environmental Stress Cracking of Ethylene Plastics
  - D1784 Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CPVC) Compounds
  - D2412 Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
  - D2444 Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
  - D2990 Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics
  - D3034 Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
  - D3350 Polyethylene Plastics Pipe and Fittings Materials
  - D5813 Cured-In-Place Thermosetting Resin Sewer Pipe
  - F1216 Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube
  - F1504 Folded Poly Vinyl Chloride (PVC) Pipe for Existing Sewer and Conduit Rehabilitation
  - F1533 Deformed Polyethylene (PE) Liner
  - F1606 Rehabilitation of Existing Sewers and Conduits with Deformed Polyethylene (PE) Liner
- B. Standard Specification for Public Works Construction, “Greenbook” adopted by Joint Cooperative Committee of Southern California Chapter, American Public Works Association and Southern California Districts, Associated General Contractors of California.

### 1.03 DEFINITIONS

- A. Deformed Polyethylene Liner: Polyethylene pipe manufactured in deformed shape that reduces cross-sectional area for insertion and rehabilitation of nonpressure pipelines, conduits, and ducts.
- B. Folded Poly Vinyl Chloride (PVC) Pipe: Pipe that has been manufactured in folded shape for use in existing sewer and conduit rehabilitation.
- C. Cured-in-Place Pipe (CIPP): Hollow cylinder containing non-woven or woven material, or combination of non-woven and woven material surrounded by cured thermosetting resin. Plastic coatings may be included. This pipe is formed within existing pipe, and takes the shape of and fits tightly to existing pipe.
- D. Inversion: Process of turning resin-impregnated tube inside out by use of water pressure or air pressure for CIPP.

## 1.04 SYSTEM DESCRIPTION

A. Design Requirements: Design newly installed liner for minimum 50-year continuous loading condition.

1. Design thickness of liner system for fully deteriorated host pipe condition.
2. For solid-wall liner systems, determine minimum thickness in accordance with modified AWWA formula as follows:

$$t = 0.721 D * [ (N * q_t / C)^2 / E_L * R_W * B' * E'_s ]^{1/3}$$

where:

t = Required minimum installed liner wall thickness, inches.

D = Inside diameter of host pipe, inches.

N = Safety factor, use 2.0.

$q_t$  = Total external pressure on pipe, psi.  
 $= 0.433 * H_W + [w * H_S * R_W / 144] + W_S$

$H_W$  = Height of water table above host pipe, feet; use zero.

w = Soil density, lbs per cubic foot. Use 120 pcf.

$H_S$  = Height of soil cover over host pipes, feet. Determine cover heights from manhole depths and line sizes given in Contract documents

$R_W$  = Water buoyancy factor.  
 $= 1 - 0.33 (H_W / H_S)$ , minimum value = 0.67.

$W_S$  = Live load, psi. Use H-20 highway loading with a 1.0 impact factor.

C = Ovality factor. Use host pipe which is 5.0% out-of-round, unless otherwise indicated in Contract documents.

$E_L$  = Long-term flexural modulus of elasticity, psi.  
 PVC Liner: 240,000 psi.  
 High-Density Polyethylene Liner: 91,000 psi.  
 Resin-Impregnated Tube System: 125,000 psi.

$B'$  = Coefficient of elastic support  
 $= 1 / [1 + 4e^{(-0.065H_S)}]$

$E'_s$  = Modulus of soil reaction. Use 1,000 psi.

This calculation yields an in-place wall thickness requirement. Provide allowances for any circumferential stretching, polymerization shrinkage, and resin migration that may occur.

B. Performance Requirements

1. Proposed rehabilitation liner system shall minimize decrease of flow-carrying capacity of existing sewer, but in no case shall system reduce capacity more than 16 percent.
  - a. Manning “n” value used for host pipe shall be 0.015, and rehabilitated line shall be 0.013.
  - b. Diameter and wall thickness of new trenchless liner shall be manufactured to size such that when installed, it will provide minimum wall thickness determined in System Description article 1.04A.
2. Proposed liner material shall be inert to attack by domestic sewage and suitable for use in underground sewer environment.
3. Liner material shall be manufactured in such manner as to result in tight-fitting liner after installation. There shall be no measurable continuous annular space between outside diameter of new liner and existing host pipe.

#### 1.05 SUBMITTALS

- A. Shop Drawings: Submit shop drawings that identify locations and method of liner insertion, liner size, thickness calculations, and assumptions used as basis for calculations.
  1. Submit for review by Sandia Delegated Representative (SDR) at least 10 working days prior to start of Work.
  2. Assume that liner shall have complete structural support, without considering structural support from existing pipe except during construction
  3. Submit bypass pumping plans and locations with sufficient detail to assure that Work can be accomplished without sewage spill.
    - a. Bypass pumping plan shall be in accordance with Drawings and requirements of Section 02955, “Sewer Flow Control”.
    - b. Include emergency response plan to be followed in event of failure of bypass pumping system.
- B. Product Data: Provide manufacturer’s data for lining materials and resins, and the following:
  1. Manufacturer’s certification that liner materials are in compliance with specifications, codes, and standards referenced herein.
  2. Installation instructions and details of component materials and construction details, including complete manufacturer’s recommendations for storage procedures and temperature control, handling and inserting liner, curing details, and trimming and finishing.
  3. Manufacturer’s certification, field measurements, and pipe-sizing calculations which demonstrate that liner has been properly sized to avoid creation of wrinkles or folds.

4. Resin manufacturer's heating requirements.
- C. Pre-liner: Provide sample and material test data, if pre-liner is used.
- D. Quality Control
  1. Design Data: Submit liner wall thickness calculations for approval by SDR prior to installation.
  2. Certificates: Certificates of compliance with design and test reports in accordance with applicable ASTM test methods.
  3. Submit evidence acceptable to SDR, such as certified copy of license or agreement, that Contractor has authority from patent Owner to use and/or install patented equipment, materials or methods.

#### 1.06 QUALITY ASSURANCE

- A. Comply with these specifications and specific product manufacturer's recommendations. Conflict between product manufacturer's recommendations and any portion of Contract documents shall be resolved with SDR prior to proceeding with Work.
- B. Manufacturer Qualifications: Products used in Work shall be produced by manufacturers regularly engaged in manufacture of similar items, and with history of successful production acceptable to SDR.
- C. Installer Qualifications: Licensed by lining system manufacturer, and have the following qualifications:
  1. Thoroughly trained and experienced in necessary crafts.
  2. Completely familiar with specified requirements and methods needed for proper performance of Work.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. Exercise adequate care during transportation, handling, and installation to ensure liner material is not torn, cut, exposed to direct sunlight, or otherwise damaged.
- B. If any part or parts of liner material becomes torn, cut, or otherwise damaged before or during insertion, repair or replace at Contractor's expense before proceeding further.

### PART 2 - PRODUCTS

#### 2.01 MANUFACTURERS

Subject to compliance with requirements, manufacturers offering products that may be incorporated in Work include the following:

- A. CSR Hydro Conduit: Deformed polyethylene liners marketed under trade name "U-liner."
- B. Insituform - USA: Folded Poly Vinyl Chloride (PVC) liners marketed under trade name "NuPipe."
- C. Insituform - USA: Cured-in-place resin-impregnated tube liners marketed under trade name "Insituform."
- D. In-Liner - USA: Cured-in-place resin-impregnated tube liners marketed under trade name "InLiner USA."

## 2.02 MATERIALS

- A. Liner Material: Provide light-colored or white liner to facilitate closed-circuit TV inspection.
  - 1. Deformed Polyethylene (PE) Liner: Comply with ASTM F1533, and minimum material requirements of ASTM D3350, Cell Class 345434-D.
  - 2. Folded PVC Pipe Liner: Comply with ASTM F1504, and minimum material requirements of ASTM D1784, Cell Class 13223-B or 12344-B.
  - 3. Cured-In-Place Liner: Comply with ASTM D5813 and F1216.
    - a. Resin-impregnated tube liner material shall consist of one or more layers of flexible needled felt, or equivalent woven or non-woven material.
    - b. Capable of carrying resin, and withstanding installation pressures and curing temperatures.
    - c. Able to stretch to fit irregular pipe sections and negotiate bends.
    - d. Resins shall be styrene-based, thermoset resin and catalyst system, or epoxy resin and hardener system that is compatible with installation process.
    - e. Outside layer of tube should be plastic-coated with material compatible with resin system used.
- B. Liners fabricated from PVC, PE, or resin-impregnated tubes shall meet the following physical requirements:

Property	Test Method	Minimum Values		
		Thermoplastic Systems	Polyester Resin Systems	Epoxy and Vinylester Resins
Corrosion Resistance			ASTM F1216 Section X2	Green Book Sec. 210-2.3.3
Flexural Modulus (Initial)	ASTM D790	136,000 psi (940 MPa)	250,000 psi (1720 MPa)	300,000 psi (2070 MPa)
Flexural Modulus (Long Term)	ASTM 2990	-	125,000 psi (860 MPa)	150,000 psi (1030 MPa)
Flexural Strength	ASTM D790	-	4500 psi (31 MPa)	5000 psi (34 MPa)
Tensile Strength (Yield)	ASTM D638	3200 psi (22 MPa)	3000 psi (21 MPa)	4000 psi (28 MPa)
Tensile Modulus (Initial)	ASTM D638	-	300,000 psi (2070 MPa)	250,000 psi (1720 MPa)
Tensile Modulus (Long Term)	ASTM D638	-	150,000 psi (1030 MPa)	125,000 psi (860 MPa)
Impact Resistance	ASTM D2444 <sup>(1)</sup>	210 ft-lb (29 m-kg)	-	-
Pipe Flattening	ASTM D3034 <sup>(2)</sup>	60% deflection	-	-
Pipe Stiffness	ASTM D2412	15 psi (103 kPa)	-	-
Environmental Stress-Crack Resistance	ASTM D1693 Condition C	2000 hours	-	-

(1) Impact testing performed with 20 lb (9.1 kg) Tup A and flat plat holder B.

(2) Without cracking, breaking, or splitting.

- C. Pre-Liner Material: If used, pre-liner shall be manufactured from material capable of withstanding temperatures and pressures encountered during installation.

### PART 3 - EXECUTION

#### 3.01 EXAMINATION

- A. Take field measurements of pipe inside diameter of sewer lines to be rehabilitated.



- B. In conjunction with review of color closed-circuit television (CCTV) DVDs, provide correct liner diameter and wall thickness to ensure tight fit with existing pipe to be restored.
- C. Confirm lengths of liner to be installed.
- D. Locate live services prior to rehabilitation activities. Each service connection shall be noted by size, position from reference manhole, and orientation with respect to circumference of pipe.

Live Service: Inactive service lines to vacant lot, vacant building, or to occupied building with more than one service line serving property.

### 3.02 PREPARATION

- A. Successfully complete the following items before installation of Work.
  - 1. Control sewer flow.
  - 2. Clean sewer.
  - 3. Perform television inspection of sewer.
- B. Take precautions to protect new liner, and existing pipe and manholes from damage that might result during insertion process.

### 3.03 SEQUENCE OF WORK

Perform Work in the following sequence:

- A. Divert sewer flow to comply with requirements of Section 02955, "Sewer Flow Control."
- B. Clean sewer and perform pre-insertion television inspection in compliance with requirements of Sections 02956, "Sewer Cleaning" and 02959, "Television Inspection." Complete cleaning and television inspection minimum of 24 hours, and maximum of 60 hours prior to rehabilitation lining for CIPP.
- C. Perform point repairs.
- D. Install liner.
- E. Leak-test liner to comply with requirements of Section 02730, "Sanitary Sewer Systems."
- F. Reconnect service connections.
- G. Perform post-insertion television inspection in compliance with Section 02959, "Television Inspection." If the liner, in sole opinion of the SDR has not been properly installed, it shall be reinstalled and CCTV-inspected by contractor at no additional cost.

### 3.04 PIPELINE POINT REPAIR

- A. Repair pipeline where point repairs are identified in Contract documents.
- B. Pipe and repair materials shall be the same as host pipeline, unless otherwise indicated.
- C. Trenching and excavation shall conform to Section 02200, "Earthwork".
- D. Bypassing and Dewatering: When required by the process, bypass sewer flow around work area, in conformance with Section 02955, "Sewer Flow Control".
- E. Notify SDR minimum of 48 hours in advance of planned time to begin pipeline point repair work at particular location.
- F. Installation and Field Inspection: Installation of replacement pipe and/or repair work shall conform to Section 02730, "Sanitary Sewer Systems". All pipeline point repairs shall be inspected by SDR prior to back filling and compaction.

### 3.05 LINER INSTALLATION - GENERAL

- A. Perform operations in strict accordance with OSHA and manufacturers' safety requirements. Particular attention is drawn to safety requirements involving entering confined spaces, work on elevated platforms, and working with pressurized equipment.
- B. To ensure proper heat distribution of rehabilitation systems using heat exchange methods, and to prevent creation of flat bottoms in liner profile, take steps to isolate new liner system from inflow, infiltration, or standing water.

Isolate new liner system by temporarily stopping inflow and infiltration, and removing standing water, or by using reinforced, flexible pre-liner to isolate new liner.
- C. Install liner through existing or new manholes. Excavation for liner insertion shall not be permitted.
- D. For cured-in-place pipe (CIPP) processes, designate location and notify SDR where resin impregnation will take place. Use vacuum impregnation process with roller system designed to uniformly distribute resin throughout tube.
- E. Equipment used to supply heat and pressure shall be capable of providing necessary heat and pressure required for installation condition. Heat sources shall be fitted with suitable monitors to gage temperatures and pressures.
- F. Cut and trim new liner at each end to conform to inside manhole wall. If liner fails to make tight seal at manhole wall, apply sealant to annular space. Sealant material shall be approved by SDR.

3.06 LINER INSTALLATION-DEFORMED POLYETHYLENE AND FOLDED POLY VINYL CHLORIDE (PVC) SYSTEMS

- A. Install liner for deformed polyethylene pipe in accordance with ASTM F1606, as amended below.
- B. Rounding devices or other approved methods may be used to reform liner to circular shape conforming to inside of host pipe.
- C. Round deformed liner systems when necessary temperature has been achieved.
- D. After new liner is completely rounded, cool to temperature specified by manufacturer prior to relieving internal pressure. In no case shall this temperature be in excess of 100°F (38°C).

3.07 LINER INSTALLATION - CIPP

- A. Install liner for cured-in-place pipe in accordance with ASTM F1216.
- B. Resin Impregnation: Designate location where uncured resin in original containers and nonimpregnated liner tube will be impregnated prior to installation.
  - 1. Impregnate liner tube by vacuum or other approved means.
  - 2. SDR may inspect materials and “wet out” procedure.
  - 3. Use resin and catalyst system compatible with requirement of this method.
- C. Liner Insertion: Ensure that pressure in liner exceeds both pressure due to groundwater head and any pressure due to sewage in laterals or connecting side sewers.
  - 1. Insert impregnated tube through existing or new manholes by means of installation process, and application of hydrostatic head, compressed air, or other means sufficient to fully extend it to next designated manhole or termination point.
    - a. Inflate and firmly adhere liner to pipe wall.
    - b. Install liner at rate greater than three feet (1 m) per minute and less than 10 feet (3 m) per minute.
  - 2. Mark exterior of manufactured tube along its entire length at regular intervals not to exceed five feet (1.5 m) as a gage to measure elongation during installation.
    - a. During insertion of resin impregnated tube into pipeline, maximum allowable longitudinal elongation or stretch of material shall be 5 percent.

- b. Longitudinal stretch of tube shall be gauged by comparing markers on fully inserted tube to actual length of pipe being rehabilitated.
3. Insertion by Inversion: Insert wet out liner through existing manhole by means of inversion process, and application of hydrostatic head or air pressure sufficient to fully extend it to next designated manhole.
    - a. At lower end of standpipe or guide chute, turn liner inside out and attach to standpipe (or chute) so that leakproof seal is created.
    - b. Adjust inversion head or air pressure to be of sufficient magnitude to cause impregnated liner to invert from manhole to manhole, hold tube tight to pipe wall, and produce dimples at service lateral connections and flared ends at manholes.
    - c. Use lubricant if required.
  4. Insertion by Winching: SDR will accept winched-in applications as alternate to inversion process, provided that liner tube and resin conform to materials and curing requirements of ASTM F1216 and this specification.
    - a. Insert wet out liner through upstream manhole, and pull through section with power winch and steel cable attached to end of liner with appropriate pulling head.
    - b. Provide monitoring device on cable to measure pulling force. Should the pulling force exceed manufacturer recommendations, tube shall be rejected and replaced.
    - c. Install rollers in upstream and downstream manholes to guide liner into and out of host pipe, and to guard against chafing of crowns at entry and exit from winch cable.
    - d. Cover sewer invert throughout section to be lined, with polyethylene foil or other suitable material to facilitate threading of liner and reduce risk of damage to liner material. Form CIPP with polyurethane coating on its interior surface.
    - e. Use flexible and impermeable calibration hose to inflate tube. Calibration hose may or may not remain in completed installation.
      - 1) Dry tube or inflation hose material that enters existing pipe that has not been previously vacuum impregnated with resin under controlled conditions cannot be included in structural wall of CIPP. Nominal thickness of this material shall be deducted from field sample thickness measured in order to verify that minimum specified wall thickness is achieved.
      - 2) Hose material remaining in installation shall be compatible with resin system used, bond permanently with tube, and be translucent to facilitate post-installation inspection.
      - 3) Hose material to be removed after curing shall be non-bondable material.

- f. Introduce water, air and/or steam into liner. Pressure will inflate and press liner material in tight fit against inner walls of host pipe, producing dimples at lateral and side connections and flared ends at manholes.
- D. Curing: After insertion of tube is completed, provide suitable heat source and distribution system to distribute and recirculate hot water, air, and/or steam throughout pipe as recommended by manufacturer,.
1. Equipment shall capable of delivering hot water, air, and/or steam throughout section by means of pre-strung hose to uniformly raise temperature above temperature required to affect cure of resin.
    - a. Temperature shall be determined by manufacturer based on resin/catalyst system employed.
    - b. Perforate hose in accordance with manufacturer's recommendations, or other methods acceptable to SDR
  2. Fit heat source piping with suitable continuous monitoring thermocouples to gage temperature of incoming and outgoing curing medium.
  3. Temperature of curing medium shall meet requirements of resin manufacturer as measured at heat source inflow and outflow return lines.
  4. Place additional continuous monitoring thermocouples between impregnated felt tube and pipe invert at manholes.
  5. Curing medium temperature in line during cure period shall be as recommended by resin manufacturer.
  6. Take care during elevated curing temperature so as not to over stress liner materials.
  7. Initial cure shall be deemed to be complete when inspection of exposed portions of liner appear to be hard and sound, and remote temperature sensor indicates that temperature is of magnitude to realize exotherm.
    - a. Cure temperature shall be held for period recommended by resin manufacturer, during which time distribution and control of curing medium shall continue.
    - b. Curing of CIPP shall consider host pipe material, resin/catalyst system, ambient temperature, moisture level, and thermal conductivity of soil.
- E. Cool-Down: Cool hardened liner to temperature below 100 degrees F (38 degrees C) before relieving pressure in section.
1. Cool-down may be accomplished by introduction of cool water or air into lined pipe to replace water or steam and water being drained.
  2. Drain water from small hole made in downstream end.
  3. Take care in release of static head or air pressure to prevent development of vacuum that could damage pipe or newly installed lining.

4. After tube has cured, use cool-down period prior to opening downstream plug and returning normal flow back into system.
- F. Sealing at Manholes: If CIPP fails to make tight seal at manhole walls, apply seal consisting of resin mixture compatible with liner/resin system, in accordance with manufacturer specifications and approved by SDR.

### 3.08 REINSTATEMENT OF SERVICES

- A. Immediately reinstate live services after leak testing is complete and acceptance of sewer line is achieved.
1. Reconnect from interior of sewer line by means of television camera and remote-controlled cutting device.
  2. Excavation will not be allowed.
  3. Holes cut through rehabilitation liner shall be neat and smooth, and match bottom of reinstated service line.
  4. Reinstate service opening to minimum of 95 percent and maximum of 100 percent of service lateral pipe area.
  5. New edge shall be crack-free with no loose or abraded material.
  6. Seam between host pipe and new liner at reinstated service shall be free of gaps, voids, or cavities. Grout gaps, voids, or cavities at this joint with packer and grouting system approved by SDR.
  7. Post-construction CCTV will show focused close-up of entire perimeter of each service reconnection.
- B. Provide fully-operational backup device for reinstating service laterals. If for any reason remote cutting device fails during reinstatement of service lateral, standby device shall be immediately deployed to complete reinstatement.

### 3.09 FIELD QUALITY CONTROL

- A. Inspection: After completion of liner insertions, side sewers, and finish work at manhole, sewer shall be televised in color DVD format, as specified in Section 02959, "Television Inspection". Provide original disk to SDR.
1. Finished liner shall be continuous over entire length of liner insertion run between manholes, and free from visual defects such as foreign inclusions, dry spots, pinholes, and delamination.
  2. Wrinkles in finished liner pipe which cause backwater of one inch (25 mm) or more, or reduce hydraulic capacity of pipe (wrinkles which exceed 5 percent of pipe diameter) are unacceptable.
    - a. Remove and repair at no additional cost to SNL.

- b. Wrinkles in finished liner pipe that reduce structural stability of pipe are unacceptable.
3. In the event SDR, based on review of post installation CCTV DVDs, has reasonable cause to suspect that annular space exists between liner and host pipe, Contractor will be directed to excavate and expose existing sewer and remove existing host pipe such that confirmation of suspected annular space can be made.
- a. If annular space is determined to exist, repair in manner approved by SDR.
  - b. If it is determined that no annular space exists, Contractor shall be reimbursed in accordance with "Changes" clause of Contract.
- B. Leak Testing: After completion of liner installation but prior to reinstatement of service lines, pressure-test rehabilitated sewer line for leakage in accordance with Section 02730, "Sanitary Sewer Systems."

### 3.10 CLEANING

- A. Keep premises free from accumulations of waste materials, rubbish and other debris resulting from work.
- B. Remove waste materials, rubbish, and debris from and about premises.
- C. Remove tools, construction equipment and machinery, and surplus materials.
- D. Restore to original condition portions of site not designated for alterations by the Contract documents.

- END OF SECTION -