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**SECTION 02545  
SANITARY SEWER PIPE LINING**

**PART I: GENERAL**

**1.1 GENERAL REQUIREMENTS**

- A. Rehabilitation of sanitary sewer lines by manhole entry method. Excavations shall not be allowed; rather trenchless methods shall be used. Reline finished, rehabilitated sanitary sewer line with continuous tight-fitting, watertight liner extending over entire length of line between manhole sections.

**1.2 MEASUREMENT AND PAYMENT**

A. Unit Prices:

1. Payment for pipe lining shall be on a unit price basis per linear foot of sanitary sewer lined as measured along the centerline of the sanitary sewer line. Payment shall be made for each sanitary sewer line, from manhole to manhole, complete in place, including all materials equipment, and labor.
2. No separate payment shall be made for Television Inspection of repaired sanitary sewer lines.
3. Refer to Section 01270 – Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum):

1. If contract is Stipulated Price Contract, payment for work in this Section is included in the Total Stipulated Price.

**1.3 REFERENCES**

A. ASTM – American Society for Testing and Materials.

1. ASTM D543 – Resistance of Plastics to Chemical Reagents.
2. ASTM D638 – Tensile Properties of Plastic.
3. ASTM D790 – Flexural Properties of Un-reinforced and Reinforced Plastic and Insulating Materials.
4. ASTM D1693- Environmental Stress Cracking of Ethylene Plastics.
5. ASTM D1784 – Rigid Poly Vinyl Chloride (PVC) Compounds and Chlorinated Poly Vinyl Chloride (CVPC) Compounds.
6. ASTM D2412 – Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
7. ASTM D2444 – Impact Resistances of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight).
8. ASTM D2990 – Tensile, Compressive, and Flexural Creep and Creep-Rupture of Plastics.
9. ASTM D3034 – Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.

- 10. ASTM D3350 – Polyethylene Plastics Pipe and Fittings Materials.
- 11. ASTM D5813 – Cured-In-Place Thermosetting Resin Sewer Pipe.
- 12. ASTM F1216 – Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube.
- 13. ASTM F1504 – Folded Poly Vinyl Chloride (PVC) Pipe for Existing Sewer and Conduit Rehabilitation.
- 14. ASTM F1533 – Deformed Polyethylene (PE) liner.
- 15. ASTM F1606 – Rehabilitation of Existing Sewers and Conduits with Deformed Polyethylene (PE) liner.
- B. CFTS – City of Friendswood Technical Specifications.

**1.4 DEFINITIONS**

- A. Deformed Polyethylene Liner: Polyethylene pipe manufactured in deformed shape that reduces cross-sectional area for insertion and rehabilitation of non-pressure pipelines, conduits and ducts.
- B. Folded Poly Vinyl Chloride (PVC) Pipe: Pipe that has been manufactured in folded shape for use in existing sanitary sewer and conduit.
- 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 thermo-setting 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.

**1.5 SYSTEM DESCRIPTION**

- A. Design Requirements: Design newly installed liner for a minimum fifty years (50 Yrs) continuous loading condition.
  - 1. Design thickness of liner system for fully deteriorated host pipe condition.
  - 2. For solid-walled liner, determine the minimum thickness in accordance with modified AWWA formula listed below.  
$$t = 0.712 D * [(N * q_t / C)^2 / E_L * R_W * B' * E'_s]^{1/3}$$
where:
    - t = Required minimum installed liner wall thickness in inches.
    - D = Inside diameter of host pipe in inches.
    - N = Safety factor, use 2.0
    - $q_t$  = Total external pressure on pipe in psi.  
 $= 0.433 * H_W + [w * H_s * R_W / 144] + W_s$
    - $H_W$  = Height of water table above host pipe in feet, use zero (0).
    - W = Soil density, pounds per cubic foot, use one hundred twenty pounds per cubic foot (120 pcf).

$H_S$  = Height of soil cover over host pipe in feet. Determine cover heights from manhole depths and line sizes given in the 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 five percent (5%) out-of-round, unless otherwise indicated in the Contract Documents.

$E_L$  = Long-term flexural modulus of elasticity, in psi.  
PVC Liner: Two hundred forty thousand pounds per square inch (240,000 psi).  
High-Density Polyethylene Liner: Ninety-one thousand pounds per square inch (91,000 psi).  
Resin-impregnated Tube System: One hundred twenty-five thousand pounds per square inch (125,000 psi).

$B'$  = Coefficient of elastic support  
=  $1 / [1 + 4e^{(-0.65H_S)}]$

$E'_S$  = Modulus of soil reaction. Use one thousand pounds per square inch (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 the loss of flow-carrying capacity of the existing sanitary sewer, but in no case shall the lining reduce capacity by more than sixteen percent (16%).
  - 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 shall provide a minimum wall thickness determined in paragraph 1.5.A.
2. Proposed liner material shall be inert to attack by sanitary sewage and suitable for use in underground sanitary 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.

**1.6 SUBMITTALS**

- A. Shop drawings: Submit shop drawings that identify locations and methods of liner insertion, liner size, thickness calculations and

assumptions used as basis for calculations.

1. Submit for review by the Project Manager as least ten working days (10 Wd) prior to start of the Work.
  2. Assume liner shall provide full 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 the Work can be accomplished without sanitary sewage spill.
    - a. Bypass pumping plan shall be in accordance with the Drawings and the requirements of Section 02555 – Sanitary Sewer Bypass Pumping.
    - b. Include emergency response action 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 the liner materials are in compliance with the 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, trimming and finishing.
  3. Manufacturer's certification, field measurements and pipe-sizing calculations which demonstrate that the 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 the Project Manager prior to installation.
  2. Certificates: Certificates of compliance with design and test reports in accordance with ASTM test methods.
  3. Submit evidence acceptable to the City, such as certified copy of license or agreement, that the Contractor has authority from patent owner to use and/or install patented materials or use patented equipment or methods.

#### 1.7 QUALITY ASSURANCE

- A. Comply with this specification and specific product manufacturer recommendations. Conflict between product manufacturer's recommendations and any portion of Contract Documents shall be resolved by the City prior to proceeding with the Work.
- B. Manufacturer Qualifications: Products used in the Work shall be produced by manufacturers regularly engaged in manufacture of similar

products and with a history of successful production acceptable to the City.

- C. Installer Qualifications: Licensed or certified by the lining system manufacturer, and must have the following qualifications:
  - 1. Thoroughly trained and experienced in the necessary crafts to complete the Work.
  - 2. Completely familiar with the specified requirements and methods needed for proper performance of the Work.

#### 1.8 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 the liner at the Contractors cost before proceeding any further.

### PART II: PRODUCTS

#### 2.1 MANUFACTURERS

- A. Subject to compliance with the requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
  - 1. CSR Hydro Conduit: Deformed polyethylene liners marketed under the trade name "U-liner."
  - 2. Inituform – USA: Folded Poly Vinyl Chloride (PVS) liners marketed under the trade name "NuPipe."
  - 3. Inituform – USA: Cured-in-place resin-impregnated tube liners marketed under the trade name "Inituform."
  - 4. In-Liner – USA: Cured-in-place resin-impregnated tube liners marketed under the trade name "InLiner USA."

#### 2.2 MATERIALS

- A. Liner material: Provide light-colored or white liner to facilitate closed-circuit television inspection that shall conform to the requirements in Section 02520 – Television Inspection of Sanitary Sewer Lines.
  - 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 ASTM F1216.
    - a. Resin-impregnated tube liner material shall consist of

- one (1) 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, thermo-set resin and catalyst system, or epoxy resin and hardener system that is compatible with the installation process.
  - e. Outside layer of tube should be plastic-coated with material compatible with resin system to be used.
- B. Liners fabricated from PVC, PE or resin-impregnated tubes shall comply with the physical specifications in TABLE 4.1 – LINER MATERIAL PHYSICAL REQUIREMENTS in this Section.
- C. Pre-Liner Material: If used, pre-liner material shall be manufactured from material capable of withstanding temperatures and pressures encountered during installation.

### **PART III: EXECUTION**

#### **3.1 EXAMINATION**

- A. Take field measurements of pipe inside diameter of sanitary 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 a tight fit with existing pipe to be restored.
- C. Confirm lengths of liner to be installed.
- D. Locate live sanitary sewer 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.
  - 1. Live Service: Inactive sanitary sewer service lines to vacant lots or vacant buildings to be occupied later or to occupied buildings with more than one (1) sanitary sewer service line serving the property.

#### **3.2 PREPARATION**

- A. Successfully complete the following items before installation of the Work.
  - 1. Control sanitary sewer flow as specified in Section 02555 – Sanitary Sewer Bypass Pumping.
  - 2. Clean sanitary sewer lines prior to television inspection and installation of liners in compliance with Section 02530 – Sanitary Sewer Line Cleaning.
  - 3. Perform closed-circuit television inspection as specified in Section 02520 – Television Inspection of Sanitary Sewer Lines.
- B. Take precautions to protect new liner, existing pipe, and manholes from

damage that might result during insertion process.

### 3.3 SEQUENCE OF WORK

- A. Divert sanitary sewer flow to comply with the requirements of Section 02555 – Sanitary Sewer Bypass Pumping.
- B. Clean sanitary sewer lines and perform pre-insertion CCTV inspection in compliance with Section 02530 – Sanitary Sewer Line Cleaning and Section 02520 – Television Inspection of Sanitary Sewer Lines. Complete cleaning and television inspection a minimum of twenty-four hours (24 Hrs) and a maximum of sixty hours (60 Hrs) prior to rehabilitation lining for Cured-In-Place Pipe (CIPP).
- C. Perform any point repairs that are needed in compliance with Section 02540 – Sanitary Sewer Point Repairs.
- D. Install liner within all requirements of this Technical Specification.
- E. Leak-test liner to comply with requirements of Section 02500 – Gravity Sanitary Sewers and Section 02525 – Acceptance Testing for Gravity Sanitary Sewer Lines.
- F. Reconnect sanitary sewer service connections to newly rehabilitated pipe.
- G. Perform post-insertion CCTV inspection in compliance with Section 02520 – Television Inspection of Sanitary Sewer Lines. If the Project Manager, after seeing the DVD's, concludes that the liner has not been installed properly and to the specifications, the Contractor shall reinstall liner and CCTV inspection until liner is in compliance, and at no additional cost to the City.

### 3.4 PIPE POINT REPAIR

- A. Repair sanitary sewer pipe where point repairs are identified on the Drawings.
- B. Sanitary sewer pipe and repair materials shall be the same as the host sanitary sewer line, unless otherwise indicated on the Drawings.
- C. Trenching and Excavation shall conform to Section 02125 – Excavation and Backfill for Utilities and Section 02280 – Trench Safety Systems.
- D. When required for completion of the Work bypass pumping shall be in conformance of Section 02555 – Sanitary Sewer Bypass Pumping.
- E. Notify the Project Manger a minimum of forty-eight hours (48 Hrs) in advance of planned time to begin sanitary sewer line point repair work at a particular location.
- F. Installation and Field Inspection: Installation of replacement pipe and/or repair work shall conform to Section 02500 – Gravity Sanitary Sewers. All sanitary sewer point repairs shall be inspected by the Project Manager prior to back filling and compaction.

### 3.5 GENERAL REQUIREMENTS FOR LINER INSTALLATION

- A. Perform operations in strict accordance with Occupational Health and Safety Administration (OSHA) and manufacturer safety requirements.

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Particular attention shall be given to safety requirements involving confined spaces, work on elevated platforms and working with pressurized equipment.

- B. To ensure proper heat distribution for rehabilitation systems using heat exchange methods, and to prevent creation of flat bottoms in liner profile, takes steps to isolate new liner system from inflow, infiltration or standing water.

Isolate new liner system by temporarily stopping the inflow and infiltration and remove 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, unless warranted by extraordinary circumstances and with the approval of the Project Manager.
- D. For cured-in-place pipe (CIPP) processes, designate location and notify the Project Manager where resin impregnation shall 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 seat at manhole wall, apply sealant to annular space. Sealant material shall be approved by the Project Manager.

### 3.6 LINER INSTALLATION OF DEFORMED POLYETHYLENE AND FOLD POLY VINYL CHLORIDE (PVC) SYTEMS

- 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 out 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 pressure in liner. In no case shall this temperature be in excess of one hundred degrees Fahrenheit (100° F).

### 3.7 LINER INSTALLATION – CURED-IN-PLACE PIPE (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 non-impregnated liner tube shall be impregnated prior to installation.
  - 1. Impregnate liner tube by vacuum or other approved means.
  - 2. The Project Manager shall inspect materials and “wetting” procedure.
  - 3. Use resin and catalyst system compatible with requirements of

this method.

- C. Liner Insertion: Ensure that the pressure in the liner exceeds both the pressure due to groundwater head and any pressure due to sanitary sewage in lateral sanitary 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 a rate greater than three feet (3 Ft) per minute and less than ten feet (10 Ft) per minute.
  2. Mark exterior of manufactured tube along its entire length at regular intervals not to exceed five feet (5 Ft) as a gage to measure elongation during installation.
    - a. During insertion of resin impregnated tube into sanitary sewer pipe, a maximum allowable longitudinal elongation or stretch of material shall not exceed five percent (5%).
    - 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 "wetted" liner through existing or new manholes by means of the inversion process, and application of hydrostatic head or air pressure sufficient to fully extend liner 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 a 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 needed.
  4. Insertion by Winching: The City shall accept winched-in applications as alternate to inversion process, provided that the liner tube and resin conform to materials and curing requirements of ASTM F1216 and this specification.
    - a. Insert "wetted" liner through upstream manhole, and pull through section with power winch and steel cable attached to the end of the liner with appropriate pulling head.
    - b. Provide monitoring device on cable to measure pulling force. Should the pulling force exceed manufacturer recommendations, the liner tube shall be rejected and replaced.

- c. Install rollers in upstream and downstream manholes to guide liner into and out of the host pipe, and to guard against chafing of crowns at entry and exit from winch cable.
  - d. Cover sanitary 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 the liner material. Form CIPP with polyethylene coating on its way to interior surface.
  - e. Use flexible and impermeable calibration hose to inflate the liner tube. Calibration hose may or may not remain in the 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 in order to verify that the minimum specified wall thickness is achieved.
    - 2) Hose material remaining in installation shall be compatible with resin system used, bond permanently with liner 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 the liner tube. Pressure shall inflate and press liner material in tight fit against inner walls of host pipe, producing dimples at lateral and side connections and flared ends.
- D. Curing: After insertion of the liner tube is completed, provide suitable heat source and distribution system to distribute and recirculate hot water, air and/or steam throughout host pipe as recommended by the manufacturer.
- 1. Equipment shall be 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 effect 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 the City.
  - 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 the 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 one hundred degrees Fahrenheit (100° F) 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 the City.

### 3.8 REINSTATEMENT OF SERVICES

- A. Immediately reinstate live services after leak testing is complete and acceptance of sanitary sewer line, in conformance with Section 02525 – Acceptance Testing for Gravity Sanitary Sewer Lines is achieved.
  1. Reconnect from interior of sanitary sewer line by means of television camera and remote-controlled cutting device.
  2. Excavation shall not be allowed.
  3. Holes cut through rehabilitation liner shall be neat and smooth, and match bottom of reinstated service line.
  4. Reinstate live service opening to a minimum of ninety-five percent (95%) and a maximum of one hundred percent (100%) 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 live service shall be free of gaps, voids, or cavities. Grout gaps, voids, or cavities at this joint with packer and grouting system approved by the Project Manager.
  7. Post-construction television inspection shall show focused close-up of entire perimeter of each service reconnection and shall conform to all requirements in Section 02520 – Television Inspection of Sanitary Sewer Lines.
- B. Provide fully-operational backup device for reinstating live service laterals. If for any reason remote cutting device fails during reinstatement of service lateral, a standby device shall be immediately deployed to complete reinstatement.

### 3.9 FIELD QUALITY CONTROL

- A. Inspection: After completion of liner insertions, reinstatement of live service laterals, and finish work at manhole, sanitary sewer shall be televised in color DVD format, as specified in Section 02520 – Television Inspection of Sanitary Sewer Lines. Provide two (2) original disks to the Project Manager.
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 (1 In) or more, or reduce hydraulic capacity of pipe [wrinkles which exceed five percent (5%) of pipe diameter] are unacceptable.
    - a. Remove and repair at no additional cost to the City.
    - b. Wrinkles in finished liner pipe that reduce structural stability of pipe are unacceptable.
  3. In the event the Project Manager, based on review of post-installation Television Inspection DVDs, has reasonable cause to suspect that annular space exists between liner and host pipe, the Contractor shall be directed to excavate and expose existing sanitary 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 a manner approved by the Project Manager.
    - b. If it is determined that no annular space exists, the Contractor shall be reimbursed in accordance with the "Changes" clause of the Contract Documents.
- B. Leak Testing: After completion of liner installation but prior to reinstatement of live service lines, pressure-test rehabilitated sanitary sewer line for leakage in accordance with Section 02500 – Gravity Sanitary Sewers and Section 02525 – Acceptance Testing for Gravity

Sanitary Sewer Lines.

3.10 CLEANING

- A. Keep premises free from accumulations of waste materials, rubbish and other debris resulting from the 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.

**PART IV: TABLES**

**4.1 – LINER MATERIAL 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 (1,720 MPa)	300,000 psi (2,070 MPa)
Flexural Modulus (Long Term)	ASTM D2990	-	125,000 psi (860 MPa)	150,000 psi (1,030 MPa)
Flexural Strength	ASTM D790	-	4,500 psi (31 MPa)	5,000 psi (34 MPa)
Tensile Strength (Yield)	ASTM D638	3,200 psi (22 MPa)	3,000 psi (21 MPa)	4,000 psi (28 MPa)
Tensile Modulus (Initial)	ASTM D638	-	300,000 psi (2,070 MPa)	250,000 psi (1,720 MPa)
Tensile Strength (Long Term)	ASTM D638	-	150,000 psi (1,030 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	ASTM D1693 Condition C	2000 hours	-	-
<sup>(1)</sup> Impact testing performed with twenty pound (20 Lb) Tup A and flat plat holder B. <sup>(2)</sup> Without cracking, breaking or splitting.				

**END OF SECTION**