Section 02427

PLASTIC LINER FOR LARGE-DIAMETER CONCRETE SEWERS AND STRUCTURES

PART 1 G E N E R A L

1.01 SECTION INCLUDES

A. Installation of plastic liners for concrete interceptor sewers and structures. Only plastic liners manufactured with integral locking ribs spaced at approximately 2-1/2 inches on center over entire liner is acceptable. Liners relying on mechanically fastened batten strips, as primary means of anchorage are unacceptable.

1.02 MEASUREMENT AND PAYMENT

A. Unit Prices.

1. No separate payment will be made for Work performed under this Section. Cost is incidental to work of large diameter sewers, precast concrete manholes, or cast- in-place, wastewater-containing structures.

2. Refer to Section 01270 - Measurement and Payment for unit price procedures.

B. Stipulated Price (Lump Sum). If Contract is Stipulated Price Contract, payment for work in this Section is included in total Stipulated Price.

1.03 REFERENCE STANDARDS

A. ASTM D 412 - Standard Test Methods for Vulcanized Rubber and Thermoplastic Rubber and Thermoplastic Elastomers-Tension.

B. ASTM D 2440 - Standard Test Methods for Oxidation Stability of Mineral Insulating Oil.

1.04 SUBMITTALS

A. Conform to requirements of Section 01330 - Submittal Procedures.

B. Prior to submittal of shop drawings, manufacturer shall approve proposed panel layout and proposed details. Contractor shall then submit shop drawings showing proposed panel layout to cover area to be lined. Show on shop drawings proposed details for installation of liner at seams, terminations, corners, openings, pipe penetrations, etc., and type of factory and field welds and attachments.

C. Provide sufficient details to permit placement of liner without use of design Drawings. Reproduction of design Drawings for use as shop drawings will not be allowed. Do not begin fabrication of liner until after shop drawings and submitted materials have been reviewed and accepted by City Engineer.

1.05 INSTALLER QUALIFICATIONS

A. Applicators. Application of plastic liner to forms and other surfaces, liner finishing, repair, and testing is considered highly specialized work and shall be performed only by firms and individuals recommended and approved by lining manufacturer. Personnel performing such work are to be trained in methods of installation and demonstrate their ability to City Engineer.

B. Welders.

1. Each welder is to pass qualification welding test before doing welding. Requalification may be required at time deemed necessary by City Engineer. Provide at least 24 hours notice to City Engineer to schedule qualification welding test.

2. Make test welds in presence of City Engineer. Test welds are to consist of following:

   a. Begin with two pieces of liner, at least 15 inches long and 9 inches wide. Hold pieces in vertical position, lapped 1-1/2 inches.

   b. Position weld strip over edge of lap and weld to both pieces of liner. Extend each end of weld strip at least 2 inches beyond liner to provide tabs.

3. The weld specimen will be tested as follows:

   a. Subject each weld strip tab, tested separately, to 10-pound pull normal to face of liner with liner secured firmly in place. Weld is acceptable when there is no separation between weld strip and liner.

   b. Cut three test specimens from welded sample and tested in tension across welds. Tensile strength measured across welded joints is to be at least 2000 psi when tested in accordance with ASTM D 412. When none of these specimens fails when tested as indicated above, weld will be considered satisfactory.

   c. If one specimen fails to pass tension test, retest will be permitted. Retest consist of testing three additional specimens cut from original welded sample. When three retest specimens pass test, weld will be considered satisfactory.

4. A disqualified welder may submit new weld sample when welder has had sufficient off-the-job training or experience to warrant re-examination.

PART 2 P R O D U C T S

2.01 MANUFACTURERS

A. Plastic liner shall be as manufactured by Ameron Protective Linings Division; Poly-Tee, Inc.; or approved equal.

2.02 MATERIALS

A. Manufacturing.

1. Manufacture plastic liner sheet, joint, corner and weld strips from high molecular weight thermoplastic polymer compounded to make permanently flexible material suitable for use as protective liner in concrete pipe or other concrete structures. Polyvinyl chloride resin is to constitute not less than 99 percent by weight of resin used in formulation. Copolymer resins will not be permitted.

2. During manufacture or prior to final acceptance of Work, City Engineer may sample specimens taken from sheets, strips, or welded joints for testing.

3. Changes in formulation will be permitted only after prior notice is given to City Engineer and manufacturer demonstrates that new plastic liner will meet or exceed requirements for chemical resistance and physical properties.

B. Properties.

1. Plastic liner sheets including locking extensions, joints, corners, and welding strips are to be free of cracks, cleavages or other defects adversely affecting protective characteristics of material.

2. Except at shop welds, plastic liner sheets, joint, corner, and weld strips are to have the following properties when tested at 77 degrees F plus or minus 5 degrees F.

PROPERTY	ASTM TEST METHOD	CHEMICAL RESISTANCE TEST	
		INITIAL	AFTER CHEMICAL EXPOSURE (Note 1)
Tensile strength, min.	D 412, Die B	2200 psi	2100 psi
Elongation at break, min.	D 412, Die B	200 percent	200 percent
Shore durometer, Type D	D 2240, Within 1 sec.	50-60	±5 (Note 2)
	D 2240, 10 sec.	35-50	±5 (Note 2)
Weight change	(Note 3)	-----	±1.5 % (Note 2)

Notes:
1. For 112 days in chemical solutions
2. With respect to initial test results
3. Specimen to be 1-inch x 3-inch sample sheet thickness, taken from sheet or strip prior to final acceptance of work.

2.03 MATERIAL TESTS

A. Material Properties. Test samples taken from sheets, joints or weld strips to determine material properties. Determine PVC tensile strength and elongation in accordance with ASTM D 412 using Die B. Determine indentation hardness in accordance with ASTM D 2240 using Type D durometer, except that single thickness of material will be used. Determination of change of weight and indentation hardness is to be made of 1-inch by 3-inch specimens. Thickness of specimens shall be thickness of sheet or strip.

B. Measurement of Initial Physical Properties. Determine initial values for tensile strength, weight, elongation and indentation hardness prior to chemical resistance tests.

C. Chemical Resistance Tests.

1. Determine physical properties of specimens after exposure to chemical solutions. Condition test specimens to constant weight at 110 degrees F before and after submersion in the following solutions for period of 112 days at 77 degrees F plus or minus 5 degrees F.

Chemical Solution	Concentration
Sulfuric acid	20%*
Sodium hydroxide	5%
Ammonium hydroxide	5%*
Nitric acid	1%*
Ferric chloride	1 %
Soap	0.1 %
Detergent (linear alkyl benzyl sulfonate or LAS)	0.1%
Bacteriological	BOD not less than 700 ppm

* Volumetric percentages of concentrated C.P. grade reagents.

2. At 28-day intervals, remove specimens from each chemical solution and test. When specimen fails to meet 112-day property requirements specified in paragraph 2.02B before completion of 112-day exposure, material will be rejected.

D. Pull Test for Locking Extensions. Liner locking extensions embedded in concrete are to withstand test pull of at least 100 pounds per linear inch, applied perpendicularly to concrete surface for period of 1 minute, without rupture of locking extensions or withdrawal from embedment. Perform this test at temperature between 70 degrees F and 80 degrees F, inclusive.

E. Shop-Welded Joints. Shop-welded joints used to fuse individual sections of liner together, are to meet minimum requirements of liner for thickness, corrosion resistance and impermeability. Welds shall show no cracks or separations and be tested for tensile strength. Tensile strength, measured across welded joint in accordance with ASTM D 412 using Die B, shall be at least 2000 psi. Test temperature is to be 77 degrees F plus or minus 5 degrees F and use measured minimum width and thickness of reduced test specimen section.

F. Spark Test. Shop and field test liners for holidays or flaws using an approved spark tester set to provide minimum of 20,000 volts (Tinker and Rasor Model AP-W with power pack, or approved equal). Satisfactorily repair sheets having holes in shop prior to shipment from manufacturer's plant. Repairs shall be made by welders qualified in accordance with these specifications.

2.04 MATERIAL DETAILS AND DIMENSIONS

A. Approval of Details. Liner sheet, strip, and other accessory pieces are to conform to requirements of these Specifications.

B. Thickness of Material. Minimum thickness of PVC sheet and strip shall be as follows:

Material	Thickness in Inches
Sheet, integral locking extensions	0.065
Sheet, plain	0.094
Joint strip	0.094
Weld strip	0.125

C. Material Sizes. Use pipe-size sheets for sheets of PVC liner to provide coverage required by Drawings. Structural sheets are to be standard 48-inches by 96-inches, with special size noted on shop drawings. Lengths specified shall include tolerance at ratio of plus or minus 1/4-inch for each 100 inches, or 0.25 percent. Joint strips shall be 4 inches plus or minus 0.25 inch in width and have each edge beveled prior to application. Weld strips shall be 1 inch plus or minus 0.125 inch in width. Weld strips are to have edges beveled at time of manufacture.

D. Locking Extensions.

1. No polygrip-type holding or locking extension will be permitted.

2. PVC liner to be embedded in concrete is to have integral locking extensions. Liner may not be bonded to concrete surfaces with adhesives except as specifically acceptable to City Engineer.

3. PVC locking extensions are to be same material as liner, be integrally molded or extruded with sheets, and have an approved cross section with minimum height of 0.375 inch and minimum web thickness of 0.085 inch. They are to be approximately 2.5 inches apart and be such that when extensions are embedded in concrete, liner will be held permanently in place.

4. PVC locking extensions are to be parallel and continuous except where interrupted for joint flaps, weep channels, strap channels and for other purposes shown on Drawings or permitted by City Engineer.

5. The liner sheet edge which will be lower terminal edge in structure is not to extend beyond base of final locking extension more than 0.375 inch.

E. Provisions for Strap Channels. Unless alternate methods are acceptable to City Engineer, liner required to be secured to inner form with straps are to have strap channels at not more than 20 inches on center perpendicular to locking extensions. Strap channels are to be maximum of 1-inch wide and formed by removing locking extensions so that maximum of 3/16-inch remains. Channels are not to be provided in final two locking extensions adjacent to terminal edge of liner coverage.

F. Flaps. When transverse flaps are specified or required, fabricated by removing locking extensions so that no more than 1/32 inch of base of locking extensions remains on sheet.

G. Adhesive Products. Adhesive products and application procedures used in installation of liner are to be according to manufacturer's recommendations. Adhesive products intended for use inside cast-in-place structures are to be non-flammable.

H. Cleaners. Cleaners used in installation of liner shall be reviewed by City Engineer prior to use. Cleaners are to be nonflammable and water soluble or water dispersible and not be detrimental to plastic liner.

I. Caulking Products. Caulking products and application procedures used in installation of liner and appurtenances are to be as recommended by manufacturer.

J. Mechanical Anchors. When approved for use with plain sheet liner, provide anchors and washers of Type 316 stainless steel, and as recommended by liner manufacturer.

PART 3 E X E C U T I O N

3.01 NOTIFICATION

A. Notify City Engineer at least 24 hours before reinforcing steel placement so that lining may be inspected and errors corrected without delaying Work.

3.02 PLACING LINER

A. Location. Place liner throughout entire length of interceptor sewer along top 300 degrees of pipe circumference, and inside structures as indicated on Drawings. Liner is to be applied and secured to forms and inspected by City Engineer prior to placement of reinforcing steel.

B. Coverage.

1. In cast-in-place structures, no offset of lower terminal edge is permitted. Unless otherwise shown on Drawings, lower terminal edge is to be one foot below low water level (Aall pumps off@ level for lift stations), or 6 inches below top of grout or concrete fillet, whichever is higher.

2. At station where there is difference in pipe’s circumferential liner coverage, as shown on Drawings, and longitudinal terminal edges of liner downstream from that station are lower than those upstream, uniformly slope terminal edges of liner installed in section of pipe or structure immediately upstream from station for entire length of section of pipe or structure from limits of smaller coverage to those of greater coverage. Wherever longitudinal terminal edges of liner downstream from station are higher than those upstream, accomplish slope uniformly throughout length of section of pipe or structure immediately downstream from station. Provide an approved locking extension along sloping lower terminal edges of liner plate.

C. Positioning Liner.

1. Position PVC liner installed in pipe so that locking extensions are parallel to longitudinal axis of pipe.

2. Position PVC liner installed in cast-in-place structures so that locking extensions are parallel to direction of concrete placement, which is normally vertically for vertical walls.

3. Closely fit liner to inner forms. Cut sheets to fit curved and warped surfaces using minimum number of separate pieces.

4. The City Engineer may require use of patterns or marking of sheet layouts directly on forms where complicated warped surfaces are involved.

5. At transverse joints between sheets of liner used in cast-in-place structures and pipe joints, space between ends of locking extensions, measured longitudinally, shall not exceed 4 inches. Where sheets are cut and joined for purpose of fitting irregular surfaces, this space shall not exceed 2 inches.

D. Securing Liner in Place.

1. Liner shall be held snugly in place against inner forms. For pipes and similar circular sections, use light steel banding straps or other approved means. Prefabricated pipe-size tubular sheets which do not require strap channels may also be used.

2. When used, place banding straps in strap channels, as specified under provision for strap channels, at spacing not to exceed 20 inches.

3. Any method of banding, other than in strap channels, shall be reviewed by City Engineer prior to use.

4. On vertical surfaces where form ties or form stabilizing rods pass through liner, make provisions to maintain liner in close contact with forms during concrete placement. These provisions shall be reviewed by City Engineer.

5. Prevent concrete from flowing around edges of sheets at joints by sealing joint or seam with waterproof tape recommended by manufacturer.

6. Forms in contact with plastic liner need not be oiled.

E. Weep Channels.

1. At each pipe joint and at transverse joints in cast-in-place structures, gap not less than 2 inches nor greater than 4 inches shall be left in locking extensions to provide transverse

weep channel. When locking extensions are removed to provide weep channel at joints, base of extension left on sheet shall not exceed 3/16 inch.

2. Provide intermediate weep channels as required to maintain maximum spacing of 8 feet. Intermediate weep channels shall not be less than 2.0 inches nor greater than 4.0 inches in width. When locking extensions are removed to provide intermediate weep channels, base of extension left on sheet shall not exceed 3/16 inch.

3. Any area behind liner, which is not properly served by regular weep channels, shall have additional weep channels 2 inches wide provided by cutting away locking extensions.

4. Provide transverse weep channel approximately 12 inches away from each liner return where surfaces lined with plastic liner join surfaces, which are not so lined.

5. As part of work of installing liner, clear outlets of weep channels of obstructions, which would interfere with their proper functions.

6. Design weep channels for external hydrostatic pressures of water column equal in height to greater of 50 feet (22 psi) or 1.1 times depth of burial.

F. Liner Returns.

1. Install liner return where shown on approved shop drawings and wherever surfaces lined with plastic liner joins surfaces, which are not so lined.

2. Unless otherwise indicated by Drawings or approved shop drawings showing liner installation methods, make returns as follows:

   a. Return liner at least 3 inches at surfaces of contact between concrete structure and items not concrete (including access frames, gate guides and pipe penetrations).

   b. Follow the same procedure at joints where type of protective lining is changed, or new work is built to join existing unlined concrete.

3. Provide locking extensions on returns to lock returns to concrete of plastic-lined, cast-in-place structures.

4. Seal each liner return to adjacent construction with which it is in contact by means of an adhesive system recommended by manufacturer and acceptable to City Engineer. When joint space is too wide or joint surfaces too rough to permit use of compound, fill joint space with 2 inches of densely caulked cement mortar, lead wool, or other caulking material and finished with minimum of 1-inch depth of an approved corrosion resistant sealant material.

3.03 CONCRETING OPERATIONS

A. Concrete Placement.

1. Carefully vibrate concrete placed against liner shall be so as to avoid damage to liner and to produce dense concrete securely anchoring locking extensions into concrete. Use external vibrators in addition to internal vibrators, particularly along lower terminal edge of liner.

2. Stiffeners, when used along locking extensions of liner installed in forms for pipe, shall be withdrawn completely during placement of concrete in forms. Revibrate concrete to consolidate concrete in void spaces caused by withdrawal of stiffeners.

B. Removing Forms.

1. In removing forms, take care to protect liner from damage. Do not use sharp instruments to pry forms from lined surfaces. When forms are removed, pull nails that remain in liner plate without tearing liner and clearly mark resulting holes. Mark form tie holes before ties are broken off. Mark areas of abrasion of liner.

2. Following completion of form removal, clean liner in pipe and structures for inspection.

3. Remove banding straps used in securing liner to forms for pipe and cast-in-place structures within limits of unlined invert.

3.04 FIELD JOINTING OF LINER

A. Installation Requirements.

1. No field joint shall be made in liner until lined pipe or structure has been backfilled and 7 days have elapsed after flooding or jetting has been completed. Where ground water is encountered, joint shall not be made until pumping of ground water has been discontinued for at least 7 days and no visible leakage is evident at joint. Liner at joints shall be free of mortar and other foreign material and be clean and dry before joints are made.

2. Hot joint compound shall not be brought in contact with liner.

3. No coating shall be applied over joint, corner or welding strip, except where nonskid coating is applied to liner surfaces.

B. Field Joints in Pipe Installation.

1. Field joints in lining at pipe joints shall be one of the following types:

a. Type P-1. Make joint with separate 4-inch joint strip and two welding strips. Center 4-inch joint strip over joint, heat-sealed to lining, then welded along each edge to

adjacent liner sheets with 1-inch weld strip. 4-inch joint strip shall lap over each sheet minimum of 2 inch.

b. Type P-2

1. Make joint with joint flap with locking extensions removed as described in paragraph 2.04 above, and extending approximately 4 inches beyond pipe end. Joint flap shall overlap lining in adjacent pipe section minimum of 2 inch and be heat-sealed in place prior to welding. Complete field joint by welding flap to lining of adjacent pipe using 1-inch weld strip.

2. Take care to protect flap from damage. Avoid excessive tension and distortion in bending back flap to expose pipe joint during laying and joint mortaring. At temperatures below 50 degrees F heating of liner may be required to avoid damage.

2. Do not make field joints in liner at pipe joints until mortar in pipe joint, when used, has been allowed to cure for at least 48 hours.

3. Joints between lined pipe and lined structures are to be either Type C-1 joint or Type C-2 joint as described below.

C. Field Joints in Concrete Structures. Field joints in liner on concrete structures are to be one of following types:

1. Type C-1. Make joint with separate 4-inch joint strip and two welding strips. Center 4-inch joint strip over joint, heat-sealed to liner, then welded along each edge to adjacent sheets with 1-inch wide weld strip. Width of space between adjacent sheets is not to exceed 2 inches. 4-inch joint strip is to lap over each sheet minimum of 2 inch. It may be used at transverse or longitudinal joint.

2. Type C-2. Make joint by lapping sheets not less than 2 inch. One 1-inch weld strip is required. Upstream sheet is to overlap one downstream. Heat-seal lap into place prior to welding on 1-inch weld strip.

3. Type C-3. Make joint by applying 2-inch wide waterproof tape or 1-inch wide welding strip on back of maximum 1/4-inch gap butt joint or by some other method approved by City Engineer to prevent wet concrete from getting under sheet. After forms have been stripped, apply 1-inch weld strip over face to sheet.

D. Installation of Welding Strips.

1. All welding of joints is to be in strict conformance with specifications and instructions of lining manufacturer.

2. Welding is to fuse both sheets and weld strip together to provide continuous joint equal in corrosion resistance and impermeability to liner plate.

3. Hot-air welding tools shall provide effluent air to sheets to be joined at temperature between 500 degrees F and 600 degrees F. Hold welding tools approximately 2 inch from and moved back and forth over junction of two materials to be joined. Move welding tool slowly enough as weld progresses to cause small bead of molten material to be visible along both edges and in front of weld strip.

4. Maintain adequate ventilation in confined spaces during welding operations.

5. After repairs have been made, defective welds will be reinspected and re-tested.

E. Joint Reinforcement. Apply 12-inch long welding strip as reinforcement across each transverse joint and weep channel which extends to lower terminal edge of liner. Center reinforcement strips over joint being reinforced and located as close to lower edge of liner as practicable. Weld in place after transverse welding strips have been installed.

F. Application of Liner to Concrete Surfaces with Adhesives. Application of liner plate to concrete surfaces by means of adhesive is allowed only where shown on Drawings for existing structures, or where specifically acceptable to City Engineer and called out on approved shop drawings, and is to be accomplished by following steps:

1. Etch concrete surface by abrasive blasting to develop slightly granular surface.

2. After abrasive blasting, thoroughly clean concrete surface of dust.

3. Apply primer, adhesive and liner in strict accordance with manufacturer's recommendations, as approved by City Engineer.

4. Place mechanical anchors at 12-inch centers each way after adherence of liner to concrete surface has been achieved. Place anchors after adhesive system has cured for minimum of 24 hours. Seal penetration of liner by anchor in accordance with manufacturer's recommendations.

G. Nonskid Surfaces. Surfaces of liner, shown on Drawings to be nonskid, treated as follows prior to installation:

1. Liner is to be cleaned, dried, and spread with an adhesive coating recommended by manufacturer of liner plate.

2. Liberally sprinkle surface with clean, dry, well graded sand, which will pass No. 30 sieve but be retained on No. 70 sieve.

3. After sanded surface has thoroughly dried, brush away excess sand and spray seal coat of adhesive coating over sand in sufficient quantity to coat and bond sand to liner plate.

4. Allow coated sand surface to dry thoroughly before handling.

H. Protection and Repair of Liner.

1. Take necessary measures and precautions to prevent damage to liner from equipment and materials used in or taken through Work. Repair damage to installed liner plate in accordance with requirements for repair of liner.

2. Patch nail and tie holes and cut, torn and seriously abraded areas in liner plate. Patches made entirely with welding strip are to be fused to liner over entire patch. Use of this method is limited to patches, which can be made with single welding strip. Use of parallel, overlapping or adjoining welding strips will not be permitted. Larger patches may consist of smooth liner over damaged area, with edges covered with welding strips fused to patch and to liner adjoining damaged area. Limit size of single patch of latter type only as to its width, which shall not exceed 4 inches.

3. Whenever liner is not properly anchored to concrete, or whenever patches larger than those permitted above are necessary, accomplish repair of liner and restoration of anchorage by injecting epoxy grout behind liner plate by method approved by City Engineer. Use of adhesives will not be allowed to repair improperly anchored liner plate.

I. Field Tests.

1. Upon completion of installation, clean surface of liner to permit visual inspection and spark testing by City Engineer, using spark-type detector complying with requirements for Spark Test. Properly repair and retest areas of liner failing to meet field test.

2. Contractor is to assist in inspection and spark testing by providing adequate ventilation, ladders for access, barricades or other traffic control devices, and is responsible for opening and closing entrances and exits.

3. Spark testing of liner by Contractor is to be done with detector complying these Specifications.

END OF SECTION