

SECTION 02xxx

**GROUTED-IN-PLACE-LINING
OF SEWERS & CONDUITS WITH PROFILED PVC**

PART I. GENERAL

1.01 SECTION INCLUDES

- A. The rehabilitation of existing sewers using an unplasticized rigid polyvinylchloride (uPVC) spiral wound or panel grouted-in-place liner system. The lining process uses a PVC profile strip which is installed into the existing sewer through an existing access point or a newly installed access location as identified on the contract drawings. The adjacent ribbed profile strips shall be mechanically locked together with a separate joiner strip with an integral seal to form a complete liner system closely fitting to the inside of the host sewer. The liner system shall be installed to a fixed diameter or shape leaving an annular space between the installed liner and existing sewer wall. Depending on the installation and approved design calculations, additional reinforcing may be installed in the annular space. The annular space is then filled with cementitious grout as specified. The annulus shall be grouted in controlled lifts and/or an independent internal bracing system shall be utilized during the grouting operations to prevent buckling and deformation of the liner. Grouting and bracing shall be per the liner manufacturer's recommendation. The PVC ribs shall be mechanically locked into the grout.

1.02 MEASUREMENT AND PAYMENT

- A. Unit Prices:
1. Measurement and payment for Grouted-In-Place Lining of sewers and conduit with profiled PVC is by the linear foot, measured along the centerline of pipe from centerline to centerline of manholes, and shall be considered full compensation for all labor and materials required to install the liner to specified requirements.
 2. No separate payment will be made for the following items of work. Include cost of these items in the unit price for installing profiled PVC lining:
 - a. Diversion pumping.
 - b. Sealing the liner at manholes or junction chambers.

- c. Sealing the liner and transitioning to the existing pipe or lining at the ends.
 3. No separate payment for pre-installation and post-installation cleaning and television inspection as specified in Section .
 4. Payment for point repairs and obstruction removals will be made according to Section .
 5. Refer to Section 01xxx – Measurement and Payment.
- B. Stipulated Price (Lump Sum): If the Contract is a Stipulated Price Contract, payment for work in this Section is included in the total Stipulated Price.

1.03 REFERENCE SPECIFICATIONS

- A. This section contains references to the following documents. They are a part of this section as specified and as modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
- B. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
- C. ASTM C138 – Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete.
- D. ASTM C939 – Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
- E. ASTM C942 – Standard Test Method for Compressive Strength of Grout for Preplaced-Aggregate Concrete in the Laboratory.

- F. ASTM C1090 – Standard Test Method for Measuring Changes in Height of Cylindrical Specimens from Hydraulic-Cement Grout.
- G. ASTM D1784 – Standard Specification for Rigid Poly (Vinyl Chloride) and Chlorinated Poly (Vinyl Chloride) Compounds.
- H. ASTM D2122 – Determining Dimensions of Thermoplastic Pipe and Fittings.
- I. ASTM F1698 – Standard Practice for Installation of Poly (Vinyl Chloride) (PVC) Profile Strip Liner and Cementitious Grout for Rehabilitation of Existing Man-Entry Sewers and Conduits.
- J. ASTM F1735 – Standard Specification for Poly (Vinyl Chloride) (PVC) Profile Strip for PVC Liners for Rehabilitation of Existing Man-Entry Sewers and Conduits.

1.04 SUBMITTALS

- A. Make Submittals in accordance with Section 01xxx.
 - 1. Submit drawings defining the liner dimensions, minimum grout thickness and reinforcing steel (if required) prepared by the Contractor and design calculations prepared by a licensed professional engineer.
 - 2. Show any modification required to line host pipe with profiled PVC liner including restoring host pipe wall thickness.
 - 3. Grout design mix and grouting plan.

1.05 QUALITY ASSURANCE

- A. The manufacturer of the liner system shall have a minimum of 50,000 linear feet (LF) of sanitary, combined sewers, storm sewers or culverts _____ - inches in diameter or larger, successfully lined in North America.
- B. Only manufacturer certified contractor or subcontractor may install PVC Pipe Lining System.
- C. The Contractor and/or Subcontractor shall be able to demonstrate that they have successfully completed a minimum of 5,000 linear feet (LF) of trenchless sewer lining

rehabilitation in sewers 36 inches in diameter or larger. In lieu of the required experience for this lining system, the Contractor and/or their Subcontractor shall obtain technical training from the product manufacturer and be certified as an installer. If the lining system manufacturer does not have an installer certification process, the Contractor and/or their Subcontractor shall obtain, in lieu of a certification, a letter from the product manufacturer indicating that the Contractor and/or their Subcontractor has completed the requisite training needed to install their product.

1.06 STRUCTURAL DESIGN CONSIDERATIONS

A. The liner shall be designed in accordance with the requirements of ASTM F1698 except as modified herein. The structural design analysis shall consider the existing condition to be Load Case Number [redacted] or as shown on the Drawings, defined as follows:

1. Load Case No. 1: It is assumed that the host-pipe/soil structure interaction system is sound and is sufficient to carry all the earth loading and live loading (including impact). The water table is below the invert of the host pipe so there is no real hydrostatic load to be considered. In this load case the liner's function is to ensure that the contents of the pipe remain inside the pipe and that transient water moving through the soil doesn't enter the pipe thus creating a stable host-pipe/soil system. Use a virtual water table standing 1.0 feet above the top of the lining for the design analysis.
2. Load Case No. 2: It is assumed that the host-pipe/soil structure interaction system is sufficient to carry all the earth loading and live loading (including impact). Use a virtual water table standing 1.0 feet above the top of the lining or the actual level of the water table, as shown on the plans or as specified herein, whichever is higher, for the design analysis.

In those situations where due to loss of wall section from H₂S corrosion (or other causes) the existing in-service safety factor has been reduced to lower than desirable levels, the rehabilitation design will be based upon the current state-of-stress of the existing host pipe and the required design safety factor.

3. Load Case No. 3: As determined through an engineering investigation the host-pipe/soil structure interaction system is not long-term stable. The host pipe is broken and/or badly distorted from its original geometry and/or pieces of the host pipe wall are missing and there has been some loss of the pipe embedment through this breach in its integrity. The design analysis will be based upon the dead and live loads plus

the hydrostatic loading per the Load Case No. 2. The rehabilitation structural design shall consider the PVC liner, grout and host pipe acting as a rigid composite structure to determine the minimum grout thickness required and the amount of additional steel reinforcement, if any, required for supporting the specified or reasonably anticipated loads. If soil voids are suspected, soil grouting may be recommended as shown on the Drawings or specified elsewhere in these Contract Documents.

- B. The structural design shall be based on the following conditions:
1. The earth loads shall be based on the ground elevation shown on the Drawings.
 2. Unit Weight of Soil = _____ lbs/ft³ [use 120 if no value specified].
 3. Minimum service life = 50 years.
 4. H-20 live load, unless noted otherwise on the Drawings or in these specifications.
 5. Modulus of soil reaction = _____ psi [use 1,000 if no value specified].
 6. Design Safety Factor = 2.0 in buckling due to ground water pressure of PVC liner at any grout void 6-inches or less in diameter.
 7. Design Safety Factor = 1.5 in flexural cracking of either the grout or host pipe due to total load from all sources, by grout thickness and strength OR Safety Factor = 2.0 in ultimate strength if reinforcing steel is included in the rehabilitation design.
 8. Uniform vertical and horizontal soil pressure distribution with $P_H/P_V = 0.4$.

PART II. PRODUCTS

2.01 APPROVED MANUFACTURERS

- A. Danby, LLC of Houston, Texas or approved equal.

2.02 MATERIALS

- A. Liner: The liner shall be made from unplasticized PVC compounds and shall meet the minimum requirements of cell class 12343 of ASTM D1784. The PVC profile shall comply with ASTM F1735.

1. Compounds that have different cell classifications because one or more properties are superior (higher number) to those of the specified compounds are also acceptable.
2. The minimum thickness and minimum profile height of the PVC panels shall be as follows:

Nominal ID of Original Pipe	Minimum Base Thickness	Minimum Profile Rib Height
Inches	Inches	Inches
36" to 72"	0.060	0.488
78" and larger	0.065	0.976

B. Grout: The grout shall consist of, but not limited to, any or all of the following:

1. Portland cement, water, fly ash or pulverized lime, and admixtures.
2. The grout mix design shall be as recommended by the PVC liner supplier and approved by the Engineer prior to commencement of work.
3. Fly ash, if used, shall meet ASTM C618, Class F.
4. Grout components should be clean, fresh, and stored in a suitably dry condition.
5. Premixed grouts and grout admixtures should be used in accordance with the manufacturer's specifications. Mixing and pump equipment may be paddle or colloidal mixers, and screw, piston, progressive cavity or peristaltic pumps.
6. All equipment should be kept clean and free from cured grout build-up.
7. Grout Tests:

TEST	ASTM	REQUIREMENT
Density	C138	115-125 lbs/ft ³
Flow Characteristic	C939	< 35 seconds
Compressive Strength	C942	> 5,000 psi @ 28 days
Compressive Strength	C942	> 1,000 psi @ 1 day
Shrinkage	C1090	< 2.0%

8. These characteristics of the Contractor proposed grout mix design shall be supported by tests of sample mixes by a certified testing laboratory.
9. Grout shall be sampled and tested with the following frequency:
 - a. Three sets of 3 cubes each shall be taken during each full day of grouting.
 - b. The sample sets shall be taken from freshly mixed grout at least 2 hours apart.
 - c. One cube from each set shall be tested for compressive strength at 28 days and the average of the results of those 3 cubes shall be compared to the strength used in the approved design calculations.
 - d. The remaining cubes may be used for the Contractor's QC purposes.
 - e. Sample preparation and testing shall conform to ASTM C942.

2.03 MATERIAL TESTS

- A. Tests shall be made in accordance with the applicable ASTM specification when testing for compliance with this specification.
 1. The manufacturer shall provide a certificate of compliance with this specification for all material furnished under this specification.

2.04 LINED PIPE DIMENSIONS

- A. Unless otherwise noted on Drawings or in these specifications, the interior dimensions of the relined sewer shall be the maximum allowed by the thickness of the material (liner plus grout), structural strength, and shape considerations.
- B. Placement of the liner relative to the existing wall of the sewer, if not shown on the Drawings, shall be as proposed by the Contractor and approved by the Engineer.

PART III. EXECUTION

3.01 INSTALLATION PROCEDURES

- A. Standards: The following installation procedures and ASTM F1698 shall be adhered to unless otherwise approved by the Engineer.
- B. Safety: The Contractor shall carry out operations in strict accordance with all applicable OSHA standards. Particular attention is drawn to those safety requirements involving working in confined spaces.
- C. Cleaning of Sewer Line: Prior to any profile lining of a pipe so designated, it shall be the responsibility of the Contractor to clean debris out of the sewer line and clean the pipe walls in accordance with ASTM F1698. All infiltration leaks (continuous stream) that may, in the opinion of the manufacturer, impact the successful installation of the liner must be corrected by using a cementitious water-plug or pressure/chemical grouting at no additional cost to the Owner.
- D. Television Inspection: Perform a pre-installation television inspection in accordance with Section [REDACTED]. Verify that sewer is clean and pipe conditions are suitable for installation for profiled PVC lining. Notify Engineer if conditions exist which will impact installation.
- E. Line Obstructions: It shall be the responsibility of the Contractor to clear the line of obstructions such as solids, dropped joints, protruding service connections or collapsed pipe that will prevent PVC liner installation.
1. If inspection reveals an obstruction that cannot be removed by conventional sewer cleaning equipment, then the Contractor shall make a point repair excavation to uncover and remove or repair the obstruction. Such excavation shall be approved in writing by the Engineer prior to the commencement of the work and shall be considered as a separate pay item.
- F. Liner Installation (Panels): If the job entails the lining of only a portion of the circumference of circular pipes/conduits or the conduit is highly non circular (e.g. low rise arch or semi-elliptical), the PVC liner will be supplied as flat panels. These panels shall be cut and trimmed to fit as near as practical to the internal circumference of the structure to be lined, or as specified. The panels shall be kept square with the pipe wall. The adjacent panel edges shall be locked together using the manufacturer supplied joiner strip as recommended by the manufacturer.
1. If necessary, the panels may be shimmed off the wall to avoid discontinuities on the surface or to insure a minimum required annulus. Such shims shall be of such a

configuration that they will not significantly impede the flow of grout into the annulus.

- G. Liner Installation (Coils): If the profiled PVC liner is provided in the form of coils, the liner shall be spirally wound with the ribbed profile of the strip as near as practical (but not less than 0.5”) to the wall of the existing structure or as specified by the Owner.
1. If necessary, the strip may be shimmed off the wall to avoid discontinuities of the wall surface or to maintain the specified annulus. Such shims shall be of such a configuration that they will not significantly impede the flow of grout into the annulus.
 2. The adjacent panel edges shall be locked together using the manufacturer supplied joiner strip as recommended by the manufacturer.
 3. Additional coils of PVC strip may be introduced by joining the ends of the strip by means of a manufacturer supplied splice strip. The joint shall be sealed on both sides of the splice strip with an approved sealant/adhesive or thermally welded.
 4. Right-angle corner strips, curved corner panels, or combinations of profile panels and splice strips shall be used to accommodate non circular shaped pipes.
- H. Liner Installation at Curves, Bends, Structures and Changes in Size or Shape: Where the existing pipe alignment is curved (either smooth or chords with deflection angles) or angular bends, at structures, manholes and junction chambers, or changes in size, shape or slope; the Contractor shall modify the liner as appropriate to closely follow the existing shape and dimensions or as shown on the Drawings. The methods used to make these modifications shall be:
1. Stretching and/or compressing the adjacent panel joints.
 2. Using fittings or profile accessories as provided by the liner manufacturer.
 3. Field trimming panels, fittings or accessories to fit the existing conditions.
 4. Modifying panels, fittings or accessories by heating and bending to shape.
- I. Reinforcing Steel Installation: The Contractor shall install reinforcing steel (steel bars or welded wire fabric) when the design calculations determine it is necessary. The

reinforcing steel shall be installed to maintain a minimum cover of 1-inch and shall be anchored to the host pipe to maintain its position during liner and grout installation.

- J. Grouting Procedures: The grouting of the annular space is very important to the structural integrity of the renovated sewer and should be designed and executed with great care. Once the liner is in place, the annulus is sealed at the manhole by dry packing with rapid setting mortar. Through this mortar and around the liner are placed a series of tubes that act as grout injection tubes or breather (vent) tubes. Alternatively, or in addition, grout holes may be drilled in the PVC lining at appropriate points and grout pumped into them until satisfactory fill is obtained.
1. Grout holes in the liner shall be sealed with PVC plugs that are then sealed with liner-manufactured approved sealant/adhesive.
 2. Grout shall be placed in controlled stages (lifts) to avoid floating or deforming the liner in accordance with the approved grouting plan.
 3. The Contractor shall submit a grout plan with supporting calculations to demonstrate that the proposed grout lift heights will not buckle or deform the liner.
 4. The Contractor may propose internal bracing to allow greater grout lift heights.
 5. Elapsed time between successive grout stages shall be adequate to allow the grout to attain a minimum compressive strength of 1,000 psi.
 6. The grouting plan shall be reviewed and approved by the Engineer in advance of the work.
- K. Service Connections: Service connections shall be cut-in as the PVC lining is being installed, leaving the lateral flow unobstructed by the lining. A short PVC sleeve, as large as can fit into the existing lateral pipe, shall be inserted into and sealed with the lateral to isolate the grout in the liner annulus from sewerage flows out of the lateral and to prevent the flow of grout into the lateral during the grouting operation. The lateral sleeve shall be sealed with a sealant/adhesive recommended by the liner manufacturer or thermally welded to the PVC liner and shall be cut flush with the liner (protrude less than 0.5 inch). Cut-outs in the PVC liner to accommodate side sewers shall be sealed by bulkheads similar to those at manholes.

- L. Liner Terminations: The beginning and end of the liner shall be cut flush at the termination of the liner system and permanently sealed to the sewer to prevent any infiltration between the installed liner and the host sewer, manhole or structure. All terminations shall be sealed with a sealing material that is recommended by the liner manufacturer that is compatible with the liner materials installed and provides a watertight seal. Sealing shall be performed at no additional cost. The transition between the liner ends and the host sewer shall be rendered smooth to reinstate the sewer flow line.

3.02 FINAL ACCEPTANCE

- A. After installation of the liner, the Contractor shall CCTV inspect the sewer line as specified. See Section [REDACTED]. Final acceptance of the liner shall be based on the Engineer's evaluation of the installation including a review of the CCTV inspection videos and/or physical inspection of the lined sewer.
- B. After the liner installation is complete there shall be no groundwater infiltration.
- C. All service connections shall be open and clear, and unobstructed. All service and manhole connections shall be watertight.
- D. The finished liner shall be continuous over the length of sewer to rehabilitated and shall conform to the size and shape of the host sewer and allowable cross sectional reduction in size as shown on the contract drawings or as specified herein. The installed liner should be free of visual and material defects. There shall be no pits, pinholes, pilot holes, gouges, bulges, unsecured or separated joints/seams or cracks in the finished liner system. The surface shall be smooth and free of excessive waviness, bumps, or bulges throughout the sewer lining.
- E. If any defective liner is discovered after or during the installation of the liner, it shall be repaired according to manufacturer's recommendations at no additional cost to the owner.
- F. After grouting is completed, the liner must be tested by sounding for complete filling of the annular space with grout. A "hammer test" shall be performed by the Owner's representative on the interior wall surfaces of the lined pipe to check for voids in the grouted annular space. The "hammer test" shall consist of tapping on the interior liner surface to determine the location and size of voids within the annular space. Voids detected during this process shall be measured to determine the extent of the void. Voids found larger than 6 inches in circumferential extent (radial direction) shall be filled by

drilling a hole into the void, pumping grout into the void, and then plugging the grouting hole with a PVC plug as above at the Contractor's own expense.

It is possible, using the "hammer test" to detect soil voids outside the existing pipe, even in locations where the annular space between the existing pipe and the PVC liner is completely filled with grout. If the Owner's representative directs the Contractor to drill a hole to confirm a grout void which, in fact does not exist, due to a false hammer test, then the cost of drilling and plugging the hole shall be paid by the Owner on a time and materials basis.

3.03 CLEANUP

- A. After the installation work has been completed and testing accepted, the Contractor shall clean up the project area affected by his operations. All excess material and debris not incorporated into the permanent installation shall be disposed of off-site in a lawful manner by the Contractor. No waste material or construction debris shall be permitted to remain in the sewer.

END OF SECTION