Designation: F1698 – 02 (Reapproved 2015)ε1

Standard Practice for Installation of Poly(Vinyl Chloride)(PVC) Profile Strip Liner and Cementitious Grout for Rehabilitation of Existing Man-Entry Sewers and Conduits[1]

This standard is issued under the fixed designation F1698; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Sections 2.1 and 5.1 were editorially corrected in May 2017.

1. Scope

1.1 This practice describes the procedures for the rehabilitation of sewer lines and conduits by the installation of a field-fabricated PVC liner. After installation of the liner, cementitious grout is injected into the annular space between the liner and the existing sewer or conduit. The rehabilitation of the host structure by this installation practice results in a rigid composite structure (PVC/grout/existing pipe). This rehabilitation process may be used in a variety of gravity applications, such as sanitary sewers, storm sewers and process piping of man-entry sizes (36 to 144 in. in vertical dimension). The profile strips used for field fabrication of PVC liners are supplied in coils for spiral winding of the liner or in custom-cut flat panels for circumferential lining of all or any portion of the circumference of the host conduit (see Figs. 1 and 2).

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Particular attention is drawn to those safety regulations and requirements involving entering into and working in confined spaces.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C942 Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory

C969 Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines

D883 Terminology Relating to Plastics

D1600 Terminology for Abbreviated Terms Relating to Plastics

F412 Terminology Relating to Plastic Piping Systems

F1735 Specification for Poly (Vinyl Chloride) (PVC) Profile Strip for PVC Liners for Rehabilitation of Existing Man-Entry Sewers and Conduits

2.2 *NASSCO Standard:*

Specification Guidelines for Sewer Collection System Maintenance and Rehabilitation[3]

3. Terminology

3.1 *General*—Definitions are in accordance with Terminologies D883 and F412. Abbreviations are in accordance with Terminology D1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *extruded PVC joiner strip*—a companion product to the profile former strip of such configuration as to provide the locking mechanism at the edges of the former strips; the joiner strip contains within it a coextruded flexible PVC seal which forms a compression seal when mated with the edges of the former strips.

3.2.2 *extruded PVC profile former strip*—a product, available in various sizes, consisting of a smooth inner surface and a ribbed outer surface (profile) with edge configurations to allow mechanical locking of adjacent strips.

[1] This practice is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from, NASSCO, Inc., 2470 Longstone Lane, Suite M, Marriottsville, MD 21104, http://www.nassco.org.

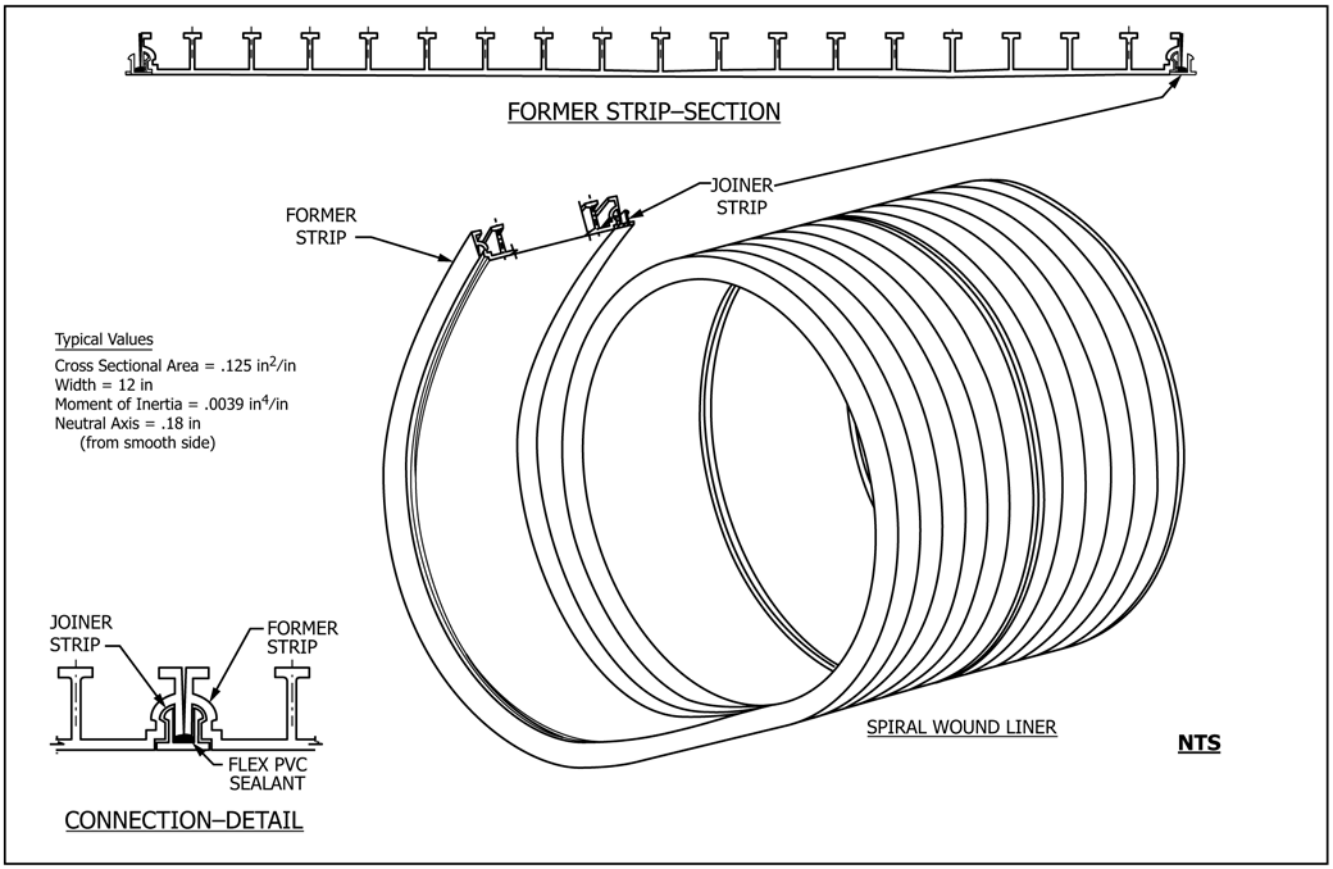


FIG. 1 Example of Profile PVC Strip

3.2.3 *production run*—a continuous extrusion of a given profile type.

3.2.4 *PVC liner*—a product field fabricated from extruded PVC profile strip into a shape substantially conforming to the shape of the existing pipe or conduit, for example, circular, oval, ovoid, and so forth (see Fig. 1).

4. Significance and Use

4.1 This practice is for use by designers and specifiers, regulatory agencies, owners, and inspection organizations involved in the rehabilitation of non-pressure sewers and conduits. As for any practice, modifications may be required for specific job conditions.

5. Materials

5.1 The extruded PVC profile strip (former and joiner) used for the field fabrication of PVC liner should be made as specified in Specification F1735.

5.2 The profile strip should be coiled in a continuous length as long as practical, or cut in custom length panels for storage and shipping to the job site. Handling and storage should be in accordance with the manufacturer's published recommendations.

5.3 The adhesive/sealant, used should be compatible with the PVC compound and the liner process, so as not to effect the properties of the finished liner. (A polyurethane-base product is suggested.)

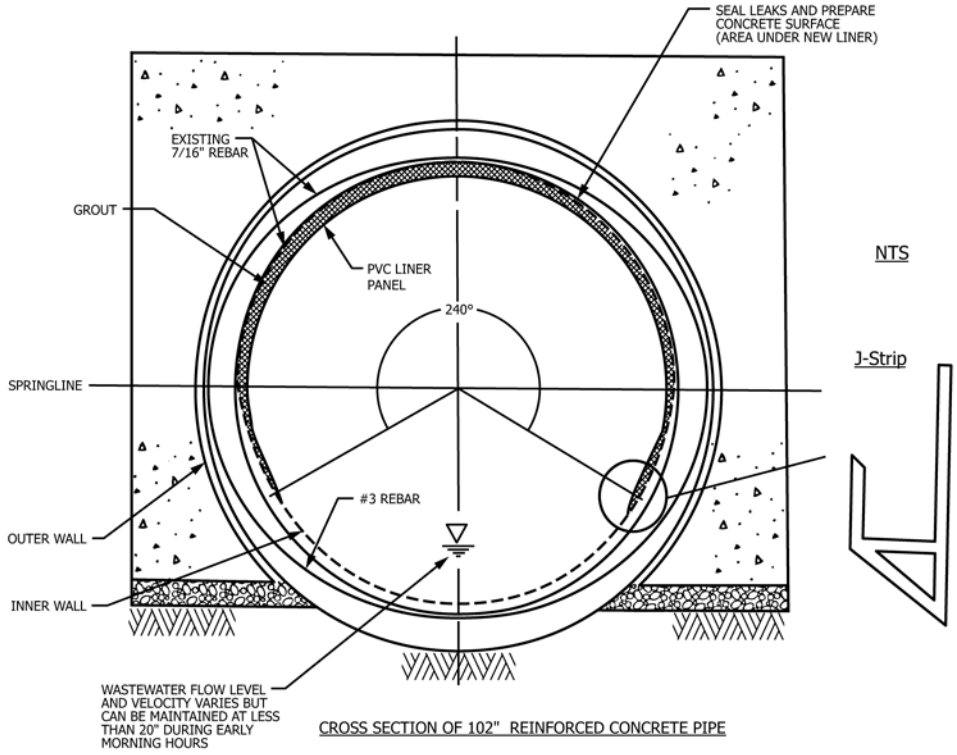
6. Installation Recommendations

6.1 *Cleaning and Inspection:*

6.1.1 Prior to entering access areas such as manholes, and performing inspection or cleaning operations, an evaluation of the atmosphere to determine the presence of toxic or flammable vapors or lack of oxygen shall be undertaken in accordance with local, state, or federal safety and confined space entry regulations.

6.1.2 *Cleaning of Pipeline*—Internal debris should be removed from the existing pipeline. Gravity pipes should be cleaned with hydraulically powered equipment, high-velocity jet cleaners, or a combination of these methods and manually directed high-pressure (2500-psi minimum) water blasting to ensure that the exposed pipe wall is free of contamination of foreign materials and corrosion products and the surface is hard, competent original pipe material.

6.1.3 *Inspection of Pipeline*—Inspection of pipeline should be performed by experienced personnel trained in locating breaks, obstacles, and service connections, either by direct visual observation or by closed-circuit television. The interior of the pipeline should be carefully inspected to determine the location of any conditions that may prevent or adversely impact proper installation of the profile liner, such as protruding service taps, collapsed or crushed pipe, significant line sags, and deflected joints. These conditions should be noted, and as appropriate, corrected prior to installation.



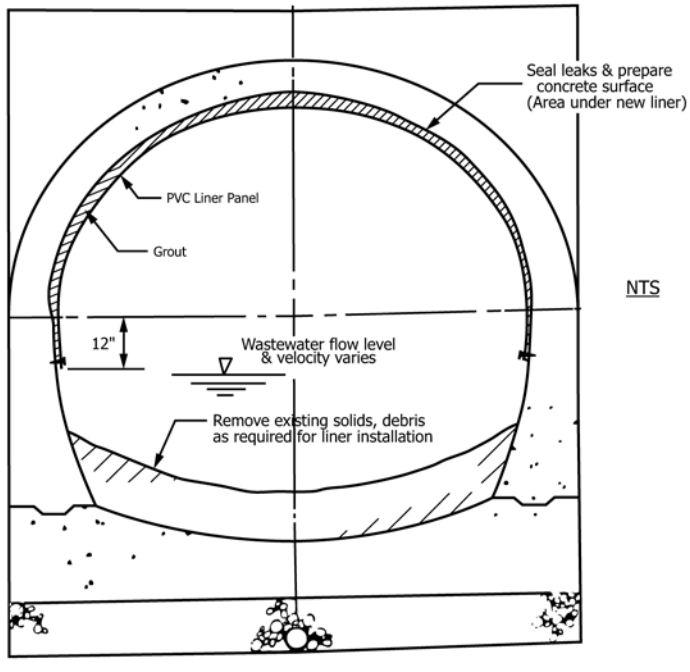


FIG. 2 Typical Installations with Panels

6.1.4 *Line Obstructions*—The existing pipeline should be clear of obstructions that will prevent the proper placement of the PVC liner. If inspection reveals an obstruction that cannot be removed by conventional equipment, then a point repair excavation should be made to uncover and remove or repair the obstruction.

6.2 *Bypassing*—The profiled PVC liner process does not always require a dry pipeline and may be installed with some flow in the existing pipe or lateral connections, or both. If necessary, the bypass should be made by plugging the line at a point upstream of the pipe to be rehabilitated and pumping the flow to a downstream point or adjacent system. The pump and

bypass lines should be of adequate capacity and size to handle any extreme flows expected during the installation period.

6.2.1 Under certain conditions, part or all of the installation may be carried out with some flow in the existing pipeline or service connections, or both.

6.3 *PVC Liner Installation:*

6.3.1 *Liner Installation (Panels)*—If the job requires the profiled PVC strips be provided in the form of panels or if the job entails the lining of only a portion of the circumference, the panels should be cut and trimmed to fit as near as practical to the internal circumference of the structure to be lined or to produce the required annulus (space between the liner and the pipe wall). The panels should be placed square with the pipe wall, that is, circumferentially (see Fig. 2). The adjacent panel edges should be locked together using the manufacturer-supplied joiner strip by means recommended by the manufacturer. End joints or supports should be made with a manufacturer-supplied connector section or support (for example, "J" strips) and sealed with a bead of an approved sealant/adhesive. If necessary, the panels may be shimmed off the wall to avoid discontinuities on the surface or to ensure a minimum annulus required by the specified design. These shims should be of such a configuration as to not significantly impede the flow of grout into the annulus.

6.3.2 *Liner Installation (Coils)*—If the job requires the profiled PVC be provided in the form of coils, the coil should be placed over the open access manhole and the strip pulled down into the pipe through the manhole from the center of the coil. The liner should be spirally wound with the ribbed profile of the strip as near as practical to the wall of the existing structure, or as specified by the owner. 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 should be of a configuration that they will not significantly impede the flow of grout into the annulus. The adjacent profile strip edges should be locked together using the manufacturer-supplied joiner strip by means approved by the material supplier. Additional coils of PVC strip may be introduced by joining the ends of the strip by means of a manufacturer-supplied PVC splicing profile (for example, "H" connector section). The splice should be sealed on both sides of the splice with an approved sealant/adhesive.

6.4 *Grouting*—Once the PVC liner is in place, the ends of the pipe at the manhole are sealed by dry packing with rapid-setting mortar. Through this mortar and around the liner are placed a series of tubes which act as grout injection tubes or breather tubes, or both. Alternatively, or in addition, grout holes may be drilled in the PVC lining at appropriate points and flowable grout injected into them until satisfactory fill is obtained. Grout holes in the liner should be sealed with PVC plugs which, in turn, should be sealed by a bead of approved sealant/adhesive (a polyurethane-base product is suggested). Grouting should proceed in lifts or stages; generally the rise of the first lift is limited by the allowable floating of the liner off the pipe invert and avoiding contact of the liner with the crown of the existing pipe, while the succeeding lifts are limited in vertical rise by liner wall deflection. There should be no leakage of the grout at the joints/seams of the liner. Due to the presence of the breather holes/tubes, the liner will be subjected only to the hydraulic head pressure of the liquid grout, that is, will not sense the grout pump pressure. Thus, pressure monitoring at the grouting hose is generally not required. 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. The grouting plan should be as recommended by the liner material supplier and be reviewed and approved by the owner's representative in advance of the work.

6.4.1 Although the goal of grouting is to fill 100 % of the annulus, hydrostatic buckling strength required by the job specifications determines the required minimum grout fill of the annulus. If no specification for the job exists, it is recommended that the required grout fill of the annulus be such that there be no voids greater in circumferential extent than 5 % of the inside circumference of the liner. Voids found larger than specified shall be filled by drilling a hole in the void, pumping grout into the void, and then plugging the grouting hole with a PVC plug as above. For purposes of this practice, adjacent voids separated circumferentially less than 4 in. should be considered one void. Also, the total void circumferential extent in any one-foot section of the pipe should not exceed 10 % of the circumference of the liner, regardless of the sizes of the individual voids. As both the compressive strength and the grout thickness (size of annulus) are design variables and, therefore, job specific, no general specification can be given here.

6.4.2 The grout should consist of the following: Cement, water, fly ash or lime, and admixtures. The grout mix design, including viscosity and minimum compressive strength to be used for the project application, should be as recommended by the manufacturer (of the PVC strips) and approved by the owner's representative prior to commencement of work. Grout components should be clean, fresh, and stored in a suitably dry condition. Premixed grouts and grout admixtures should be used in accordance with their manufacturer's specifications. Mixing and pump equipment may be either paddle or colloidal mixers, and screw, peristaltic, or piston pumps. All equipment should be kept clean and free from buildup.

6.5 *Service Connections*—Service connections should be cut in as the PVC lining is being installed, leaving the lateral flow unobstructed by the lining. Provisions should be made 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.

7. Inspection and Acceptance

7.1 The installation should be inspected by closed-circuit television or visually, if appropriate. The PVC liner should be continuous over the entire length of the installation. Variations from true line and grade may be inherent because of the conditions of the existing pipeline. No infiltration of ground water through the PVC liner should be observed. All service entrances should be accounted for and be unobstructed.

7.2 *Leakage Testing*—It is impractical to test pipes above a 36-in. diameter for leakage due to the technology available in

the pipe rehabilitation industry. Post-inspection will detect major leaks or blockages.

7.3 *Grout Compressive Strength Testing*—If required by the buyer or designated in the contract documents or purchase order, or both, samples from the mixed grout being injected into the annulus should be collected and tested for compressive strength, in accordance with Test Method C942. Samples should be taken and tested for each manhole-to-manhole pipe section where the annulus is grouted. Measured values of compressive strength should meet the job specifications.

8. Design Considerations

8.1 *General Guidelines*—The design of the grouted PVC liner is largely a function of the condition of the existing pipeline. Design equations and details are given in Appendix X1.

APPENDIX

(Nonmandatory Information)

X1. STRUCTURAL DESIGN CONSIDERATIONS

X1.1 Terminology

X1.1.1 *fully deteriorated pipe*—the existing pipe is not structurally sound and cannot support soil and live loads or is expected to reach this condition over the design life of the rehabilitated pipe. This condition is evident when sections of the existing pipe are missing, the existing pipe has lost its original shape, or the existing pipe has corroded due to the effects of the fluid, atmosphere, soil, or applied loads.

X1.1.2 *partially deteriorated pipe*—the existing pipe can support the soil and surcharge loads throughout the design life of the rehabilitated pipe, and the soil adjacent to the existing pipe must provide adequate side support and bedding. The conduit may have longitudinal cracks and up to 10 % distortion of the diameter.

X1.2 Design

X1.2.1 *Partially Deteriorated Design Condition*—The grouted PVC liner is designed to support only the external hydraulic loads due to ground water (and internal vacuum) since the soil and surcharge loads can be supported by the existing pipe. The ground water level should be determined and the buckling strength of the largest ungrouted arch (normally 5 % or 18° of circular arc) of PVC liner should be sufficient to withstand this hydrostatic pressure without buckling. The following equation may be used to determine the safe height of ground water above the PVC liner crown:

$$P = \frac{8E_L I\,(k^2 - 1)}{0.433 D_m^{\,3} N} \text{ water, ft}$$

where:

P = allowable external pressure of water, ft,
E_L = modulus of elasticity of PVC liner, psi (MPa), reduced to account for long-term effects (see Note X1.1),
I = moment of inertia of PVC liner, in.^{4}/in. (mm^4/mm),
k = factor determined from ungrouted arc (k = 25 for 5 % maximum grout void, that is, ungrouted arc = 18°) (see Note X1.2),
D_m = mean diameter of PVC liner, in. (mm),
= inside diameter of liner + 2(y−bar),
= inside diameter of liner + 2(y-bar),
y-bar = distance to neutral axis of profile from inner (smooth) surface, in. (mm), and
N = factor of safety (2.0 is recommended).

NOTE X1.1—The choice of value (from manufacturer's literature) of E_L will depend on the estimated duration of the application of the load, P, in relation to the design life of the structure. For example, if the total duration of the load, P, is estimated to be 50 years, either continuously applied, or the sum of intermittent periods of loading, the appropriately conservative choice of value of E_L will be that given for 50 years of continuous loading at the maximum ground or fluid temperature expected to be reached over the life of the structure.

NOTE X1.2—The value of k is determined by the iterative solution of the equation: $\sin k\varphi \cos \varphi = k \sin \varphi \cos k\varphi$; where 2φ = ungrouted arc.[4]

X1.2.2 *Fully Deteriorated Design Condition*—The rehabilitation of the host structure by this installation practice results in a rigid composite structure (PVC/grout/existing pipe); the composite structure should be designed to sustain the loads (with safety factor) specified by the applicable project specifications. The contractor and product supplier should provide design details and test data to the owner's engineer to prove to his satisfaction that this level of rehabilitation will be accomplished by the design and installation of the grouted PVC liner system. This design for fully deteriorated conditions should also meet the requirement of X1.2.1 for ground water resistance.

NOTE X1.3—A design method and example are given for RCP in the paper "Structural Rehabilitation of Rigid Pipes."[5] For brick host pipe use of WRC Type I design is suggested.[6]

[4] Timoshenko and Gere *Theory of Elastic Stability* pp. 300, Eq(h).

[5] McAlpine, George. "Structural Rehabilitation of Rigid Pipes," published in *Proceedings of the ASCE/Pipeline Division Conference, "Trenchless Pipeline Projects Practical Applications"* Boston, Massachusetts, June 8–11, 1997. Edited by Lynn E. Osborn. Available from ASCE (ISBN 0–7844–0244–2) or single reprints from the author.

[6] *Sewerage Rehabilitation Manual*, Water Research Centre U.K.,1990