Designation: F 1867 – 98

An American National Standard

Standard Practice for Installation of Folded/Formed Poly (Vinyl Chloride) (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation[1]

This standard is issued under the fixed designation F 1867; 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.

1. Scope

1.1 This practice covers the procedures for the rehabilitation of sewer lines and conduits 4 in. (102 mm) to 18 in. (457 mm) in diameter by the insertion of a folded/formed PVC pipe that is heated, pressurized, and expanded to conform to the wall of the original conduit forming a new structural pipe-within-a-pipe. This rehabilitation process can be used in a variety of gravity applications such as sanitary sewers, storm sewers, and process piping.

1.2 This practice is to be used with the material specified in Section 6 of Specification F 1871.

1.3 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are provided for information only.

1.4 *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.*

1.5 There is no similar or equivalent ISO Standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 638 Test Method for Tensile Properties of Plastics[2]

D 648 Test Method for Deflection Temperature of Plastics Under Flexural Load[2]

D 790 Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[2]

D 1600 Terminology for Abbreviated Terms Relating to Plastics[2]

D 1784 Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds And Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds[2]

D 2122 Test Method of Determining Dimensions of Thermoplastic Pipe and Fittings[3]

F 412 Terminology Relating To Plastic Piping Systems[3]

F 1417 Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low Pressure Air[3]

F 1871 Specification for Folded/Formed Poly (Vinyl Chloride) Pipe Type A for Existing Sewer and Conduit Rehabilitation[3]

2.2 *Uni-Bell Standard:*

UNI-B-5-89 Recommended Practice for the Installation of Polyvinyl Chloride (PVC) Sewer Pipe[4]

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F 412, and abbreviations are in accordance with Terminology D 1600, unless otherwise indicated. The abbreviation for poly(vinyl chloride) plastics is PVC.

3.1.1 The term TYPE A is not an abbreviation but rather an arbitrary designation for PVC compounds with a minimum value for modulus in tension as listed in 6.1 and a maximum value as defined by cell limit 1 of Specification D 1784.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *folded pipe, n*—pipe that has been manufactured and calibrated round, then subsequently cooled and deformed into a folded shape for use in existing sewer and conduit rehabilitation (see Fig. 1).

3.2.2 *formed pipe, n*—a folded pipe that has been inserted into an existing sewer or conduit and expanded with steam heat and pressure, and, if required by the manufacturer, with a squeegee device or similar device to provide a close fit to the existing pipe (see Fig. 1).

3.2.3 *formed field sample, n*—A formed field sample is formed when the folded pipe has been inserted into a mold pipe and expanded with steam heat and pressure, and, if required by the manufacturer, with a squeegee or similar device to provide a close fit to the mold pipe.

3.2.4 *liner, n*—PVC formed pipe fully functional as a pipe within a rehabilitated pipe.

---

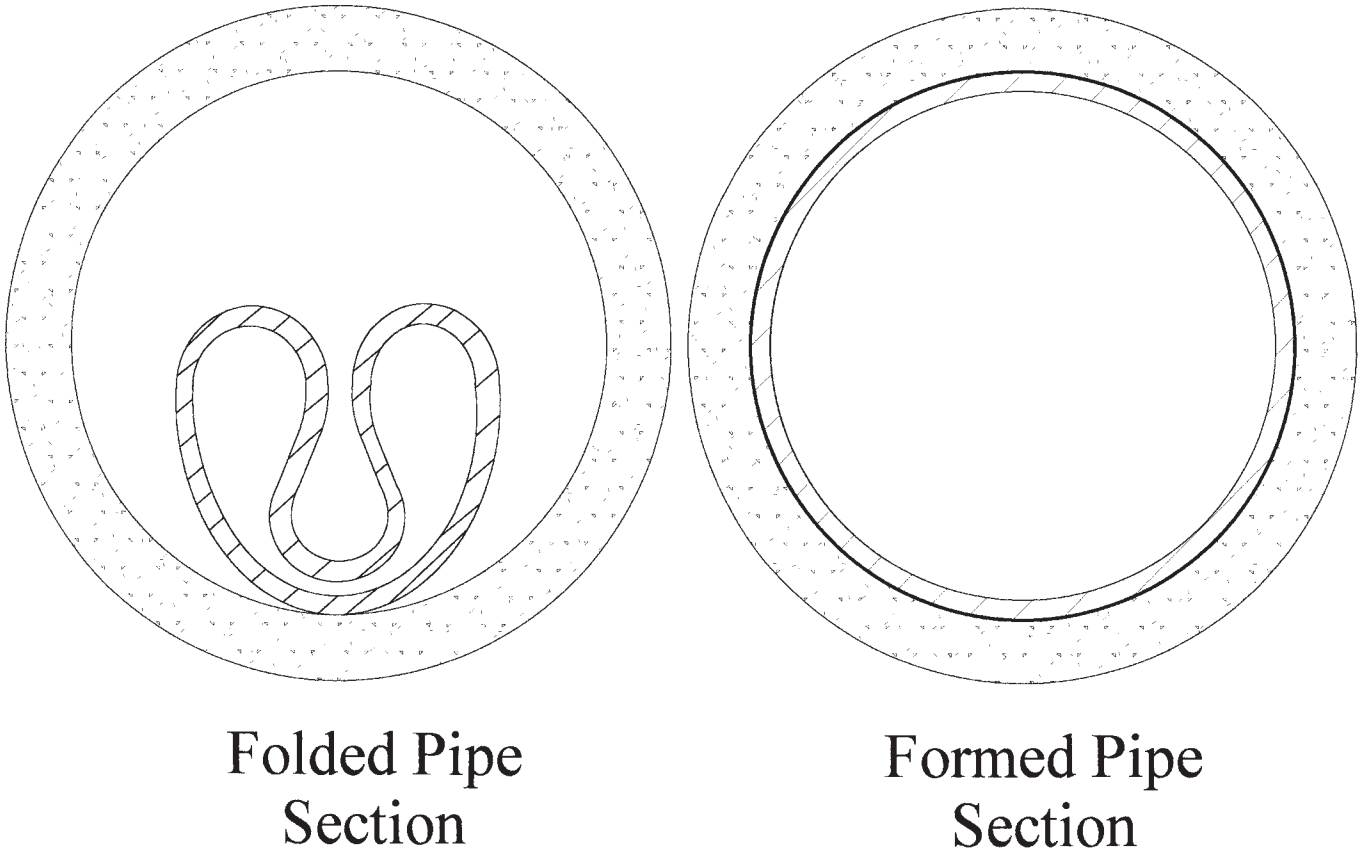
[1] This standard is under the jurisdiction of Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.67 on Trenchless Plastic Pipeline Technology.

Current edition approved July 10, 1998. Published September 1998.

[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.04.

[4] Available from Uni-Bell PVC Pipe Association, 2655 Villa Creek Drive, Suite 155, Dallas, TX 75234.



NOTE 1—This figure is intended only for clarification of terms specific to this practice and shows a representative folded pipe shape. Other folded pipe shapes may meet the requirements of this practice.

FIG. 1 Folder Pipe and Formed Pipe—Clarification of Terms

3.2.5 *squeegee or similar device, n*—a device to sequentially heat and expand the folded pipe to provide a close fit to the existing pipe.

3.2.6 *dimples (dimpling), n*—Where a side connection meets the existing conduit, there is no support for the PVC pipe during forming, causing a point of thermoplastic pipe expansion slightly beyond the existing pipe wall. This formation of an external departure from the formed pipe wall is termed dimpling.

3.2.7 *insertion point, n*—An existing manhole, existing access shaft, or an excavation that serves as the point of entrance for the folded pipe into the existing pipe.

3.2.8 *termination point, n*—An existing manhole, existing access shaft, or an excavated pit that serves as the point of exit of the folded pipe from the existing pipe.

4. Significance and Use

4.1 This practice is for use by designers, and specifies regulatory agencies, owners, and inspection organizations involved in the rehabilitation of non-pressure sewers and conduits. Modifications may be required, depending on specific job conditions, to establish a project specification. The manufacturer of the product should be consulted for design and installation information. Industrial waste disposal lines should be installed only with the specific approval of the cognizant code authority, since chemicals not commonly found in drains and sewers and temperatures in excess of 140 °F (60 °C) may be encountered.

5. Materials

5.1 The folded/formed PVC liner pipe should be made from PVC compound, meeting all the requirements for cell classification 12111-C as defined in Specification D 1784 and with minimum physical properties as listed below:

Tensile Strength	Test Method D 638	3600 PSI	(25 MPa)
Tensile Modulus	Test Method D 638	155 000 PSI	(1069 MPa)
Flexural Strength	Test Method D 790	4100 PSI	(28 MPa)
Flexural Modulus	Test Method D 790	145 000 PSI	(1000 MPa)
Heat Deflection Temperature Tested at 264 psi	Test Method D 648 (2 MPa)	115 °F	(46 °C)

5.1.1 Compounds meeting the above minimum properties that have different cell classifications because one or more properties are greater to those of the specified compounds are also acceptable, except modulus in tension shall not exceed 280 000 psi.

5.2 *Rework Material*—Clean rework material from this type of pipe, generated from the manufacturer's own pipe production may be used by the same manufacturer provided that the rework material meets all the requirements of 5.1.

6. Installation Recommendations

6.1 *Cleaning and Inspection*:

6.1.1 *Access Safety*—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 must be conducted in accordance with local, state, or federal safety regulations.

6.1.2 *Cleaning of Pipeline*—Internal debris should be removed from the existing pipeline. Gravity pipes should be cleaned with one or more of the following: hydraulically powered equipment, high velocity jet cleaners, or mechanically powered equipment.

6.1.3 *Inspection of Pipelines*—The interior of the pipeline should be carefully inspected to determine the location of any condition that may prevent proper installation of the folded pipe, such as protruding service taps, collapsed or crushed pipe, out-of-roundness, significant line sags, and deflected joints. These conditions should be noted, and, if deemed necessary by the end-user, corrected prior to installation. Inspection of pipelines should be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television.

6.1.4 *Line Obstructions*—The existing pipeline should be clear of obstructions that will prevent the proper insertion and expansion of the folded pipe. Such conditions require access at these points for termination and start of a new insertion. Changes in pipe size may be accommodated, if the wall thickness of the liner pipe has been designed for expansion. Obstructions could include dropped or offset joints of more than 12.5 % of inside pipe diameter and service connections that protrude into the pipe more than 12.5 % of the inside diameter of 1 in. (25 mm), whichever is greater. Other obstructions may be reduction of the cross-sectional area of more than 14 % (based on the inside diameter of the existing pipe), which may be the result of point repairs or patches, and would prevent the folded pipe from totally and properly forming. If inspection reveals an obstruction that cannot be removed by cleaning or rodding, then a point repair excavation should be made to uncover and remove or repair the obstruction. Typically, with bends along the pipe length in excess of 30°, the manufacturer shall be consulted.

6.1.5 *Bypassing*—If flow cannot be interrupted for the necessary duration, bypassing of flow is required around the sections of the existing pipeline designated for rehabilitation. The pump and bypass lines should be of adequate capacity and size to handle any flows during the installation period. The bypass should be made by plugging the line at the point upstream of the pipe to be reconstructed and pumping the flow to a downstream point or adjacent system. Services within this work area will be temporarily out of service.

6.1.6 Public advisory services will be required to notify all parties whose service lateral will be out of commission and to advise against water usage until the main line is back in service.

6.2 *Insertion*:

6.2.1 The reel of folded pipe should be positioned near the insertion point. The end of the reel of folded pipe should be tapered and have holes drilled for the attachment of a pulling head. If recommended by the manufacturer, the coil of folded pipe may be heated to about 110°F prior to insertion. An enclosure should be designed so that hot air is continually exiting from it and not allowing ambient air to be drawn in.

6.2.2 A steel cable should be strung through the existing conduit and attached to the beveled cut end of the folded pipe. The folded pipe should be pulled with a power winch unit and cable directly from the reel, through the insertion point, and through the existing pipe to the termination point and extending 4 ft (1.2 mm) beyond. The pulling force should be monitored and limited to the allowable tensile stress of the folded pipe (50 % of yield at 212°F) times the pipe wall cross-sectional area.

6.2.3 After insertion is completed, the pipe should be secured at the termination end.

6.3 *Expansion*:

6.3.1 Through the use of heat, pressure, and, if recommended by the manufacturer, the use of a squeegee or similar device, the folded pipe should be fully expanded. Temperature and pressure must be sufficient to overcome the extrusion memory of the thermoplastic material. The manufacturer must be consulted as to suggested temperature and pressure. Expansion pressures must be sufficient to press the PVC liner pipe against the wall of the existing conduit so as to neatly and tightly fit the internal circumference of the existing line and to form dimples at the service connections.

NOTE 1—Folded pipe expansion pressures are typically in the range of 3 to 5 psi (20.6 to 34.4 kPa), but may vary based on field conditions.

6.3.2 If recommended by the manufacturer, and a squeegee or similar device is used for expansion, it should be propelled at a controlled rate within the heated unfolded liner pipe, expanding the liner pipe in a progressive manner, which should not exceed 4 to 6 ft per minute (1.2 to 1.8 m). This should allow the water and air between the unfolded PVC liner pipe and existing pipe to escape downstream as the squeegee device or similar device moves along.

6.3.3 Once the squeegee or similar device has reached the termination point, or if expansion is only by the use of heat and pressure and the liner at the termination point has fully formed against the host pipe, the expansion pressure should be maintained for a minimum of 5 min to ensure the complete expansion of the pipe at local deformities and to allow for complete dimpling at side connections.

6.3.4 *Cool-down*—The formed pipe should be cooled to a temperature below 100 °F (38 °C) before relieving the pressure required to hold the PVC pipe against the existing pipe wall. This cool-down procedure may take approximately one half to one hour.

6.3.5 After the formed pipe has cooled down, the terminating ends should be trimmed to a minimum of 3 in. (76.2 mm) beyond the existing pipe as allowance for possible shrinkage during cooling to ambient temperature.

6.4 *Service Connections*—After the formed pipe has been installed, the existing active service connections should be reconnected, unless otherwise specified by the owner. This should be done without excavation from the interior of the pipeline by means of a television camera and a remote control device used to re-establish the service connections.

NOTE 2—In many cases, a seal is provided where the formed pipe dimples at service connections. If total elimination of infiltration and inflow is desired, other means, which are beyond the scope of this practice may be necessary to seal service connections and to rehabilitate service lines and manholes.

7. Inspection and Acceptance

7.1 The installation may be inspected by closed-circuit television. The formed pipe should be continuous over the entire length of the insertion, be free of cracks, and conform to the wall of the existing pipe evidenced by visible joint definition and mirroring of existing pipe irregularities. Variations from true line and grade may be inherent because of the conditions of the existing pipeline. All service entrances should be accounted for and unobstructed.

7.2 *Leakage Testing*—If required by the owner or designated in the contract documents or purchase order, gravity pipes should be tested for leakage. This test should take place after the formed pipe has cooled down to ambient temperature. This test is limited to pipe lengths with no service laterals or lines with service laterals that have not yet been reinstated. One of the following two methods should be used.

7.2.1 An exfiltration test method involves plugging the formed pipe at both ends and filling it with water. The allowable water exfiltration for any length of pipe between termination points should not exceed 50 U.S. gallons per inch of internal pipe diameter per mile per day, providing that all air has been bled from the line. The leakage quantity should be gaged by the water level in a temporary standpipe placed in the upstream plug. During exfiltration testing, the maximum internal pipe pressure at the lowest end should not exceed 10 ft (3 m) of water or 4.3 psi (29.7 kPA), and the water level inside the standpipe should be 2 ft (0.6 m) higher than the top of the pipe or 2 ft (0.6 m) higher than the groundwater level, whichever is greater. The test should be conducted for a minimum of one hour.

7.2.2 An air test should be conducted in accordance with Test Method F 1417.

NOTE 3—The leakage test is intended to evaluate the water tightness of pipe lengths before service laterals have been reinstated.

7.3 *Field Sampling*—For each insertion length designated by the owner in the contract documents or purchase order, a rounded field sample should be prepared at the insertion or termination point, or both, by installing the folded PVC pipe into a mold pipe. The mold pipe shall be of like diameter to the existing pipe and should be a minimum of one diameter in length. The following test procedures should be followed after the sample is expanded and cooled down as an integral part of the folded PVC installation process and removed from the mold pipe.

7.3.1 *Dimensions*:

7.3.1.1 *Formed Field Sample Diameter*—The nominal outside diameter of the formed field sample should meet the requirements given in Table 1 with a tolerance of -7.0 %/ +5.0 % when tested in accordance with the applicable sections of Test Method D 2122.

7.3.1.2 *Formed Field Sample Wall Thickness*—The minimum wall thickness of the sample, when measured in accordance with the applicable sections of Test Method D 2122, should not be less than the values specified in Table 1.

7.3.2 *Flexural Properties*—The flexural modulus of elasticity should be measured in accordance with Test Method D 790, Test Method I-Procedure A, and should meet the requirements of Table 2. Specimens should be oriented on the testing machine with the interior surface of the rounded field sample against the loading supports.

7.3.3 *Tensile Properties*—The tensile strength should be measured in accordance with Test Method D 638, Type I specimen, and should meet the requirements of Table 2.

8. Keywords

8.1 plastic pipe, thermoplastic; poly(vinyl chloride)(PVC) plastic pipe; rehabilitation, trenchless technology

TABLE 1 Formed Field Sample Dimensions

Nominal Outside Diameter, in. (mm)	Minimum Wall Thickness, in. (mm)		
	DR26	DR32.5	DR41
4.000(102)	0.153(3.87)	0.123(3.12)	
6.000(152)	0.231(5.87)	0.185(4.70)	
8.000(203)	0.308(7.82)	0.246(6.25)	
9.000(229)	0.346(8.79)	0.277(7.04)	
10.000(254)	0.386(9.80)	0.308(7.82)	
12.000(305)	0.462(11.73)	0.369(9.37)	
15.000(381)	0.577(14.66)	0.462(11.7)	
18.000(457)			0.439(11.15)

TABLE 2 Formed Field Sample Physical Properties

PVC Compound Classification	Minimum Flexural Modulus of Elasticity, psi (MPa)	Minimum Tensile Strength, psi (MPa)
12111-C	145000 (1000)	3600 (24.8)

NOTE 1—The PVC Compound Classification is in accordance with Specification D 1784; the Minimum Flexural Modulus of Elasticity is measured in accordance with 7.3.2; and the Minimum Tensile Strength is measured in accordance with 7.3.3.

NOTE 2—The evaluation of rounded field sample flexural and tensile properties is intended as installation quality control tests to verify that these properties were not negatively affected through installation processing of the PVC material. In this respect, the purchaser may designate that samples be taken from the folded, short radius portions of the cross-section.

APPENDIX

(Nonmandatory Information)

X1. STRUCTURAL DESIGN CONSIDERATIONS

X1.1 *Terminology*:

X1.1.1 *partially deteriorated pipe, n*—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. The conduit may have longitudinal cracks and some distortion of the diameter.

X1.1.2 *fully deteriorated pipe, n*—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 rounded PVC 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, or soil.

X1.2 *Design*:

X1.2.1 *Partially Deteriorated Design Condition*—The formed PVC pipe is designed to support only the external hydraulic loads due to groundwater (and internal vacuum), since the soil and surcharge loads can be supported by the existing pipe. The groundwater level should be determined and the thickness of the formed PVC pipe should be sufficient to withstand this hydrostatic pressure without collapsing. The following equation may be used to determine the thickness required:

$$P = \frac{2\,KE_L}{(1-\mu^2)} \times \frac{1}{(DR-1)^2} \times \frac{C}{N} \qquad \text{(X1.1)}$$

where:

P = external pressure, psi (MPa),
DR = dimension ratio of PVC pipe (outside diameter/thickness), and
C = ovality reduction factor =

$$\left[\left(1-\frac{q}{100}\right) / \left(1+\frac{q}{100}\right)^2\right]^3$$

q = percentage ovality of original pipe =

$$100 \times (D - D_{min})/D$$

or

$$100 \times (D_{max} - D)/D$$

D = mean inside diameter of existing pipe, in. (mm),
D_{min} = minimum inside diameter of existing pipe, in, (mm),
D_{max} = maximum inside diameter of existing pipe, in. (mm),
N = factor of safety (2.0 recommended),
E_L = modulus of elasticity of formed PVC pipe, psi (MPa), reduced to account for long-term effects (see Note X1.1).
K = enhancement factor of the soil and existing pipe adjacent to the new pipe (a value of 7.0 is recommended where there is full support of the existing pipe), and
μ = Poisson's ratio (0.38 average).

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 for E_L will be that given for 50 years of continuous loading at the maximum ground of fluid temperature expected to be reached over the life of the structure.

X1.2.2 Rearrange Eq X1.1 and solve for formed PVC pipe thickness, t:

$$t = \frac{D}{\left[\frac{2KE_LC}{PN(1-\mu^2)}\right]^{\frac{1}{3}} + 1} \qquad \text{(X1.2)}$$

X1.2.3 *Fully Deteriorated Design Condition*—The formed PVC pipe is designed to support hydraulic, soil, and live loads.

$$q_t = \frac{C}{N}[32R_W B' E'_s (E_L I/D^3)]^{\frac{1}{2}} \quad \text{(X1.3)}$$

where:

q_t = total external pressure on pipe, psi (MPa),
= 0.433 H_w + $wHR_w/144$ + Ws, (English units),
= 0.00981 H_w + $wH_sR_w/1000$ + Ws, (metric units),
R_w = water buoyancy factor (0.67 minimum) = 1 – 0.33 (H_w/H),
H_w = height of groundwater above top of pipe, ft (m),
H = height of soil above top of pipe, ft (m),
w = soil density, lb/ft^3(KN/m^3),
Ws = live load, psi (MPa),
B' = coefficient of elastic support = $1/(1+4e^{-0.065H})$ (inch-pound units), $(1/(1+4e^{-0.213H})$ (centimetre-kilogram units),
I = moment of inertia of PVC pipe, in.^{4}/in. (mm^4/mm) = $t^3/12$,
t = thickness of PVC, in. (mm),
C = ovality reduction factor (see X1.2.1),
N = factor of safety (2.0 recommended)
E'_s = modulus of soil reaction, psi (MPa) (see Note X1.2),
E_L = modulus of elasticity of formed PVC pipe, psi (MPa), reduced to account for long-term effects (see Note X1.1), and
D = mean inside diameter of existing pipe, in. (mm).

NOTE X1.2—For definition of modulus of soil reaction, see the Handbook of PVC Pipe.[4]

X1.2.4 Rearrange Eq X1.3 and solve for thickness, t:

$$t = 0.721D\,(Nq_t/C)^2 E_L R_W B' E_s)^{\frac{1}{3}} \quad \text{(X1.4)}$$