Guideline Document Guide – 1/95

Guidance and Recommendations on the Use of Polyethylene (PE) Pipe for the Sliplining of Sewers

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FOR
PPI GUIDANCE DOCUMENT ON SLIPLINING

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GUIDANCE AND RECOMMENDATIONS ON THE USE OF POLYETHYLENE (PE) PIPE FOR THE SLIPLINING OF SEWERS

1.0 Intent

1.1 The intent of sliplining is to rehabilitate sewer lines by the insertion of a polyethylene liner pipe into the existing sewer line. When complete, the liner pipe should extend from one manhole to the next manhole in a continuous, watertight length.

1.2 The ASTM document F 585, "Standard Practice for Insertion of Flexible Polyethylene Pipe into Existing Sewers", is a useful reference describing the Sliplining procedure and some of the design characteristics of the system. An additional reference and guide is the Plastics Pipe Institute publication "Pipeline Rehabilitation with Polyethylene Pipe" (Chapter 10 of the PPI Handbook of Polyethylene Pipe).

2.0 Reference Specifications

2.1 This document references American Society for Testing and Materials (ASTM) standard specifications, which are made a part hereof by such reference and shall be the latest edition and revision. It is incumbent upon the owner's representative to have a working familiarity with the following ASTM Standards:

D 2321	Standard Practices for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
D 2412	Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
D 2657	Practices for Heat-Joining Polyolefin Pipe and Fittings
D 3035	Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
F 1417	Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
F 585	Practice for Insertion of Flexible Polyethylene Pipe into Existing Sewers
F 714	Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter (3” IPS and larger)
F 477	Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
F 894	Specification for Polyethylene (PE) Larger Diameter Profile Wall

Sewer and Drain Pipe.

3.0 Sewer Liner Pipe and Fittings Requirements:

3.1 The polyethylene material used to manufacture the pipe and fittings should be either a high density or a medium density polyethylene compound which meets or exceeds the minimum requirements for cell class 334433 or cell class 234333, respectively, in accordance with ASTM D 3350, and

3.2 The dimensions and performance properties of the system should be in accordance with the requirements of any one of the following documents: ASTM D 3035, F 714, or F 894.

4.0 Liner Pipe Dimensions and Structural Characteristics

4.1 The purchaser should establish the required liner dimensions and structural characteristics based on considerations of both the Sliplining process and the service loads and other conditions. These considerations normally include an evaluation of (1) minimum anticipated clearance between the liner and the pipe being lined (including allowances for joint offsets and separations); (2) flow capacity; (3) external loads (hydrostatic pressure and/or earth loads); (4) internal pressure, (5) construction loads (external grout pressure and jacking force), and (6) structural support of the pipe developed by grouting.

4.2 The liner outside diameter should allow for sufficient clearance to accommodate the Sliplining process. The minimum outside diameter of the existing sewer should be determined in the field by using a "pig" or mandrel (see Section 9.2). If this cannot be done, a liner of outside diameter at least 10 percent smaller than that of the pipe being lined will generally provide sufficient clearance. When lining pipe 24 inches and larger in diameter, this differential can be reduced from 10 to 5 percent. If the liner is much smaller than the existing sewer, consideration must be given to preventing it from floating, particularly on force mains. Two groups of standard dimensioned pipes are available for Sliplining:

4.2.1 Solid wall PE made in standard outside diameters and to Standard dimension ratios (SDR). This group is represented by ASTM standards D 3035 and F 714. Of the choice of standard sizes covered by these documents, Table I represent some of the more frequently used constructions for Sliplining.

4.2.1.1 The Standard Dimension Ratios (SDR's) are from an ASTM standard series of ratios. These are referred to as

SDR 32.5, SDR 26, SDR 21, SDR 17, etc. Standard Dimension Ratio is calculated by dividing the specified outside diameter by the specified minimum wall thickness for pipe of solid wall construction. The smaller the SDR the thicker is the pipe's wall relative to its diameter and therefore, the stiffer the pipe wall.

4.2.1.2 For sewer force mains, an appropriate SDR must be based on the pressure requirements of the system.

TABLE 1

COMMONLY USED CHOICES OF STANDARD DIMENSION RATIO (SDR) PE PIPE WITH OUTSIDE SPECIFIED DIAMETER, MADE IN ACCORDANCE WITH ASTM D3035 AND F714*

(All dimensions are in inches)

Size of Sewer	OD of Liner	Nominal OD	Minimum Wall Thickness			
			SDR 32.5	SDR 26	SDR21	SDR17
4	3.500	3” IPS	--	--	.167	--
6	4.500	4" IPS	--	--	.214	--
6	5.375	5.375"	.165	.207	.256	.316
6	5.563	5” IPS	.171	.214	.265	.327
8	6.625	6" IPS	.204	.255	.315	.390
8	7.125	7.125"	.219	.274	.339	.419
10	8.625	8" IPS	.265	.332	.411	.507
11	10.75	10" IPS	.331	.413	.512	.632
15	12.75	12" IPS	.392	.490	.607	.750
15	13.38	13.380"	.412	.515	.637	.787
18	16.00	16" IPS	.492	.615	.762	.941
21	18.00	18" IPS	.554	.692	.857	1.059
24	22.00	22" IPS	.677	.846	1.048	1.294
27	24.00	24" IPS	.738	.923	1.143	1.305
30	28.00	28" IPS	.862	1.077	1.333	1.647
35	32.00	32" IPS	.985	1.231	1.524	1.882
42	36.00	36" IPS	1.108	1.385	1.714	2.118
42	40.00	40" IPS	1.231	1.538	1.905	--
48	40.00	40" IPS	1.231	1.538	1.905	--
48	42.00	42" IPS	1.292	1.615	2.000	--
54	48.00	48" IPS	1.477	1.845	2.286	--
60	54.00	54" IPS	1.661	2.077	--	--
72	63.21	63" IPS (1600mm)	1.937	2.421	--	--

*Consult these standards for complete listing of standard diameters and SDR's.

4.2.1.3 Profile wall pipe is made in standard inside diameters and ring stiffness constants (RSC) in accordance with ASTM F 894 (see Table II). This pipe may include ribs or other profiles in the wall, which help strengthen the pipe against diametrical deformation. The RSC is the value obtained by dividing the parallel plate load in pounds per foot of pipe length by the deflection. The standard RSC classes for profile pipe are 40, 63, 100, and 160. Profile pipe is made in standard inside diameters ranging from 18 to 120 inches.

TABLE 2

MINIMUM PIPE DIMENSIONS AND TOLERANCES - RSC PIPE

(All dimensions are in inches)

Nominal Pipe Size	OD of Liner	Average Inside Diameter	Tolerance on Average Inside Diameter	Closed Profile	Open Profile	Min. Wall Thickness
18	*	18.00	±0.38	0.18	0.18	0.5
21	*	21.00	±0.38	0.18	0.18	0.5
24	*	24.00	±0.38	0.18	0.18	0.5
27	*	27.00	±0.38	0.18	0.18	0.5
30	*	30.00	±0.38	0.18	0.18	0.5
33	*	33.00	±0.38	0.18	0.18	0.5
36	*	36.00	±0.38	0.18	0.18	0.5
42	*	42.00	±0.42	0.18	0.24	0.5
48	*	48.00	±0.48	0.18	0.24	0.5
54	*	54.00	±0 54	0.18	0.24	0.5
60	*	60.00	±0.60	0.18	0.26	0.6
66	*	66.00	±0.66	0.18	0.30	0.6
72	*	72.00	±0.72	0.18	0.30	0.6
78	*	78.00	±0.78	0.18	0.30	0.6
84	*	84.00	±0.84	0.18	0.38	0.7
90	*	90.00	±0.90	0.18	0.38	0.7
96	*	96.00	±0.96	0.18	0.38	0.7
108	*	108.00	±1.08	0.18	0.42	0.7
120	*	120.00	±1.20	0.18	0.52	0.8

*The OD of the liner can vary depending on the manufacturing process utilized. Consult the manufacturer for specification information on outside diameter dimensions.

4.3 The liner inside diameter should allow for sufficient flow capacity for the anticipated hydraulics of the rehabilitated sewer system.

4.4 The liner should have sufficient wall stiffness to safely resist external hydrostatic pressure and the pressure generated by grouting, if appropriate. Under gravity flow conditions, a polyethylene liner pipe will be subjected to external hydrostatic pressure if a water table exists above the pipe or if the pipe is buried or installed under water. An appropriate wall stiffness is required to safely resist this pressure. In cases where the pipe does not have adequate stiffness to resist the ground water, the annular space between the liner pipe and the existing pipe should be grouted with a cement or cement-fly ash grout. Actual grout selection and design shall be as directed by the Owner's Representative. When grouted, the pipe will react as though it was buried in soil; thus flexible pipe/soil backfill design equations apply. Grouting also results in increase of the resistance of the pipe to external hydrostatic pressure.

4.4.1 For solid wall pipe the significant variable that determines adequate wall stiffness is the pipe SDR. It is a simple matter to specify the SDR once the amount of the loading on the pipe is determined. A typical manufacturer's recommendation for safe long term (50 year) external pressure loading might follow the guidelines in the following table, which was derived according to the procedure shown in ASTM F 585 and the information in Section 4.4:

SDR	Height of Water Above Pipe (50 yrs) (No Grout)	Height of Water Above Pipe (50 yrs) (With Grout)
32.5	4.0 feet	14.0 feet
26	8.0 feet	28.0 feet
21	15.0 feet	52.0 feet
17	28.0 feet	98.0 feet

The figures in this table represent a Safety Factor of 1.0. If the existing sewer will not provide structural integrity, a more conservative Safety Factor should be used.

4.4.2 For profile wall pipe the variable that determines adequate wall stiffness is a function of the RCS and pipe inside mean diameter. The following equation can be used to estimate maximum allowable long-term (50 year) height of water above the pipe with no grout:

$$H = \frac{RSC}{D_m}$$

Where:

H = Height of water in feet
RSC = Ring Stiffness Constant (if RSC is not measured, use 90% of RSC class value)
Dm = Mean Diameter

This equation contains a Safety Factor of 2.0 based on pipe with a maximum 3% deflection.

4.4.3 For grout with a minimum compressive strength of 500 psi at 24 hours (1800 psi at 28 days) the allowable long-term (50 year) height of water above the pipe may be determined from the following equation:

$$H = 30\sqrt{\frac{RSC}{D_m}}$$

This equation contains a Safety Factor of 2.0

5.0 Special Sizes

Where existing conditions or special design requirements call for other diameters or wall constructions than specifically listed by ASTM D 3035, F 714, or F 894, the liner pipe and fittings should be manufactured from compounds referenced in Section 3.1, and their performance and test parameters should be calculated on the same basis as that used by any of the above referenced standards, as may be specified by the purchaser.

6.0 Certificate of Compliance

Upon request by the purchaser, a certificate of compliance with the specified material requirements should be provided by the manufacturer for all PE piping material furnished under this specification. In addition, the purchaser may, at his own expense, witness inspection and test of the materials, when requested at the time of purchase by the purchaser.

7.0 Rejection

Any PE piping materials may be rejected for failure to meet any of the requirements of this specification.

8.0 Deviations

Should the Contractor choose to submit a bid using PE piping material that does not meet all the requirements of these specifications, he should include a description of the deviation with data showing the magnitude of the deviation. Acceptance of such deviations to these specifications should be subject to approval by the Owner's Representative.

9.0 Installation Procedures

The following installation procedures should be adhered to unless otherwise specified by the Owner's Representative:

9.1 Cleaning of Sewer Line: Prior to any sliplining of a line so designated, the Contractor should clean debris out of the sewer line.

9.2 Television Inspection: If internal cleaning and inspection has been performed by the Owner or others, copies of the original reports and videotape records may be used by the Contractor in planning and execution of the work. If the Owner has not performed this work or if the work is not satisfactory to the Contractor, the Contractor may, at his option, elect to perform additional inspection of the existing sewer line. Upon written consent or direction of the Owner's Representative, the Contractor shall inspect, by closed-circuit TV, the section or sections to be sliplined and shall record the locations of all obstructions and service taps of the section or sections.

9.3 Bypassing Sewage: The Contractor shall bypass the sewage around the section or sections of line that are to be sliplined if the annular space and pulling head openings are incapable of handling the flow. The bypass shall be made by plugging an existing upstream manhole, if necessary, and pumping the sewage into a downstream manhole or adjacent system. The pump and bypass lines shall be of adequate capacity and size to handle the flow. All bypassing of flow shall conform to the specifications.

9.3.1 Where the pipe is assembled with gasketed joints, bypassing is normally not required. The sewage can be directed through the liner pipe as it is being inserted, since gasketed joints can be assembled in the flow stream.

9.3.2 Under no circumstances will the dumping of raw sewage onto private property or into city streets be allowed.

9.3.3 At the end of each working day, temporary tie-in shall be made between the relined section and the existing system and the bypass plug removed.

9.4 Line Obstructions: It shall be the responsibility of the Contractor to clear the line of obstructions, solids, dropped joints, or collapsed pipe that will prevent the insertion of the liner. If inspection reveals an obstruction (such as a badly dropped or misaligned joint) that is not at the location of the entry shaft, the Contractor shall make an excavation to expose and remove or repair the obstruction. Such excavation shall be approved in writing by the Owner's Representative prior to the commencement of the work.

9.5 Excavation: Where excavations for insertion of the polyethylene liner are made in a line section between two manholes, the Contractor will establish the excavation points on the basis of location of the lines to be sliplined, pulling or pushing distances, and traffic conditions. The locations of the excavation points should be such as to minimize traffic disruption. The number of excavations can be reduced by planning to insert the pipe in both directions from a single opening. Normally, more than one manhole section can be lined from a single excavation. The length of the insertion pit will depend on whether fused jointed pipe or gasket jointed pipe is used. For fused pipe, the length of the insertion pit(s) should be a minimum of 12 times the diameter of the liner plus the sloping ends of the pit(s).

9.5.1 The ends of the pit should be sloped at a 2.5 to 1 slope from the ground surface to the top of the existing sewer. The sides of the pit should be properly braced per local, state and federal regulations. For gasketed pipe, the length of the insertion pit should be equal to the length of the pipe plus sufficient working room for jointing and pushing.

9.5.2 The width of the insertion pit should be a minimum of the outside diameter of the existing sewer plus 12 inches for existing sewer pipe smaller than 18 inches in diameter, a minimum of the outside diameter plus 18 inches for existing sewer pipe 18 inches in diameter but less than 48 inches in diameter and the outside diameter plus 24 inches for existing sewer pipe 48 inches or larger in diameter.

9.5.3 Sheeting and bracing requirements will depend on depth and ground conditions and the Contractor shall determine the necessity of such sheeting and bracing in accordance with local, state and federal regulations.

9.5.4 The top of the existing sewer line shall be exposed to the spring line and the crown of the pipe shall be removed for the full length of the insertion pit. Care should be taken not to disturb the bottom portion of the existing sewer line, as this will afford a stable base for the liner pipe.

9.6 Welded or Fused-Joint Assembly Pipe Joining: Sections of the polyethylene pipe shall be assembled and joined together prior to insertion of the pipe. Assembly shall be accomplished above ground, either at the job site or a remote location. In-ground assembly is acceptable provided appropriate equipment is utilized.

9.6.1 Joining shall be accomplished by the thermal-butt-fusion or thermal extrusion welding method, in strict accordance with the manufacturer's recommendations and in accordance with applicable provisions of ASTM D 2657. All fusion joining shall be performed by trained personnel with properly maintained equipment designed for butt-fusion or thermal extrusion welding of thermoplastic pipe.

9.6.2 Joining S D R solid wall PE pipe liner in cases where the insertion pit is not at a manhole may be accomplished by the use of a stainless steel full encirclement clamp and proper gasketing material or the installation of a new manhole. Consult the pipe liner manufacturer for recommended minimum lengths of such clamps to afford adequate pullout protection.

9.6.3 Alternate methods of joining shall be subject to approval by the Owner’s Representative.

9.7 Gasket Joint Assembly: Sections of the polyethylene pipe with gasket joints should be assembled in the pit with flow passing through the previously inserted sections. Joining shall be accomplished in accordance with the manufacturer's recommendations.

9.8 Insertion of the Fused and Welded Liner: The polyethylene liner shall be inserted into the existing sewer line with a power winch and steel cable connected to the end of the liner by use of an appropriate pulling head. A second pulling head may be attached to the other end of the liner for attachment of a tag line to pull the liner back out of the sewer line, if necessary. The length of the liner pipe to be inserted at any one time shall be governed by the winch drum capacity and winching power available and consideration of the size and condition of the sewer.

9.8.1 During insertion, precautions should be taken to protect the liner pipe to prevent the ragged edges of the broken sewer pipe from scoring the outside of the liner as it is being pulled into the sewer. For force main applications, any cut, gouges or scrapes equal to 10% of the liner wall thickness shall be cause for rejection of that portion of the liner.

Once the insertion is initiated, it is desirable to continue the pull to completion without interruption.

9.8.2 At the Contractor's option, with the consent of the Owner's Representative, the liner pipe may be pushed into position. Further, a combination of pushing and pulling techniques may be used to insert the liner.

9.8.3 The manufacturer's recommendations should be followed regarding relaxation and thermal equilibrium of the liner prior to sealing the annular space between the liner and the existing sewer pipe at the manholes.

9.9 Insertion of Gasketed Pipe: The liner pipe should be lowered into the pit one piece at a time. A fabricated guide heat should be placed on the lead end of the first length of liner pipe Each new piece placed on the pit should be joined to the preceding piece by gasket jointing. After jointing, new length should be pushed into the existing pipe, leaving enough room in the insertion pit to place the next piece.

9.9.1 Care should be exercised to secure the liner pipe during insertion to prevent the liner pipe from moving should it tend to float with the flow of water through the existing pipe.

9.9.2 A jacking plate or block should be used during liner pipe insertion to ensure even load distribution on the end of the liner pipe if the liner pipe is to be jacked or pushed into position. If the load increases abruptly and non-uniformly during the jacking operation, indicating a possible obstruction in the existing pipe, the jacking operation shall be stopped until any obstruction has been removed.

9.9.3 If segments of the existing pipe have curves with a radius of curvature of less than 500 feet or have angle points, the Contractor shall provide to the Owner's Representative a submittal defining special product dimensions as recommended by the manufacturer.

9.10 Grouting: There is an occasional requirement to fill the annular space between the existing pipe and the liner for a long distance with grout in order to prevent a collapsing or seriously weakened host pipe from eventually point loading and locally deflecting the liner. Precautions should be taken to prevent buckling the liner with grouting pressure, since the external pressure resistance of PE sewer pipe is relatively low. Either the grout should be placed under very low pressure, or the liner should be hydrostatically pressurized during the grouting procedure to resist buckling. Consult the liner manufacturer for allowable grouting pressures and the grout company for suitable grout mixtures.

9.11 Manhole Replacement: In those places where the entrance shaft is excavated at an existing manhole, the manhole shall be repaired or it shall be replaced with a new manhole conforming to the specifications for manhole construction and in accordance with the engineering drawings.

9.12 Sealing Polyethylene Pipe in Manhole: The annular space between the polyethylene liner and the existing sewer line shall be sealed where the sewer line enters or exits each manhole. This annular space shall be sealed for a distance of $1^1/_2$ times the diameter of the liner inside the old sewer line. The method of sealing shall be approved by the Owner's Representative and shall begin only after thermal equilibrium and relaxation of the liner has occurred. Relaxation time can vary, but, generally, a 24-hour period will be adequate.

9.12.1 Foam sealant should not protrude into the manhole and should be finished over with a quick-set, non-shrink type of cement grout. Finishing inside the manhole shall be accomplished using a quick-set cement type grout to raise the manholes through the invert of the liner pipe. (NOTE: Only the upstream seal should be made prior to connecting services.)

10.0 Service Connections: After the liner has been secured in the upstream manhole, each existing service connection shall be reconnected to the new liner. A portion of the existing sewer, at the liner pipe, around each service connection may be removed to expose the liner/pipe to provide adequate working space for making the new service connection. Service laterals shall be connected to the liner pipe using either polyethylene heat-fusion saddles in accordance with the manufacturer's recommendations or strap-an saddles as conditions require or as specified. Strap-on saddles shall be secured to the liner pipe using stainless steel bands. A neoprene gasket shall be inserted between the liner and the strap-on saddle.

10.1 Connections of the saddle fittings to the existing lateral shall be made using boots, full-encirclement clamps, or by other methods specified by the Owner's Representative.

10.2 Prior to backfilling where the existing sewer has been broken open, the adjacent annular space between the existing sewer and the new liner shall be sealed to preclude migration of the backfill material into this annular foam; or the upper half of the sewer pipe may be replaced and grouted.

10.3 Reconnection of service connections may be made by utilizing remote tapping equipment as approved and directed by the Owner's Representative.

11.0 Backfill: At all points where the polyethylene pipe has been exposed (such as the insertion shafts, at service connection fittings, or other points where the old pipe must be removed), the polyethylene pipe and fittings shall be encased in cement-stabilized sand or other high-density material as specified by the Owner's Representative to prevent deflection due to earth loading or subsidence.

11.1 At this point, in preparation for the placing of the encasement material, debris and soil shall be removed along each side of the existing pipe down to the spring line.

11.2 After the encasement material is in place and accepted by the Owner's Representative, backfill is placed and compacted to required finished grade in accordance with the specifications of the Owner's Representative. Particular care shall be taken to ensure compaction of earth beneath the lateral pipe in order to reduce subsidence and resultant bending at the lateral connection of the sewer main.

12.0 Final Acceptance: After installation of the liner, the Contractor shall, at the option of the Owner's Representative, either TV inspect the sewer line as specified or perform a test on the sewer line in accordance with ASTM F1417.

13.0 Cleanup: After the installation work has been completed and all testing found acceptable, the Contractor shall clean up the entire project area and return the ground cover to grade. All excess material and debris not incorporated into the permanent installation shall be disposed of by the Contractor. Sidewalks, driveways, and street surfaces shall be recovered.