



Standard Practice for Design and Installation of Underground Thermoplastic Irrigation Systems With Maximum Working Pressure of 125 psi¹

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^{ε1} NOTE—Keywords added editorially in November 2003.

1. Scope

1.1 This practice establishes procedures for the design and installation of thermoplastic flexible piping systems, for underground irrigation systems. Because there is considerable variability in end-use requirements, soil conditions, and thermoplastic piping characteristics, the intent of this practice is to outline general objectives and basics of systems design, proper installation procedures, and to provide pertinent references.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units which are 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.*

2. Referenced Documents

2.1 ASTM Standards:

- D 1600 Terminology for Abbreviated Terms Relating to Plastics²
- D 2241 Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)³
- D 2487 Practice for Classifications of Soils for Engineering Purposes (Unified Soil Classification System)⁴
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)⁴
- D 2657 Practice for Heat-Joining Polyolefin Pipe and Fittings³

- D 2749 Symbols for Dimensions of Plastic Pipe Fittings³
- F 402 Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings³
- F 412 Terminology Relating to Plastic Piping Systems³
- F 690 Practice for Underground Installation of Thermoplastic Pressure Piping Irrigation Systems³
- F 714 Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter³
- F 771 Specification for Polyethylene (PE) Thermoplastic High-Pressure Irrigation Pipeline Systems³
- F 1290 Practice for Electrofusion Joining Polyolefin Pipe and Fittings³

3. Terminology

3.1 The terminology used in this practice is in accordance with Terminology F 412, Terminology D 1600, and Symbols D 2749, unless otherwise specified.

4. Summary of Practice

4.1 This practice gives standardized criteria and procedures for underground installation of thermoplastic pipe in pressure irrigation systems.

4.2 Thermoplastic pipe used in this practice is made of poly(vinyl chloride) (PVC) or polyethylene (PE) and shall be assembled to withstand the design working pressure for the pipeline without leakage, internal restriction, or obstruction that could reduce line capacity below design requirements.

4.3 Joining materials shall be of composition that will not damage the pipe and shall be recommended for use at the design pressure for the pipeline. Consult the manufacturer for design and installation recommendations.

4.4 When materials subject to corrosion are used in the line, they shall be adequately protected by wrapping or coating with high-quality corrosion preventatives. Wrappings or coatings applied to metallic surfaces should not be applied on plastic

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

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

⁴ *Annual Book of ASTM Standards*, Vol 04.08.

pipe or fittings unless it is first established by consulting the piping manufacturer so that they have no detrimental effect on the plastic.

5. Requirements

5.1 *Working Pressure*—The pipe line shall have a pressure rating (see Table 1 and Annex A1) greater than the static pressure or working pressure plus the surge pressure, at any point in the system. Surge and working pressures shall not exceed the pipe’s pressure class.

5.2 *Service Factor*—Determine all pressure ratings in a water environment of 73.4 ± 3.6°F (23 ± 2°C). As the temperature of the environment or fluid increases, the pipe becomes more ductile. Therefore, the pressure rating must be decreased for use at higher temperatures to allow for safe operation of the pipe. The service factors for PVC and PE are shown in Table 2. For PE pipe having improved strength retention with an increase in temperature and PE pipe used at temperatures exceeding 100°F (38°C), consult the manufacturer for recommended service factors.

5.3 *System Capacity*—The design capacity of the pipe line shall be sufficient to provide an adequate flow of water for all methods of irrigation planned.

5.4 *Friction Losses*—For design purposes, friction head losses shall be no less than those computed by the Hazen-Williams equation using a flow coefficient (C) equal to 150.

5.5 *Flow Velocity*—The designed water velocity in a pipeline when operating at system capacity should not exceed 5 ft/s (1.5 m/s), unless special considerations are given to the control of surge or water hammer. Adequate protection from these pressures is provided (see 5.1 and Table 3). Use adequate pressure- or air-relief valves, or both, with all velocities.

5.6 *Outlets*—Outlets shall have adequate capacity at the pipeline working pressure to deliver the designed flow to the distribution system at the designed operating pressure of the respective system, that is, sprinklers, surface pipe, emitters, tricklers, and so forth.

5.7 *Check Valves*—Install a check valve between the pump discharge and the pipeline where detrimental back flow may occur. The check valve shall be designed to close without slamming shut at the point of zero velocity before damaging reversal flow can occur.

TABLE 2 Pressure Rating Service Factors for Temperatures from 73.4 to 140°F (23 to 60°C) for PVC and PE Pipes

| Temperature, | | PVC Factor | PE Factor |
|--------------|------|------------|-----------|
| °F | °C | | |
| 73.4 | 23 | 1.00 | 1.00 |
| 80 | 26.7 | 0.88 | 0.92 |
| 90 | 32.2 | 0.75 | 0.81 |
| 100 | 37.8 | 0.62 | 0.70 |
| 110 | 43.3 | 0.50 | ... |
| 120 | 48.9 | 0.40 | ... |
| 130 | 54.4 | 0.30 | ... |
| 140 | 60.0 | 0.22 | ... |

5.7.1 The time that should be taken to close a valve in order that the pressure shall not exceed the normal pressure at no flow may be determined from the following equation:

$$\text{Time, s} = \frac{0.027 \times L \times V}{P - p}$$

where:

- L = length of the pipe before the valve, ft,
- V = velocity of flow, ft/s,
- P = pressure in the pipe, lb/in.²(where there is no flow), and
- p = pressure in the pipe at full flow.

5.8 *Pressure-Relief Valves*—Install these between the pump discharge and the pipeline when excessive pressures can develop by operating with all valves closed. Install pressure-relief valves or surge chambers on the discharge side of the check valve where back flow may occur, and at the end of the pipeline when needed to relieve the surge.

5.8.1 *Low-Pressure Systems*—Pressure-relief valves may be used as alternatives to serve pressure-relief functions of vents and stands open to the atmosphere. They do not function as air release valves and should not be substituted for such valves where release of entrapped air is required.

5.8.1.1 Pressure-relief valves shall be large enough to pass the full pump discharge with a pipeline pressure no greater than 50 % above the permissible working head of the pipe.

5.8.1.2 Mark pressure-relief valves with the pressure at which the valve starts to open. Install adjustable valves in such a manner to prevent changing of the adjustment marked on the valve.

5.8.2 *High-Pressure Systems*—The ratio of nominal size pressure-relief valves to pipeline diameter shall be no less than 0.25. Set the pressure-relief valves to open at a pressure no greater than 5 psi (34.5 kPa) above the pressure rating of the pipe, or the lowest pressure-ratio component in the system.

5.9 *Air-Release and Vacuum-Relief Valves*—Install air-release and vacuum-relief valves, at all summits, at the ends, and at the entrance of pipelines to provide for air escape and air entrance. Combination air- and vacuum-release valves, which provide both functions, may be used.

5.9.1 *Air Flow Capacity*—Valves having large orifices to exhaust large quantities of air from the pipelines when filling and to allow air to enter to prevent a vacuum when draining are required at the end and entrance of all pipelines. Valves

TABLE 1 Pressure Ratings for Poly(Vinyl Chloride) (PVC) and Polyethylene (PE)

| SDR | PVC 12454 | PE 2406 and PE 3406 | PE 3408 |
|-------|-----------|---------------------|-----------|
| 50'hd | 22 | | |
| 93.5 | 43 | | |
| 81 | 50 | | |
| 64 | 63 | | |
| 51 | 80 | | |
| 41 | 100 | 40 (276) | 31 (214) |
| 32.5 | 125 | 51 (352) | 40 (276) |
| 26 | | 64 (441) | 50 (345) |
| 21 | | 80 (552) | 63 (435) |
| 17 | | 78 (538) | 78 (538) |
| 15.5 | | 86 (593) | 86 (593) |
| 13.5 | | 100 (689) | 100 (689) |
| 11 | | 125 (862) | 125 (862) |

intended to release only entrapped air may have smaller orifices and are required at all summits.

5.9.2 *Low-Pressure Systems (Not Open to the Atmosphere):*

5.9.2.1 Provide air-release and vacuum-relief, or combination air- and vacuum-release, valves at the downstream end of each lateral, at all summits of the line, at points where there are changes in grade of more than 10° (18 %) in a downward direction of flow, and immediately below any stand if the downward velocity in the stand exceeds 2 ft/s (0.6 m/s).

5.9.2.2 Air vacuum release valve outlets shall have a 2-in. minimum diameter. The valves shall be sized as shown in Table 3.

6. Trench Preparation

6.1 *Trench Depth*—In stable, granular soils that tend to be relatively smooth and free of rocks and debris larger than ½ in. (13 mm) in size, excavation may proceed directly to final grade. Where rocks or other protrusions are encountered which may cause point loading on the pipe, re-excavate the trench bottom to permit installation of proper bedding (see 6.5).

6.2 *Trench Width*—Establish the width of the trench at the top of the pipe with attention given to these considerations:

6.2.1 The wider the trench at the top of the pipe the greater the earth load on the pipe until the prism load has been achieved.

6.2.2 Trench width should allow sufficient assembly of joints. Generally, a trench width at the top of the pipe of a minimum of 18 in. wider than the pipe diameter is adequate. If a wider trench becomes necessary, restrict the enlargement as much as possible to only that section above the top of the pipe.

6.2.3 Trench width should allow adequate room for snaking when recommended by the manufacturer or as may be required to accommodate thermal expansion or contraction.

6.2.4 Narrow trench widths may be utilized by joining the pipe above ground and lowering it into the trench, provided enough room is available in the trench for proper haunching. Precautions outlined in 6.2.2 shall be followed.

6.3 *Trench Depth*—Establish the trench depth with consideration given to requirements imposed by foundation, beddings, pipe size, and cover.

6.4 *Foundation*—An adequate and stable foundation should be present, or provided, for proper support of the total load.

6.4.1 Foundation preparation is not necessary when smooth, stable trench bottoms are encountered.

6.4.2 Foundation preparation is necessary when unstable trench bottom conditions are encountered. The designer should specify the stabilizing method and materials which will satisfactorily stabilize the encountered condition and provide adequate and permanent support.

TABLE 3 Design Criteria for Vacuum Release Valve Outlets

| Pipe Diameter, in. (mm) | Minimum Air-Relief Vacuum Release Valve Outlet Diameter, in. (mm) |
|------------------------------|---|
| 6 (152) | 2 (51) |
| 7 to 10 (178 to 254) | 3 (76) |
| 12 or larger (305 or larger) | 4 (102) |

TABLE 4 Pipe stiffness of PVC

| SDR | PS |
|------|----|
| 64 | 7 |
| 51 | 14 |
| 41 | 28 |
| 32.5 | 57 |

6.5 *Bedding*—The bedding material should consist of gravel, sand, silty sand, silty gravel, or clayey sand in granular form and have a maximum particle size of ¾ in. (19 mm).

6.5.1 Provide bedding whenever rocks, hard pan, boulders, or other materials that might damage pipe are encountered in the trench bottom at the established grade.

6.5.2 When bedding is used, keep it as uniform in depth as possible to minimize differential settlement (see Fig. 1).

6.6 *Minimum Earth-Cover*—Protection from traffic loading or frost protection, or both, should be considered when establishing minimum earth cover requirements.

6.6.1 For installations exposed to normal farm vehicle traffic, the minimum total cover shall not be less than 30 in. (750 mm).

6.6.2 Install the pipe line at sufficient depths to provide protection from traffic crossing, farm operations, and soil cracking. Load-bearing capabilities of installed pipe vary with the type of pipe, type of backfill, soil conditions, and installation procedures. Consult the manufacturer for information on product response to expected maximum earth-load or live-load, or both.

6.6.3 The trench depth shall be sufficient to ensure placement of the top of the pipe at least 10 in. (250 mm) below the known frost line. When conditions and design requirements prevent satisfaction of this requirement, system design and installation must ensure proper drainage in the portions of the line without sufficient cover.

7. Other Requirements

7.1 *Preparation of Joints*—Joint assembly shall be done in accordance with specifications listed under 2.1.

7.2 If the pipe is to be assembled above ground, lower it into the trench, taking care not to drop it or damage it against the trench walls or to subject the pipe or its joints to treatment, such as dragging or excessive bending, which could be injurious to the piping. With elastomeric seal joints, take care to avoid joint displacement and pull-out. Allow heat-fused joints to cool or solvent-cement joints to cure for the minimum prescribed time before moving the pipe. Take care to avoid excessive stressing at the joints.

7.3 Changes in grade or line of direction of the pipe shall be limited and shall be gradual enough so that the bending of the pipe will develop neither excessive diametrical expansion, nor excessive bending stresses. At no time should the pipe be blocked or braced to hold a bend. Excess curvature can create stresses which could induce pipe failing under pressure. Consult the pipe manufacturer for the recommended minimum pipe-bending radius.

7.4 When installing pipe with elastomeric seal, flanged joints, or with any connector which protrudes beyond the pipe diameter bell, excavate holes in the bedding material or trench

TABLE 5 Pipe Stiffness Ranges for PE Materials and DR's psi

| DR | 41 | 32.5 | 26 | 21 | 17 | 11 |
|---------------------------------|------|-------|-------|-------|---------|---------|
| Modulus, Cell Classification | | | | | | |
| 3 | 2-6 | 6-11 | 11-23 | 22-45 | 71-87 | 179-358 |
| 4 | 6-8 | 11-16 | 23-31 | 45-61 | 87-120 | 358-492 |
| 5 | 8-11 | 16-23 | 31-46 | 61-89 | 120-175 | 492-716 |

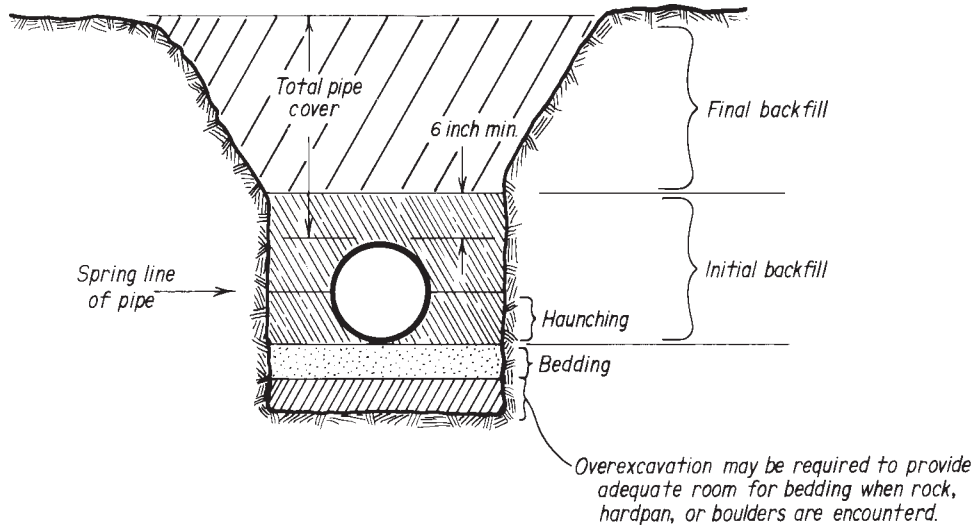


FIG. 1 Trench Cross Section

bottom to permit the pipe to be continuously supported. After pipe assembly and placement in the trench, fill each bell hole with bedding material and compact as necessary to attain the same general density as to the rest of the bedding.

7.5 It is advisable to permit newly installed pipe to cool to approximately ground temperature prior to backfilling. This will minimize the development of contraction stressed on the joints and in the case of solvent-cemented connections, it will prevent the possibility of joint separation due to contraction forces acting on the incompletely cured bond. Typically, pipe will cool adequately soon after being placed in a shaded trench bottom or covered with sufficient backfill material to shade it.

7.6 Where differential settlement could create concentrated loading on a pipe or joint, for example, at a point of connection of a buried pipe to a rigid structure, such as a manhole, follow the manufacturer's recommendations to prevent or to properly relieve damaging and shearing forces. One technique is to use extra care when compacting the foundation and bedding under a rigid structure. Other techniques might include construction of a supporting structure underneath the joint and pipe of about three diameters in cross section or another technique is the utilization of a flexible joint.

8. Thrust Blocking

8.1 When installing piping systems that include joints that are not self-restraining (for example, elastomeric seal joint), thrust blocking may be necessary at certain points in the system, such as changes in direction, in order to prevent possible disengagement of the fitting from the pipe.

8.2 Thrust blocking is required when line shift or joint separation at system operating pressure can be anticipated, that

is, pump discharge, directional changes, reducers, tees, and dead ends. Thrust blocking is essential to the proper performance of pressure irrigation piping when the systems include non-self restraining joints (reference Practice F 690).

8.3 Thrust Block Construction:

8.3.1 The thrust block should be constructed of concrete having a compression strength of 2000 psi (14 MPa) or more. Wood blocking or stone blocking with wood edges are not acceptable.

8.3.2 The thrust block acts to distribute forces between pipe or fittings and the solid trench wall. The size of the thrust block should be adequate to prevent pipe movement at the point of thrust. Consult the system designer for size of thrust block.

8.3.3 The thrust block cavity should be hand dug in undisturbed soil and framed with soil or wood to hold freshly poured concrete. The earth-bearing surfaces should be undisturbed.

8.3.4 Before pressurizing the line, ensure that adequate time is allowed for the concrete blocks to set.

9. Line Charging and Testing

9.1 If possible, the pipeline should be thoroughly inspected and tested before backfilling. When so testing, it is advisable to anchor the pipe by placing haunching and initial backfill to about 6 in. (150 mm) over the pipe, taking care to leave all joints and fittings exposed for inspecting.

9.2 Line Charging:

9.2.1 Before filling and proceeding to test, allow sufficient time for solvent-cemented joints to cure or heat-fused joints to cool.

9.2.2 With valves at ends and high points open, slowly fill the pipeline with water, limiting the flow velocity to 1 ft/s (0.3 m/s) to prevent surge, water hammer, air entrapment, or combination thereof.

9.2.3 Ensure that all entrapped air is released from the line while filling. The system should include appropriate air and vacuum relief valves for proper function during operations after installation.

9.2.4 The pipeline should be filled but not pressurized until the engineer is ready to witness or conduct the pressure test.

9.3 *Inspection and Repairs*—Pressurize the line to 125 % of the system’s designed operating pressure, but not more than the pipe pressure rating, for the time necessary to check all joints but not to exceed 1 h. While under pressure inspect all joints for leaks. Repair any leaks found, recharge the line, and retest.

10. Backfilling Procedures

10.1 *Haunching and Initial Backfill*—This practice covers those thermoplastic piping products which may be deflected considerably without structural damage. The flexibility of the pipe enables it to utilize the passive resistance of the soil to support loads externally applied to the pipe. The resistance of the soil is affected by the type of soil and its density and moisture content. Therefore, the higher the soil resistance, the less the pipe will deflect. Proper techniques for pipe embedment are necessary to ensure that the passive soil resistance required to prevent excessive pipe deflection will be developed and maintained. The designer will determine the minimum material requirements and extent of compaction depending on pipe selected for the end-use condition. The following embedment materials are recommended (see Practice D 2487 and Practice D 2488 for classification of soils) as follows:

10.1.1 Coarse-grained soils containing less than 5 % fines, such as clean (that is, essentially silt-free) gravels or sands (the maximum density will be obtained by saturation and vibration).

10.1.2 Coarse-grained soils containing some fines, between 5 and 12 % (the maximum density may be obtained by either tamping or saturation and vibration).

10.1.3 Coarse-grained soils containing more than 12 % fines, such as silty gravels, clayey gravels, silty sands, and clayey sands (the maximum compaction will be obtained by tamping).

10.1.4 Fine-grained inorganic soils (silts or clays) with low liquid limits, including some silts, silty or clayey fine sands, clays, gravelly clays, sandy clays, silty clays, and lean clays (the maximum compaction will be obtained by tamping). Note that because of their nature, these materials may, under certain conditions, present problems in proper placement and compaction. Their use, therefore, requires greater care.

10.1.5 Haunching and initial backfill materials should consist of stable soil, which is free of rocks, stones, or hard clods greater than ¾ in. (19 mm) in diameter.

10.1.6 Initially, work sufficient material carefully under the haunches of the pipe to provide adequate and continuous support throughout the entire pipe length. Avoid pipe movement during this placement.

10.1.7 Place initial backfill in two stages: the first up to the spring line of the pipe, and the second to a point at least 6 in. (150 mm) over the top of the pipe to protect it from final backfilling. Place the first stage in approximately 6-in. (150-mm) layers and each layer compacted as required. The material above the spring line need only be compacted to the same requirements as for the final backfill.

10.2 *Compaction Methods:*

10.2.1 During installation of pipe with stiffness PS14 or greater, and when using mechanical tamping to achieve desired backfill soil-densities, take care to ensure that the tamping or vibrating equipment does not come in contact with the pipe. Take care to avoid deformation and displacement of the pipe during compaction. If using a hydro-hammer, the setting should not be greater than 1000 lb/ft (47.8 kPa).

10.2.2 When installing pipe with stiffness less than PS14, water packing is accomplished by adding sufficient water to saturate the initial backfill. Excess inundation should be avoided. To keep the pipeline from floating or shifting during initial backfilling procedures, fill the pipeline with water and place and compact haunching material prior to water packing.

10.3 *Final Backfill:*

10.3.1 Ensure that final backfill material is free of debris and rocks or boulders larger than 3 in. (75 mm) and add and compact in a manner that will leave the fill at ground level after settlement has occurred.

10.3.2 Place and spread final backfill in approximately uniform, compacted layers until the trench is filled, while taking care to ensure that no unfilled voids remain in the backfill (reference Practice F 690).

10.3.3 Ensure that rolling equipment is not run over the pipeline unless compacted and stable backfill covers the pipe to minimum cover requirements given in 6.6. In addition, because wet soils may lose their stability, do not run rolling equipment over pipelines in freshly irrigated fields.

10.4 *Handling and Storage*—Handling and storage of plastic piping should be in accordance with the manufacturer’s recommendations. Depending on the material, prolonged outdoor storage or storage under adverse weather conditions may require protection from the elements.

11. Keywords

11.1 design; installation; irrigation system; thermoplastic; underground; working pressure

ANNEX
(Mandatory Information)
A1. PLASTIC PIPE IRRIGATION FOR PRESSURE-RATED SYSTEMS 63 PSI OR LESS

A1.1 To fill the needs of the agriculture industry, plastic pipes that have a variety of sizes and wall thicknesses have been used in irrigation systems over the past 25 years. Some of the systems were standard products, for example, Plastic Irrigation Pipe (PIP) O.D. SDR pipe. Other products were

made to special outside diameters and wall thicknesses expressly to fill the needs of various system designers and installers. See Tables A1.1 and A1.2 for information on irrigation pipe.

TABLE A1.1 PVC Pressure Irrigation Pipe

| Nominal Size, in. | mm | Outside Diameter, in. | Minimum Wall Thickness (inches) | | | | | | |
|----------------------|---------|--------------------------|---------------------------------|-------------------------------|-----------------------------|-----------------------------|-----------------------------|------------------------------|--------------------------------|
| | | | 50' hd 22 psi 150 kPa | SDR 93.5 43 psi 295 kPa | SDR 81 50 psi 345 kPa | SDR 64 63 psi 435 kPa | SDR 51 80 psi 550 kPa | SDR 41 100 psi 690 kPa | SDR 32.5 125 psi 860 kPa |
| 4 IPS | 114.30 | 4.500 ± 0.009 | ... | ... | ... | 0.070 | ... | 0.110 | 0.138 |
| 6 PIP | 156.00 | 6.140 ± 0.011 | 0.070 | ... | 0.076 | ... | 0.120 | 0.150 | 0.189 |
| 6 IPS | 168.28 | 6.625 ± 0.011 | ... | ... | ... | 0.104 | ... | 0.162 | 0.204 |
| 8 PIP | 207.00 | 8.160 ± 0.015 | 0.087 | ... | 0.101 | ... | 0.160 | 0.199 | 0.251 |
| 8 IPS | 219.08 | 8.625 ± 0.015 | ... | ... | ... | 0.135 | ... | 0.210 | 0.265 |
| 10 PIP | 259.00 | 10.200 ± 0.015 | 0.109 | ... | 0.126 | ... | 0.200 | 0.249 | 0.314 |
| 10 IPS | 273.05 | 10.750 ± 0.015 | ... | ... | ... | 0.168 | ... | 0.262 | 0.331 |
| 12 PIP | 311.00 | 12.240 ± 0.018 | 0.131 | ... | 0.151 | ... | 0.240 | 0.299 | 0.377 |
| 12 IPS | 323.85 | 12.750 ± 0.015 | ... | ... | ... | 0.199 | ... | 0.311 | 0.392 |
| 15 PIP | 388.62 | 15.300 ± 0.016 | 0.164 | ... | 0.189 | 0.239 | 0.300 | 0.375 | 0.471 |
| 18 IP | 466.34 | 18.360 ± 0.018 | ... | 0.197 | ... | ... | ... | ... | ... |
| 18 PIP | 475.00 | 18.701 ± 0.020 | ... | ... | ... | 0.292 | 0.367 | 0.456 | 0.575 |
| 20 IP | 518.16 | 20.400 ± 0.022 | ... | 0.219 | ... | ... | ... | ... | ... |
| 21 PIP | 559.99 | 22.047 ± 0.025 | ... | ... | ... | 0.345 | 0.432 | 0.538 | 0.678 |
| 24 PIP | 629.99 | 24.803 ± 0.032 | ... | ... | ... | 0.388 | 0.486 | 0.605 | 0.763 |
| 27 PIP | 710.00 | 27.953 ± 0.038 | ... | ... | ... | ... | 0.548 | 0.682 | 0.860 |
| 30 CI | 812.80 | 32.000 ± 0.040 | ... | ... | ... | ... | 0.627 | 0.780 | 0.985 |
| 36 CI | 972.80 | 38.300 ± 0.050 | ... | ... | ... | ... | 0.751 | 0.934 | 1.178 |
| 42 CI | 1130.30 | 44.500 ± 0.060 | ... | ... | ... | ... | 0.872 | 1.085 | 1.369 |
| 48 CI | 1290.30 | 50.800 ± 0.075 | ... | ... | ... | ... | 0.996 | 1.239 | 1.563 |

TABLE A1.2 PVC Low-Pressure Irrigation Pipe

| Nominal Size, in. | Outside Diameter, in. | SDR 93.5 | | SDR 81 | | SDR 64 | |
|----------------------|-----------------------------|-------------------|-----|-------------------|-----|-------------------|-----|
| | | Minimum Wall, in. | psi | Minimum Wall, in. | psi | Minimum Wall, in. | psi |
| 14 | 14.000 | 0.151 | 43 | 0.175 | 50 | 0.219 | 63 |
| 15 | 15.300 | 0.165 | 43 | 0.191 | 50 | 0.234 | 63 |
| 16 | 16.000 | 0.172 | 43 | 0.200 | 50 | 0.250 | 63 |
| 18 | 18.000 | 0.194 | 43 | 0.225 | 50 | 0.281 | 63 |
| 18 | 18.360 | 0.197 | 43 | 0.230 | 50 | 0.287 | 63 |
| 18 | 18.701 | 0.201 | 43 | 0.234 | 50 | 0.292 | 63 |
| 20 | 20.000 | 0.215 | 43 | 0.250 | 50 | 0.313 | 63 |
| 20 | 20.400 | 0.219 | 43 | 0.255 | 50 | 0.319 | 63 |
| 21 | 22.047 | 0.237 | 43 | 0.276 | 50 | 0.344 | 63 |
| 24 | 24.000 | 0.258 | 43 | 0.300 | 50 | 0.375 | 63 |
| 24 | 24.083 | 0.259 | 43 | 0.301 | 50 | 0.376 | 63 |
| 27 | 27.953 | 0.301 | 43 | 0.349 | 50 | 0.438 | 63 |
| 30 | 30.000 | 0.323 | 43 | 0.450 | 50 | 0.563 | 63 |
| 36 | 36.000 | 0.387 | 43 | 0.450 | 50 | 0.563 | 63 |

TABLE A1.3 PE Irrigation Pipe Minimum Wall Thickness IPS Sizing System, in.

| Nominal IPS Pipe Size | Actual Pipe Size | Dimension Ratio | | | | | | | | | | |
|--------------------------|------------------|-----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | | 32.5 | 26 | 21 | 17 | 15.5 | 13.5 | 11 | 9.3 | 9 | 8.3 | 7.3 |
| 3 | 3.500 | 0.108 | 0.135 | 0.167 | 0.206 | 0.226 | 0.259 | 0.318 | 0.376 | 0.389 | 0.422 | 0.479 |
| 4 | 4.500 | 0.138 | 0.173 | 0.214 | 0.265 | 0.290 | 0.333 | 0.409 | 0.484 | 0.500 | 0.542 | 0.616 |
| 5 ^A | 5.375 | 0.165 | 0.207 | 0.256 | 0.316 | 0.347 | 0.398 | 0.489 | 0.578 | 0.597 | 0.648 | 0.736 |
| 5 | 5.563 | 0.171 | 0.214 | 0.265 | 0.327 | 0.359 | 0.412 | 0.506 | 0.598 | 0.618 | 0.670 | 0.762 |
| 6 | 6.625 | 0.204 | 0.255 | 0.315 | 0.390 | 0.427 | 0.491 | 0.602 | 0.712 | 0.736 | 0.798 | 0.908 |
| 7 ^A | 7.125 | 0.219 | 0.274 | 0.340 | 0.420 | 0.460 | 0.528 | 0.648 | 0.766 | 0.792 | 0.858 | 0.976 |
| 8 | 8.625 | 0.265 | 0.332 | 0.411 | 0.507 | 0.556 | 0.639 | 0.784 | 0.927 | 0.958 | 1.039 | 1.182 |
| 10 | 10.750 | 0.331 | 0.413 | 0.512 | 0.632 | 0.694 | 0.796 | 0.977 | 1.156 | 1.194 | 1.295 | 1.473 |
| 12 | 12.750 | 0.392 | 0.490 | 0.607 | 0.750 | 0.823 | 0.944 | 1.159 | 1.371 | 1.417 | 1.536 | 1.747 |
| 13 ^A | 13.375 | 0.412 | 0.514 | 0.637 | 0.787 | 0.863 | 0.991 | 1.216 | 1.438 | 1.486 | 1.611 | 1.832 |
| 14 | 14.000 | 0.431 | 0.538 | 0.667 | 0.824 | 0.903 | 1.037 | 1.273 | 1.505 | 1.556 | 1.687 | 1.918 |
| 16 | 16.000 | 0.492 | 0.615 | 0.762 | 0.941 | 1.032 | 1.185 | 1.455 | 1.720 | 1.778 | 1.928 | 2.192 |
| 18 | 18.000 | 0.554 | 0.692 | 0.857 | 1.059 | 1.161 | 1.333 | 1.636 | 1.935 | 2.000 | 2.169 | 2.466 |
| 20 | 20.000 | 0.615 | 0.769 | 0.952 | 1.176 | 1.290 | 1.481 | 1.818 | 2.151 | 2.222 | 2.409 | ... |
| 21.5 ^A | 21.500 | 0.662 | 0.827 | 1.024 | 1.265 | 1.387 | 1.593 | ... | ... | ... | ... | ... |
| 22 | 22.000 | 0.677 | 0.846 | 1.048 | 1.294 | 1.419 | 1.630 | 2.000 | 2.366 | 2.444 | ... | ... |
| 24 | 24.000 | 0.738 | 0.923 | 1.143 | 1.412 | 1.548 | 1.778 | 2.182 | 2.581 | 2.667 | ... | ... |
| 26 | 26.000 | 0.800 | 1.000 | 1.238 | 1.529 | 1.677 | 1.926 | 2.364 | 2.796 | ... | ... | ... |
| 28 | 28.000 | 0.862 | 1.077 | 1.333 | 1.647 | 1.806 | 2.074 | 2.545 | 3.011 | ... | ... | ... |
| 30 | 30.000 | 0.923 | 1.154 | 1.429 | 1.765 | 1.935 | 2.222 | 2.727 | 3.226 | ... | ... | ... |
| 32 | 32.000 | 0.985 | 1.231 | 1.524 | 1.882 | 2.065 | 2.370 | 2.909 | ... | ... | ... | ... |
| 34 | 34.000 | 1.046 | 1.308 | 1.619 | 2.000 | 2.194 | 2.519 | 3.091 | ... | ... | ... | ... |
| 36 | 36.000 | 1.108 | 1.385 | 1.714 | 2.118 | 2.323 | 2.667 | 3.273 | ... | ... | ... | ... |
| 42 | 42.000 | 1.292 | 1.615 | 2.000 | 2.471 | 2.710 | ... | ... | ... | ... | ... | ... |
| 48 | 48.000 | 1.477 | 1.846 | 2.286 | 2.824 | 3.097 | ... | ... | ... | ... | ... | ... |

^ASpecial sizes.

TABLE A1.4 PE Minimum Wall Thickness

| | | DIPS Sizing System, in. | | | | | |
|---------------------------|------------------------|-------------------------|-------|-------|-------|-------|-------|
| Nominal DIPS Pipe Size | Actual OD Pipe Size | Dimension Ratio | | | | | |
| | | 32.5 | 26 | 21 | 17 | 13.5 | 11 |
| 3 | 3.96 | 0.122 | 0.153 | 0.189 | 0.233 | 0.294 | 0.360 |
| 4 | 4.80 | 0.148 | 0.185 | 0.229 | 0.283 | 0.356 | 0.437 |
| 6 | 6.90 | 0.213 | 0.266 | 0.329 | 0.406 | 0.512 | 0.628 |
| 8 | 9.05 | 0.279 | 0.348 | 0.431 | 0.533 | 0.670 | 0.823 |
| 10 | 11.10 | 0.342 | 0.427 | 0.529 | 0.653 | 0.823 | 1.009 |
| 12 | 13.20 | 0.407 | 0.508 | 0.629 | 0.777 | 0.978 | 1.200 |
| 14 | 15.30 | 0.471 | 0.589 | 0.729 | 0.900 | 1.134 | 1.391 |
| 16 | 17.40 | 0.536 | 0.670 | 0.829 | 1.024 | 1.289 | 1.582 |
| 18 | 19.50 | 0.600 | 0.750 | 0.929 | 1.147 | 1.445 | 1.773 |
| 20 | 21.60 | 0.665 | 0.831 | 1.029 | 1.271 | 1.600 | 1.964 |
| 24 | 25.80 | 0.794 | 0.993 | 1.229 | 1.518 | 1.912 | 2.346 |
| 30 | 32.00 | 0.985 | 1.231 | 1.524 | 1.883 | 2.371 | 2.909 |
| 36 | 38.30 | 1.179 | 1.473 | 1.824 | 2.253 | 2.837 | 3.482 |
| 42 | 44.50 | 1.370 | 1.712 | 2.119 | 2.618 | 3.297 | 4.046 |
| 48 | 50.80 | 1.563 | 1.954 | 2.419 | 2.989 | 3.763 | 4.619 |

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