Designation: F 771 – 99 (Reapproved 2005)

An American National Standard

Standard Specification for Polyethylene (PE) Thermoplastic High-Pressure Irrigation Pipeline Systems[1]

This standard is issued under the fixed designation F 771; 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 specification covers polyethylene (PE) thermoplastic pipelines used to convey, at rated pressures of 80 to 200 psi, water that is to be used for irrigation purposes. This specification includes criteria for classifying the pipe materials, a system of nomenclature for plastic pipe, requirements for pipe, test methods, joints, fittings, certification, and marking.

1.2 The values stated in inch-pound units are to be regarded as the standard.

1.3 The following safety hazards caveat pertains only to the test method portion, Section 7, of this specification: *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:* [2]

D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastomer

D 1248 Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable

D 1505 Test Method for Density of Plastics by the Density-Gradient Technique[2]

D 1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure

D 1599 Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings

D 1600 Terminology for Abbreviated Terms Relating to Plastic

D 2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

D 2239 Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Control Inside Diameter

D 2609 Specification for Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe

D 2683 Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

D 3035 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

D 3261 Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

F 412 Terminology Relating to Plastic Piping Systems

2.2 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[3]

2.3 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *General*—Nomenclature is in accordance with Terminology F 412 and abbreviations are in accordance with Terminology D 1600, unless otherwise indicated.

3.1.2 *high-pressure irrigation pipeline*—this term applies to underground pipelines constructed of PE pipe from 0.5 to 6 in. nominal diameter and subject to pressures, including surge pressures, from 80 to 200 psi (550 to 1380 kPa).

3.1.3 *hydrostatic design stress*—the recommended maximum hoop stress that can be applied continuously with a high degree of certainty that failure of the pipe will not occur.

3.1.4 *pressure rating (PR)*—the estimated maximum pressure that the medium in the pipe can exert continuously with a high degree of certainty that failure of the pipe will not occur.

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F 17.61 on Water.

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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 Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

3.1.5 *relation between standard dimension ratio, hydrostatic design stress and pressure rating*—the following expression, commonly known as the ISO equation, is used to relate standard dimension ratio, hydrostatic design stress, and pressure rating:
For outside diameter-controlled pipe:

$$2S/P = \text{SDR} - 1 \text{ or } 2S/P = (D_0/t) - 1 \quad (1)$$

For inside diameter-controlled pipe:

$$2S/P = \text{SIDR} + 1 \text{ or } 2S/P = (D_i/t) + 1 \quad (2)$$

where:
S = hydrostatic design stress, psi (or kPa),
P = pressure rating, psi (or kPa),
D_0 = average outside diameter, in. (or mm),
D_i = average inside diameter, in. (or mm),
SDR = D_0/t, and
SIDR = D_i/t.

3.1.6 *standard dimension ratios (SDR)*—a specific ratio of the average specified outside diameter to the minimum specified wall thickness

$$D_0/t \quad (3)$$

for outside diameter-controlled plastic pipe, the value of which is derived by adding one to the pertinent number selected from the ANSI preferred number series 10.

3.1.7 *standard inside diameter dimension ratio (SIDR)*—a specific ratio of the average specified inside diameter to the minimum specified wall thickness

$$D_i/t \quad (4)$$

for inside diameter-controlled plastic pipe, the value of which is derived by subtracting one from the pertinent number selected from the ANSI preferred number series 10.

3.1.8 *standard thermoplastic pipe material designation code*—the pipe material designation code consists of the abbreviation PE, followed by the Specification D 1248 grade in arabic numerals and the hydrostatic design stress in units of 100 psi with any decimal figures dropped. When the design stress code contains less than two figures, a cipher is used before the number. Example: PE2306, PE3406, PE3408, etc.

3.1.9 *working pressure*—the maximum allowable pressure in the system. ASAE 5376 establishes this pressure shall not exceed 72 % of the pressure rating of the pipe in order to provide for surge protection.

4. Classification

4.1 *General*—This specification covers PE pipe made from four PE plastic materials in both controlled inside diameter with standard dimension ratios of SIDR 5.3, SIDR 7, SIDR 9, SIDR 11.5, SIDR 15, and SIDR 19 and controlled outside diameter with SDR 21, SDR 17, SDR 13.5, and SDR 11. The pressure rating is uniform for all nominal pipe sizes for a given PE pipe material and SDR/SIDR (see Table X1.1 and Appendix X1).

5. Materials

5.1 *General*—The polyethylenes used to make pipe meeting the requirements of this specification are categorized by means of two criteria, namely: (*1*) short-term strength tests and (*2*) long-term strength tests.

5.2 *Basic Materials and Compound*—Basic material and plastic extrusion compound shall meet the requirements for one of three basic PE grades as defined in Specification D 1248, in which the requirements are based on short-term tests, or similar grades as defined in Specification D 3350 in which the requirements are based on both short-term and long-term tests.

5.3 *Hydrostatic Design Stresses*—This specification covers PE pipe made from PE plastics as defined by two hydrostatic design stresses developed on the basis of long-term tests and four standard thermoplastic pipe material designation codes (see Appendix X1).

5.4 *Rework Material*—Clean rework material, generated from the manufacturer's own pipe production, may be used by the same manufacturer as long as the pipe produced meets all the requirements of this specification.

6. Requirements

6.1 *Workmanship*—The pipe shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, or other defects. The pipe shall be as uniform as commercially practicable in color, opacity, density, and other properties.

NOTE 1—Pipe meeting the requirements in Specifications D 2239 or D 3035 will meet all the requirements in this specification.

6.2 *Dimensions and Tolerances*:
6.2.1 *Controlling Diameter*:
6.2.1.1 *Outside Diameter Controlled Pipe*—The outside diameters and tolerances shall be as shown in Table 1 when measured in accordance with 7.4 and 7.4.1.1.
6.2.1.2 *Inside Diameter Controlled Pipe*—The inside diameters and tolerances shall be as shown in Table 2 when measured in accordance with 7.4 and 7.4.1.2.
6.2.2 *Wall Thickness*:
6.2.2.1 *Outside Diameter Controlled Pipe*— The wall thicknesses and tolerances shall be as shown in Table 3 when measured in accordance with 7.4 and 7.4.2.
6.2.2.2 *Inside Diameter Controlled Pipe*— The wall thicknesses and tolerances shall be as shown in Table 4 when measured in accordance with 7.4 and 7.4.2.

TABLE 1 Outside Diameters and Tolerances for SDR-PR PE Plastic Pipe

Nominal Pipe Size, in.	Outside Diameter, in.	Tolerances, in.
½	0.840	±0.004
¾	1.050	±0.004
1	1.315	±0.005
1¼	1.660	±0.005
1½	1.900	±0.006
2	2.375	±0.006
3	3.500	±0.008
4	4.500	±0.009
6	6.625	±0.011

TABLE 2 Inside Diameters and Tolerances for SIDR-PR PE Plastic Pipe

Nominal Pipe Size, in.	Average Inside Diameter, in.	Tolerances, in.
½	0.622	+0.010 –0.010
¾	0.824	+0.010 –0.015
1	1.049	+0.010 –0.020
1¼	1.380	+0.010 –0.020
1½	1.610	+0.015 –0.020
2	2.067	+0.015 –0.020
2½	2.469	+0.015 –0.250
3	3.068	+0.015 –0.030
4	4.026	+0.015 –0.035
6	6.065	+0.020 –0.035

6.2.3 *Wall Thickness Range*—The wall thickness range of any cross section shall not exceed 12 % when measured in accordance with 7.4 and 7.4.3.

6.3 *Sustained Pressure*—The pipe shall not fail, balloon, burst, or weep as defined in Test Method D 1598 at the test pressures given in Table 5 when tested in accordance with 7.5.

6.4 *Burst Pressure*—The minimum burst pressures for PE plastic pipe shall be as given in Table 6 when determined in accordance with 7.6.

6.5 *Carbon Black*—The polyethylene pipe extrusion compound shall contain at least 2 % carbon black when tested in accordance with 7.7. For pipe produced by simultaneous multiple extrusion, this requirement shall apply to the outer layer.

6.6 *Elevated Temperature Sustained Pressure*—The average failure time must meet or exceed the specified minimum average failure time in Table 7 for both hoop stresses of a given pipe test category when tested in accordance with 7.9.

7. Test Methods

7.1 *Conditioning*:

7.1.1 *Qualification Tests*—Condition the test specimens at 73 ± 3°F (23 ± 2°C) in accordance with Procedure A of Methods D 618 for those tests where conditioning is required.

7.1.2 *Quality Control Tests*—Condition the test specimens at 73 ± 3°F (23 ± 2°C) for 4 h in air or 1 h in water.

7.2 *Test Conditions*—Conduct the tests in the Standard Laboratory Atmosphere of 73 ± 3°F (23 ± 2°C) unless otherwise specified in the test methods or in this specification.

7.3 *Sampling*—The selection of the sample or samples of pipe shall be as agreed upon between the purchaser and seller. In case of no prior agreement, any sample selected by the testing laboratory shall be deemed adequate.

7.4 *Dimensions and Tolerances*—Any length of pipe may be used to determine the dimensions.

7.4.1 *Controlling Diameter*:

7.4.1.1 With controlled outside diameter, measure the outside diameter and tolerances of the pipe in accordance with Method D 2122. The tolerances for out-of-roundness shall apply only on pipe prior to shipment.

7.4.1.2 With controlled inside diameter, measure the inside diameter of the pipe with a tapered plug gage in accordance with Method D 2122.

7.4.2 *Wall Thickness*—Make micrometer measurements of the wall thickness in accordance with Method D 2122 to determine the minimum value. Measure the wall thickness at both ends of the pipe to the nearest 0.001 in. (0.02 mm).

7.4.3 *Wall Thickness Range*—The wall thickness range of any cross section shall not exceed 12 % when measured in accordance with Method D 2122.

7.5 *Sustained Pressure Test*—Select the test specimens at random. Test individually with water at two controlled temperatures under the pressures given in Table 3, twelve specimens of pipe, each specimen at least ten times the nominal diameter in length, but not less than 10 in. (250 mm) nor more than 3 ft (1000 mm) between end closures and containing the permanent marking on the pipe. Test six specimens at each temperature. Maintain the specimens at the pressures indicated for the appropriate temperature for a period of 1000 h. Hold the pressure as closely as possible, but within ± 10 psi (±70 kPa). Prior to pressurization, condition the specimens for at least 2 h at within ± 2°C of the specified test temperatures. Maintain the test temperature within ± 2°C of the specified temperature. Test in accordance with Test Method D 1598, except maintain the pressure at the values given in Table 3 for 1000 h. Failure of two of the six specimens tested at either temperature constitutes failure of the test. Failure of one of six specimens tested at either temperature is cause for retest of six additional specimens at that temperature. Failure of one of six specimens tested at either temperature in retest constitutes failure in the test. Failure of the pipe shall be in accordance with Test Method D 1598.

7.6 *Burst Pressure*—The test equipment, procedures and failure definitions shall be as specified in Test Method D 1599. In addition, the failure must be ductile.

7.7 *Carbon Black*—Determine in duplicate the carbon black content of the pipe, in accordance with Test Method D 1603. The average value shall meet the requirements of 6.5.

7.8 *Density*—Determine the density of the pipe compound in accordance with Test Method D 1505, using three specimens. Calculate the density of the PE base resin (uncolored PE) in the pipe compound as follows:

$$D_R = D_P - 0.0044C \quad (5)$$

where:

D_R = average density of resin, g/cm ^{3},
D_P = density of pipe compound, g/cm^3, and
C = weight percent of carbon black.

TABLE 3 Wall Thicknesses and Tolerances[A] for SDR-PR PE Plastic Pipe with Controlled Outside Diameters

Nominal Pipe Size, in.	SDR 21		SDR 17		SDR 13.5		SDR 11	
	Minimum, in.	Tolerance, in.	Minimum, in.	Tolerance, in.	Minimum, in.	Tolerance, in.	Minimum, in.	Tolerance, in.
½	0.062[B]	+0.020	0.062[B]	+0.020	0.062	+0.020	0.076	+0.020
¾	0.062[B]	+0.020	0.062	+0.020	0.078	+0.020	0.095	+0.021
1	0.062	+0.020	0.077	+0.020	0.097	+0.020	0.119	+0.026
1¼	0.079	+0.020	0.098	+0.020	0.123	+0.020	0.151	+0.026
1½	0.090	+0.020	0.112	+0.020	0.141	+0.020	0.173	+0.026
2	0.113	+0.020	0.140	+0.020	0.176	+0.021	0.216	+0.026
3	0.167	+0.020	0.206	+0.025	0.259	+0.031	0.318	+0.038
4	0.214	+0.026	0.264	+0.032	0.333	+0.040	0.409	+0.049
6	0.315	+0.038	0.390	+0.047	0.491	+0.059	0.602	+0.068

[A] The minimum is the lowest wall thickness of the pipe at any cross section. The maximum permitted wall thickness, at any given cross section, is the minimum wall thickness plus the stated tolerance. All tolerances are on the plus side of the minimum requirement.
[B] Not minimum for the indicated SDR but minimum allowed for any pressure rating for outside diameter controlled pipe.

TABLE 4 Wall Thicknesses and Tolerances for SIDR-PR PE Plastic Pipe with Controlled Inside Diameter Wall Thickness[A], in.

Nominal Pipe Size, in.	SIDR 19		SIDR 15		SIDR 11.5		SIDR 9		SIDR 7		SIDR 5.3	
	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance	Minimum	Tolerance
½	0.060[B]	+0.020	0.060[B]	+0.020	0.060[B]	+0.020	0.069	+0.020	0.089	+0.020	0.117	+0.020
¾	0.060[B]	+0.020	0.060[B]	+0.020	0.072	+0.020	0.092	+0.020	0.118	+0.020	0.155	+0.020
1	0.060[B]	+0.020	0.070	+0.020	0.091	+0.020	0.117	+0.020	0.150	+0.020	0.198	+0.024
1¼	0.073	+0.020	0.092	+0.020	0.120	+0.020	0.153	+0.020	0.197	+0.024	0.260	+0.031
1½	0.085	+0.020	0.107	+0.020	0.140	+0.020	0.179	+0.020	0.230	+0.028	0.304	+0.036
2	0.109	+0.020	0.138	+0.020	0.180	±0.022	0.230	+0.028	0.295	+0.035	0.390	+0.047
2½	0.130	+0.020	0.165	+0.020	0.215	+0.025						
3	0.162	+0.020	0.205	+0.020	0.267	+0.032						
4	0.212	+0.025	0.268	+0.032	0.350	+0.042						
6	0.319	+0.038	0.404	+0.048	0.527	+0.063						

[A] The minimum is the lowest wall thickness of the pipe at any cross section. The maximum permitted wall thickness, at any cross section, is the minimum wall thickness plus the stated tolerance. All tolerances are on the plus side of the minimum requirement.
[B] Not minimum for the indicated SIDR but minimum allowed for any pressure rating for inside diameter controlled pipe.

TABLE 5 Sustained Pressure Test Conditions for Water for SDR and SIDR Plastic Pipe

Standard Dimension Ratio		Pressure Required for Test[A]							
		73°F (23°C)				100°F (38°C)			
		PE 3408		PE 2306 PE 2406		PE 3306 PE 3406	PE 3408		PE 2306 PE 2406 PE 3306 PE 3406
SDR	SIDR	psi	MPa)	psi	(MPa)	psi	(MPa)	psi	((MPa)
. . .	5.3	. . .	. . .	420	(2.90)	420	(2.90)	340	(2.48)
. . .	7	400	(2.76)	330	(2.28)	330	(2.28)	270	(1.86)
. . .	9	320	( )	265	(1.83)	265	(1.83)	215	(1.48)
11	. . .	. . .	. . .	265	(1.83)	265	(1.83)	215	(1.48)
. . .	11.5	255	(1.77)	210	(1.45)	210	(1.45)	170	(1.17)
13.5	. . .	255	(1.77)	210	(1.45)	210	(1.45)	170	(1.17)
. . .	15	200	(1.38)	165	(1.14)	165	(1.14)	135	(0.93)
17	. . .	200	(1.38)	165	(1.14)	165	(1.14)	135	(0.93)
. . .	19	160	(1.10)	. . .	. . .	130	(0.90)	. . .	. . .
21	. . .	160	(1.10)	. . .	. . .	130	(0.90)	. . .	. . .

[A]The fiber stresses used to derive these test pressures are:

	73°F (23°C)		100°F (38°C)	
	psi	(MPa)	psi	MPa
PE 3408	1600	(11.03)	(1320)	(11.03)
PE 2306, PE 2406, PE 3306 PE 3406	1320	(9.10)	(1070)	(7.38)

7.9 *Elevated Temperature Test*—Determine pipe test category in Table 7 for a given piping material. Base resin melt index is determined in accordance with Test Method D 1238 and base resin density is determined in accordance with Test Method D 1505. Prepare at least three test specimens as in 7.5. Test at 176°F (80°C) and the hoop stress (*S*) specified in Table 7 for the given pipe category in accordance with Test Method

TABLE 6 Burst Pressure Requirements for PE Pipe in Water at 73°F (23°C)

Standard Dimension Ratio		Minimum Burst Pressure[A]			
		PE 3408		PE 2306 PE 2406 PE 3306 PE 3406	
SDR	SIDR	psi	(MPa)	psi	(MPa)
. . .	5.3	. . .	. . .	800	(5.52)
. . .	7	630	(4.34)	630	(4.34)
. . .	9	505	(3.48)	505	(3.48)
11	. . .	. . .	. . .	505	(3.48)
. . .	11.5	405	(2.79)	405	(2.79)
13.5	. . .	405	(2.79)	405	(2.79)
. . .	15	305	(2.24)	305	(2.24)
17	. . .	305	(2.24)	305	(2.24)
. . .	19	250	(1.72)	. . .	. . .
21	. . .	250	(1.72)	. . .	. . .

[A] The fiber stresses used to derive these test pressures are:

	psi	(MPa)
PE 3408	2520	(17.38)
PE 2306, PE 2406, PE 3306 PE 3406	2520	(17.38)

D 1598. Two of three specimens must meet or exceed the specified minimum average failure time. Use water as internal medium.

8. Joints

8.1 *General*—All joints shall be constructed to withstand the design maximum working pressures for the pipeline without leakage, and shall leave the inside of the line free of any obstruction that may tend to reduce its capacity below design requirements.

8.2 *Couplings*—The separate coupling shall meet the same strength requirements as the pipe.

9. Fittings

9.1 *General*—All fittings, such as couplings, reducers, bends, tees, and crosses, shall be made of material that is recommended for use with the pipe and shall be installed in accordance with the recommendations of the manufacturer. Where fittings made of steel or other materials subject to corrosion are used in the line, appropriate corrosion protection methods shall be used. Where plastic tape is used, all surfaces to be wrapped shall be thoroughly cleaned and then coated with primer compatible with the system prior to wrapping.

9.2 *Requirements*—Plastic fittings shall meet all the dimensional and quality requirements in accordance with Specifications D 2609, D 2683, and D 3261.

9.3 *Fabricated PE Fittings*—Fabricated PE fittings units shall meet the dimensional and quality requirements of the pipe with which it is used in the system.

10. Product Marking

10.1 Product marking on the pipe shall include the following, spaced at intervals of not more than 5 ft (1.5 m):

10.1.1 Nominal pipe size (for example, 2 in.).

10.1.2 Type of plastic pipe material in accordance with the designation code given in 3.8 (for example, PE2306).

10.1.3 Standard thermoplastic pipe dimension ratio in accordance with the designation code given in 4.1 (for example, SDR11).

10.1.4 This designation F 771 with which the pipe complies.

10.1.5 Manufacturer's name (or trademark) and code.

10.1.6 Pressure rating in pounds-force per square inch for water at 73°F (23°C) shown as the number followed by psi (for example, 100 psi).

10.2 The markings shall be applied to the pipe in such a manner that they remain legible after installation and inspection have been completed.

11. Quality Assurance

11.1 When the product is marked with this designation, F 771, the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

12. Keywords

12.1 high-pressure; irrigation; pipeline system; polyethylene; thermoplastic

TABLE 7 176°F (80°C) Sustained Pressure Requirements for Water Pipe[A,B]

Pipe Test Category[C]	Base Resin Melt Index, D 1238 (g/10 min)	Base Resin Density,[D] D 1505 (g/cc)	Minimum Average Hours to Failure		
			S = 725 psi (5 MPa)	S = 580 psi (4 MPa)	S = 435 psi (3 MPa)
C1	< 0.05	0.941–0.948	100	200	—
C2	< 0.05	0.935–0.940	100	200	—
C3	0.05–0.25	0.941–0.948	60	150	—
C4	0.05–0.25	0.935–0.940	60	150	—
C5	>0.25	0.941–0.948	45	100	—
C6	>0.25	0.935–0.940	45	100	—
C7	>0.50	0.926–0.940	—	80	150

[A] For inside diameter controlled pipe, calculate internal pressure according to the following formula:

$$P = \frac{2S}{\frac{D_i}{t} + 1}$$

[B] For outside diameter controlled pipe, calculate internal pressure according to the following formula:

$$P = \frac{2S}{\frac{D_o}{t} - 1}$$

where:
P = pressure, psig (MPa),
S = hoop stress, psi (MPa),
D_i = average outside diameter, in. (mm),
D_o = average outside diameter, in. (mm), and
t = minimum wall thickness, in. (mm).

[C] Supplier to determine pipe test category appropriate for his product.

[D] Pipe categories for water pipe with resin density below 0.926 g/cc or above 0.948 g/cc will be added to this table when the data are available.

SUPPLEMENTARY REQUIREMENTS

GOVERNMENT/MILITARY PROCUREMENT

These requirements apply *only* to Federal/Military procurement, not domestic sales or transfers.

S1. *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless the purchaser disapproves. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

NOTE S00001—In U.S. Federal contracts, the contractor is responsible for inspection.

S2. *Packaging and Marking for U.S. Government Procurement:*

S2.1 *Packaging*—Unless otherwise specified in the contract, the materials shall be packaged in accordance with the supplier's standard practice in a manner ensuring arrival at destination in satisfactory condition and which will be acceptable to the carrier at lowest rates. Containers and packing shall comply with Uniform Freight Classification rules or National Motor Freight Classification rules.

S2.2 *Marking*—Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

NOTE S00002—The inclusion of U.S. Government procurement requirements should not be construed as an indication that the U.S. Government uses or endorses the products described in this document.

APPENDIXES

(Nonmandatory Information)

X1. SOURCE OF HYDROSTATIC DESIGN STRESSES FOR PE

X1.1 The hydrostatic design stresses recommended by the Plastics Pipe Institute[4] are used to pressure rate PE plastic pipe. These hydrostatic design stresses are 400 psi (2.76 MPa), 500 psi (3.45 MPa), 630 psi (4.34 MPa), and 800 psi (5.25 MPa) for water at 73°F (23°C). These hydrostatic design stresses apply only to the pipe meeting all the requirements of this specification.

X1.2 Five PE pipe materials are included, based on the requirements of Specification D 1248 and the PPI-recommended hydrostatic design stresses, as follows:

X1.2.1 *Grade P 23*, with a hydrostatic design stress of 630 psi (4.34 MPa) for water at 73°F (23°C), designated as PE 2306.

X1.2.2 *Grade P 24*, with a hydrostatic design stress of 630 psi (4.34 MPa) for water at 73°F (23°C), designated as PE 2406.

X1.2.3 *Grade P 33*, with a hydrostatic design stress of 630 psi (4.34 MPa) for water at 73°F (23°C), designated as PE 3306.

X1.2.4 *Grade P 34*, with a hydrostatic design stress of 630 psi (4.34 MPa) for water at 73°F (23°C), designated as PE 3406.

X1.2.5 *Grade P 34*, with a hydrostatic design stress of 800 psi (5.25 MPa) for water at 73°F (23°C), designated as PE 3408.

X1.3 Information regarding criteria used in developing these hydrostatic design stresses may be obtained from the Plastics Pipe Institute, and refer also to Method D 2837. These hydrostatic design stresses may not be suitable for materials that show a wide departure from a straight-line plot of log stress versus log time to failure. All the data available to date on PE pipe materials made in the USA exhibit a straight-line plot under these plotting conditions.

X1.4 The pipe is rated for use with water at 73°F (23°C) at the maximum internal pressures shown in Table X1.1. Lower pressure ratings than those calculated in accordance with 3.5 may be recommended, at the option of the pipe manufacturer, in which case the SDR or SIDR shall be included in the marking. Experience of the industry indicates that PE plastic pipe meeting the requirements of this specification gives satisfactory service under normal conditions for a long period at these pressure ratings. The sustained pressure requirements (6.3) are related to these ratings through the slopes of the strength-time plots of these materials in pipe form.

X1.5 The hydrostatic design stresses recommended by the Plastics Pipe Institute are based on tests made on pipe ranging in size from ½ to 2 in.

TABLE X1.1 Standard Thermoplastic Pipe Dimension Ratios (SDR and SIDR) and Water Pressure Ratings (PR) at 73°F (23°C) for PE Plastic Pipe

Pressure Rating, psi (MPa)					
		PE Pipe Materials[A]			
Standard Dimension Ratio		PE 3408		PE 2306 PE 2406 PE 3306 PE 3406	
SDR	SIDR	psi	(MPa)	psi	(MPa)
. . .	5.3	. . .	. . .	200	(1.38)
. . .	7	200	(1.38)	160	(1.10)
. . .	9	160	(1.10)	125	(0.86)
11	. . .	. . .	. . .	125	(0.86)
. . .	11.5	125	(0.86)	100	(0.69)
13.5	. . .	125	(0.86)	100	(0.69)
. . .	15	100	(0.69)	80	(0.55)
17	. . .	100	(0.69)	80	(0.55)
. . .	19	80	(0.55)	. . .	. . .
21	. . .	80	(0.55)	. . .	. . .
Standard Dimension Ratio, SDR (SIDR)					
Pressure Rating		PE 3408		PE 2306 PE 2406 PE 3306 PE 3406	
psi	(MPa)	SDR	(SIDR)	SDR	(SIDR)
200	(1.38)	. . .	(7)	. . .	(5.3)
160	(1.10)	. . .	(9)	. . .	(7)
125	(0.86)	13.5	(11.5)	11	(9)
100	(0.69)	17	(15)	13.5	(11.5)
80	(0.55)	21	(19)	17	(15)

[A] See 3.6 for code designation.

[4] Plastics Pipe Institute, a division of the Society of the Plastics Industry, 355 Lexington Park Ave., New York, NY 10017.

X2. DESIGN CRITERIA

X2.1 *System Capacity*—The design capacity of the pipelines should be sufficient to provide an adequate flow of water for all methods of irrigation planned.

X2.2 *Friction Losses*—For design purposes, friction head losses should be no less than those computed by the Hazen-Williams equation using a flow coefficient, *C*, equal to 150.

$$f = 0.0983 \frac{q1.852}{d4.8655} \text{ (for } C = 150)$$

where:
f = friction head, ft/100 ft length,
q = flow rate, gal/min,
d = inside diameter of pipe, in., and
p = friction head, psi/100 ft length = 0.4335f.

X2.3 *Flow Velocity*—The design water velocity in a pipeline when operating at system capacity generally should not exceed 5 ft/s (1.52 m/s) except under controlled circumstances. Specific safety practices to protect the pipeline shall be included in all instances where the velocity exceeds 5 ft/s (1.52 m/s). The maximum design velocity should not exceed 7 ft/s (2.13 m/s). Where the velocity will exceed 5 ft/s (1.52 m/s) slow acting valves, positive acting pressure relief valves, and positive means of slowly filling the pipeline and bringing it up to pressure will be incorporated into the pipeline system. It is recommended that the above mentioned safety practices be incorporated into all pipeline systems. Specific consideration must be given to assure that proper pressure or air relief valves, or both are used with all velocities.

$$V = \frac{0.4087q}{d^2}$$

where:
V = velocity, ft/s,
q = flow rate, gal/min, and
d = inside diameter of pipe, in.

X2.4 *Outlets*—Outlets should have adequate capacity at the design working pressure to deliver the design flow to the distribution system at the design operating pressure of the respective systems; that is sprinklers, surface pipe, emitters, tricklers, etc.

X2.5 *Check Valves*—A check valve should be installed between the pump discharge and the pipeline where detrimental back flow may occur. The check valves should be of the nonslam type.

X2.6 *Pressure Relief Valves*—These should be installed between the pump discharge and the pipeline when excessive pressure can develop by operating with all valves closed. Pressure relief valves or surge chambers should be installed on the discharge side of the check valves where back flow may occur and at the end of the pipeline when needed to relieve surge.

X2.6.1 *High-Pressure Systems*—Pressure relief valves should be large enough to pass the full pump discharge with a pipeline pressure no greater than 50 % above the permissable working head of the pipe and should be set to open at a pressure no greater than 5 psi (29.0 kPa) above the pressure rating of the pipe.

X2.7 *Air-Release and Vacuum-Relief Valves*—Continuous acting air-release and vacuum-relief valves should be installed at all summits, at the ends, and at the entrances of pipelines to provide for air escape and air entrance. Combination air/vacuum release valves that provide both functions may be used.

X2.7.1 *Air-Flow Capacity*—Valves having large orifices to exhaust large quantities of air from pipelines when filling and to allow air to enter to prevent a vacuum when draining are recommended at the end and entrance of all pipelines. Valves intended to release entrapped air only may have similar orifices and are recommended at all summits.

X2.7.2 *High-Pressure Systems*—The ratio of air-release valve diameter to pipe diameter should not be less than 0.1. It is not only very important to select the correct air-release or vacuum-breaker valve, but also to select the right size and to locate them properly at all places where needed. Air-vacuum release valves should be used as follows where all valve diameters refer to the total cross sectional flow area of the vent or port outlet:

X2.7.2.1 For pipelines 4 in. in diameter or less, a valve outlet of at least 0.5 in. (13 mm) nominal diameter.

X2.7.2.2 For pipelines 5 to 8 in. in diameter, a minimum valve outlet diameter of 1 in. (25 mm).

X2.7.2.3 For pipelines 10 to 15 in. in diameter, a minimum valve outlet diameter of 2 in. (51 mm).

X2.8 *Service Factor*—All pressure ratings are determined in a water environment of 73°F (23°C). As the temperature of the environment or fluid increases, the pipe becomes more ductile. Because of this effect, the pressure rating should be decreased for use at higher temperatures to allow for safe operation of the pipe. If the PE pipe material used has a hydrostatic design stress rating at elevated temperature then this value should be used for the design pressure when operating at temperatures above 73°F (23°C).

X2.9 *Draining*—Provisions shall be made for draining the pipeline to a point where the pipe is less than half full of water, where a hazard is imposed by freezing temperatures, drainage is recommended by the manufacturer of the pipe, or drainage of the line is specified for the job for any reason. Where provisions for drainage are required, drainage outlets should be located at all low places in the line. The outlets may drain into dry wells or to points of low elevation. If drainage cannot be provided by gravity, provisions should be made to empty the line by pumping.

X2.10 *Flushing*—Where provision is needed to flush the

line free of sediment, a suitable valve should be installed at the distal end of the pipeline.

X2.11 *Surge Allowance*—The maximum allowable working pressure should not exceed 72 % of the pressure rating of the pipe. The remaining 28 % is provided for surge protection.