Designation: F 714 – 01

An American National Standard

Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter[1]

This standard is issued under the fixed designation F 714; 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) pipe made in dimensions based on outside diameters of 90 mm (3.500 in.) and larger.

1.2 Three standard outside diameter sizing systems are detailed: one known as the ISO metric system, one known as the IPS system, and the other known as the DIPS system. See 5.2.5 for guidelines for special sizes.

1.3 The piping is intended for new construction and insertion renewal of old piping systems used for the transport of water, municipal sewage, domestic sewage, industrial process liquids, effluents, slurries, etc., in both pressure and nonpressure systems.

NOTE 1—The user must consult the manufacturer to ensure that any damage of the polyethylene pipe caused by the material being transported will not affect the service life beyond limits acceptable to the user.

1.4 All pipes produced under this specification are pressure-rated.

1.5 This specification includes criteria for choice of raw material and test methods for evaluation of raw material, together with performance requirements and test methods for determining conformance with the requirements.

1.6 Quality-control measures to be taken by manufacturers, are outlined in the appendix as a nonmandatory part of this specification.

1.7 In referee decisions, the SI units shall be used for metric-sized pipe and inch-pound units for pipe sized in the IPS system (ANSI B36.10) and DIPS system. In all cases, the values given in parentheses are provided for information only.

1.8 The following safety hazards caveat pertains only to the test methods portion, Section 6, 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:*

D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer[2]

D 1248 Specification for Polyethylene Plastics Molding and Extrusion Materials[2]

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[3]

D 1599 Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings[3]

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

D 2290 Test Method for Apparent Tensile Strength of Ring or Tubular Plastics and Reinforced Plastics by Split Disk Method[3]

D 2321 Practice for Underground Installation of Flexible Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications[3]

D 2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading[3]

D 2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials[3]

D 3350 Specification for Polyethylene Plastics Pipe and Fittings Materials[4]

F 412 Terminology Relating to Plastic Piping Systems[3]

F 585 Practice for Insertion of Flexible Polyethylene Pipe Into Existing Sewers[3]

2.2 *ANSI Standard:*

B 36.10 Standard Dimensions of Steel Pipe (IPS)[5]

2.3 *ISO Standards:*

161 Thermoplastic Pipe for the Transport of Fluids - Nominal Outside Diameters and Nominal Pressures[6]

3607 Polyethylene Pipe: Tolerances on Outside Diameters and Wall Thicknesses[6]

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.26 on Olefin Based Pipe.

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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 08.02.

[5] Available from American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036.

[6] Available from International Organization for Standardization, Central Secretariat, 1, rue de Varembe, Case Postale 56, CH-1211 Geneve 20, Switzerland/Suisse.

4427 Polyethylene Pipes and Fittings for Water Supply Specification[6]

2.4 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[7]

2.5 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[7]

2.6 *Canadian Standard:*

CGSB 41 GP-25M Pipe, Polyethylene for the Transport of Liquids[8]

2.7 *NSF Standards:*

Standard No. 14 for Plastic Piping Components and Related Materials[9]

Standard No. 61 for Drinking Water Systems Components—Health Effects[9]

3. Terminology

3.1 *Definitions*—General terms used in this specification are as defined in Terminology F 412.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *relation between dimension ratio, hydrostatic design stress, and hydrostatic pressure:*

$$P = \frac{2S}{(D_O/t) - 1}$$

where:

S = hydrostatic design stress, psi (or Pa),
P = pressure rating, psi (or Pa),
D_O = average outside diameter, in. (or mm),
t = minimum wall thickness, in. (or mm), and
D_O/t = dimension ratio.

3.2.2 *relations between hydrostatic design basis and hydrostatic design stress*—the hydrostatic design stress, *S*, is determined by multiplying the hydrostatic design basis (HDB) by the design factor, *n*. The design factor, *n*, has a value less than 1.0.

3.2.2.1 The hydrostatic pressure rating of pipes (see Table 1(a)) described in this specification is based on the use of a (service) design factor (see 2.3) of 0.5 in accordance with the instruction given in Test Method D 2837.

NOTE 2—This factor is valid for water and domestic sewage transported at temperatures up to 23°C when the pipe is installed in accordance with the appropriate standard procedures. Smaller design factors should be applied to systems operating at higher temperatures, or high surge pressures resulting from changing velocity or where pipe is to be used for the transport of industrial effluents known to have some degrading effect on the properties of polyethylene, or where erosion of the pipe wall by the fluid being transported will adversely affect the service life of the system. The actual choice of design factor for a given installation must be reviewed by the designing engineer, taking into account the transportation and on-site handling conditions, the difficulties of site preparation, the contractual specifications for trenching, bedding, haunching, backfilling, and the possibility of deviation from operating at hydrostatic pressures or external load conditions specified for the use of the piping system. A further uncertainty factor should be applied at the designing engineer's discretion where warranted by consideration of these conditions.

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

[8] Available from Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ontario, Canada, M 9W 1R3.

[9] Available from the National Sanitation Foundation, P.O. Box 1468, Ann Arbor, MI 48106.

TABLE 1 Pressure Rating and Pressure Performance Tests[A]

Table 1(a) Standard Pressure Rating (2.2)[B]

HDB		DR41		DR32.5		DR26		DR21		DR17		DR15.5		DR11		DR9.3		DR9		DR7.3	
MPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi
8.6	1250	215	31	275	40	345	50	430	63	540	78	595	86	860	125	1035	150	1075	156	1365	198
10	1450	250	36	315	46	400	58	500	72	625	91	690	100	1000	145	1205	175	1250	181	1585	230
11	1600	275	40	350	50	440	64	550	80	690	100	760	110	1100	160	1325	192	1380	200	1750	254

TABLE 1(b) Short-Term Pressure Test (6.2.1)

HDB and Density	DR41		DR32.5		DR26		DR21		DR17		DR15.5		DR11		DR9.3		DR9		DR7.3	
	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi
All HDB																				
Medium density	860	125	1095	159	1380	200	1725	250	2155	312	2380	345	3450	500	4155	602	4310	625	5475	794
High density	1000	145	1270	184	1600	232	2000	290	2500	363	2760	400	4000	580	4820	699	5000	725	6350	921

TABLE 1(c) Sustained Pressure Test, 1000 h (6.2.2)

HDB		DR41		DR32.5		DR26		DR21		DR17		DR15.5		DR11		DR9.3		DR9		DR7.3[AB]	
MPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi
8.6	1250	445	64	570	83	720	104	895	131	1125	162	1235	179	1790	260	2150	312	2240	325	2840	412
10	1450	520	75	655	96	830	121	1040	150	1300	189	1435	208	2080	302	2510	364	2595	376	3275	478
11	1600	552	80	701	102	883	128	1103	160	1379	200	1580	229	2207	320	2750	399	2870	416	3640	528

[A] Pressures specified for the performance tests are derived as follows:

Table 1(b) Short-Term Pressures:

All HDB, medium-density materials – 2500 psi fiber stress

All HDB, high-density materials – 2900 psi fiber stress

Table 1(c) Sustained pressure for 1000 h is 2.08 × standard pressure rating,Table 1 (a) or maximum of 1600 psi fiber stress.

[B] In some international standards, this rating may be expressed in "bars" (1 bar = 100 kPa). The "bar" is not a recognized unit in U.S. or Canadian Standard Codes of metric (SI) practice.

4. Materials

4.1 *Polyethylene Plastics*, used to make pipe meeting the requirements of this specification are categorized, by testing, for long-term strength and by the analysis of results of this testing to determine the hydrostatic design basis. Three categories of polyethylene plastic compounds having hydrostatic design basis of 1250 psi (8.6 MPa), 1450 psi (10 MPa), or 1600 psi (11 MPa) as categorized in Table 2 shall be used for the manufacture of pipe under this specification.

4.2 *Compound*—The resin compounds used shall meet the general physical requirements listed in Specification D 3350, except that the hydrostatic design basis shall be in accordance with 4.1 and Table 2 of this specification. The polyethylene compounds shall be color and UV stabilizer Code C (black with 2 % minimum carbon black) or Code E (colored with UV stabilizer) as specified in Specification D 3350.

4.2.1 The 80°C sustained pressure performance requirements of 5.3.4 (pipe test category in Table 3) are not currently in PE material Specifications D 1248 or D 3350. To identify the correct pipe test category (C1 to C7), the PE material base resin density and melt index must be obtained from the PE material supplier.

NOTE 3—Committee F-17 has requested that Committee D-20 add the 80°C sustained pressure performance requirements to Specifications D 1248 and D 3350.

NOTE 4—The hydrostatic design basis of 1450 psi (10 MPa) is not included in the cell classifications of Property 6, in Table 1 of Specification D 3350. However, it is an internationally recognized value and is used in the form of a standardized design stress of 725 psi (5 MPa) in many national and international standards outside of the United States, including ISO 4427 and CGSB 41-GP-25M.

4.3 *Rework Material*—Clean polyethylene compound reclaimed from the manufacturer's own pipe production may be reextruded into pipe, either alone or blended with new compound of the same cell classification. Pipe containing the rework material must meet all the material and product requirements of this specification.

4.4 *Cell Classification of Polyethylene Pipe Materials*—Polyethylene materials suitable for use in the manufacture of pipe under this specification shall be classified in accordance with Specification D 3350, and as shown in Table 4, for example, for a polyethylene material having a HDB of 1250 psi (8.6 MPa), the base resin density must have a cell classification of 2 or 3; the melt index cell classification must be 1, 2, or 3, etc.

5. Requirements

5.1 *Workmanship*—The pipe shall be homogeneous throughout and essentially uniform in color, opacity, density, and other properties. The inside and outside surfaces shall be semimatte or glossy in appearance (depending on the type of plastic) and free of chalking, sticky, or tacky material. The surfaces shall be free of excessive bloom, that is, slight bloom is acceptable. The pipe walls shall be free of cracks, holes, blisters, voids, foreign inclusion, or other defects that are visible to the naked eye and that may affect the wall integrity. Holes deliberately placed in perforated pipe are acceptable. Bloom or chalking may develop in pipe exposed to direct rays of the sun (ultraviolet radiant energy) for extended periods and, consequently, these requirements do not apply to pipe after extended exposure to direct rays of the sun.

TABLE 2 Hydrostatic Design Basis

Minimum Calculated LTHS Value[A]		Hydrostatic Design Basis	
psi	MPa	psi	MPa
1200	(8.3)	1250	(8.6)
1390	(9.6)	1450	(10.0)
1530	(10.6)	1600	(11.0)

[A] 96 % of hydrostatic design basis.

5.2 *Dimensions and Tolerances:*

5.2.1 *Outside Diameters*—These shall be in accordance with Table 5 (SI units), Table 6 (inch-pound units) or Table 7 (inch-pound units) when measured in accordance with Test Method D 2122 at any point not closer than 300 mm (11.8 in.) to the cut end of a length of pipe. Conditioning to standard temperature but not to standard humidity is required.

5.2.2 *Wall Thicknesses*—The minimum thicknesses shall be in accordance with Table 8 (inches), Table 9 (inches), or Table 10 (inches) when measured in accordance with Test Method D 2122. Conditioning to standard temperature but not to standard humidity is required.

5.2.3 *Eccentricity*—The wall thickness variability as measured and calculated in accordance with Test Method D 2122 in any diametrical cross section of the pipe shall not exceed 12 %.

5.2.4 *Toe-In*—When measured in accordance with 5.2.1, the outside diameter at the cut end of the pipe shall not be more than 1.5% smaller than the undistorted outside diameter. Measurement of the undistorted outside diameter shall be made no closer than 1.5 pipe diameters or 11.8 in. (300 mm), whichever distance is less, from the cut end of the pipe. Undistorted outside diameter shall meet specifications in Table 5, Table 6, or Table 7.

5.2.5 *Special Sizes*—Where existing system conditions or special local requirements make other diameters or dimension ratios necessary, other sizes or dimension ratios, or both, shall be acceptable for engineered applications when mutually agreed upon by the customer and the manufacturer, if the pipe is manufactured from plastic compounds meeting the material requirements of this specification, and the strength and design requirements are calculated on the same basis as those used in this specification. For diameters not shown in Table 5, Table 6, or Table 7, the tolerance shall be the same percentage as that shown in the corresponding tables for the next smaller listed size. Minimum wall thicknesses for DRs not shown in Table 8,Table 9, or Table 10 shall comply with 3.2.2.1 and the tolerance shall comply with 5.2.3.

5.3 *Pressure Test Performance*—All grades of PE pipe shall meet the requirements of 5.3.1. Pipe made from PE materials designated PE2406, PE3406 or PE3408 shall meet the requirement of 5.3.2. Pipe made from other PE materials shall meet the requirements of 5.3.3 and 5.3.4.

NOTE 5—The requirements of 5.3.1 and 5.3.3 are for laboratory proof-testing only and should not be interpreted as applicable to in situ testing for acceptance of installed systems. See appropriate installation standards or manufacturer's recommendations for field testing procedure.

5.3.1 *Short-Term Pressurization*—The pipe shall not rupture, leak, nor exhibit localized deformation when tested in

TABLE 3 176°F (80°C) Sustained Pressure Requirements for Water Pipe[A]

Pipe Test Category[B]	Base Resin Melt Index, D 1238 (g/10 min)	Base Resin Density,[C] D 1505 (g/cm³)	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 outside diameter controlled pipe, calculate internal pressure in accordance with the following formula:

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

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

[B] Supplier to determine pipe test category appropriate for his product.
[C] Pipe categories for water pipe with resin density below 0.926 g/cm³ or above 0.948 g/cm³ will be added to this table when the data are available.

TABLE 4 Classification of Polyethylene Pipe Materials

For HDB of	1250 psi (8.6 MPa)	1450 psi (10 MPa)	1600 psi (11 MPa)
Physical Properties and Cell Classification Limits are:			
Density (base resin)	2 or 3	2 or 3	2 or 3
Melt/Index	1, 2, or 3	3, 4, or 5	3, 4, or 5
Flexural modulus	4 or 5	3, 4, or 5	4 or 5
Tensile strength	2 or 3	3, 4, or 5	3, 4, or 5
ESCR	1, 2, or 3	3	3
Color and UV stabilizer code	C or E	C or E	C or E

TABLE 5 Outside Diameters and Tolerances

ISO Sizing System (ISO 161/1)			
Nominal Pipe Size	Equivalent	Outside Diameter, D_o, mm	
mm	in.	min	max[A]
90	3.543	90	90.8
110	4.331	110	111.0
160	6.299	160	161.4
200	7.874	200	201.8
250	9.843	250	252.3
280	11.024	280	282.5
315	12.402	315	317.8
355	13.976	355	358.2
400	15.748	400	403.6
450	17.717	450	454.1
500	19.685	500	504.5
560	22.047	560	565.0
630	24.803	630	635.7
710	27.953	710	716.4
800	31.496	800	807.2
900	35.433	900	908.1
1000	39.370	1000	1009.0
1200	47.244	1200	1210.8
1400	55.118	1400	1412.6
1600	62.992	1600	1614.4

[A] As specified in ISO 3607.

TABLE 6 Outside Diameters and Tolerances IPS Sizing System (ANSI B36.10)

Nominal Pipe Size, in.	Equivalent, mm	Actual Outside Diameters, in.	
		Average	Tolerance ± in.
3	88.9	3.500	0.016
4	114.3	4.500	0.020
5[A]	136.5	5.375	0.025
5	141.3	5.563	0.025
6	168.3	6.625	0.030
7[A]	181.0	7.125	0.034
8	219.1	8.625	0.039
10	273.1	10.750	0.048
12	323.8	12.750	0.057
13[A]	339.7	13.375	0.060
14	355.6	14.000	0.063
16	406.4	16.000	0.072
18	457.2	18.000	0.081
20	508.0	20.000	0.090
21.5[A]	546.1	21.500	0.097
22	558.8	22.000	0.099
24	609.6	24.000	0.108
26	660.4	26.000	0.117
28	711.2	28.000	0.126
30	762.0	30.000	0.135
32	812.8	32.000	0.144
34	863.6	34.000	0.153
36	914.4	36.000	0.162
42	1066.8	42.000	0.189
48	1219.2	48.000	0.216
54	1371.6	54.000	0.243

[A] Special sizes.

accordance with 6.2.1 at the pressures given in Table 1(b).

5.3.2 *Alternate Elevated Temperature Sustained Pressure Test*—The average failure time and the failure time of two of the three specimens shall meet or exceed the minimum values shown in Table 11 when tested in accordance with 6.2.3.1.

5.3.3 *Sustained Pressure*—The pipe shall not rupture, leak, nor exhibit localized deformation (ballooning) when tested in accordance with 6.2.2 for a period of 1000 h at the pressure given in Table 1(c).

5.3.4 *Elevated Temperature Sustained Pressure*—The average failure time must meet or exceed the specified minimum average failure time in Table 3 for both hoop stresses of a given pipe test category, when tested in accordance with 6.2.3.

5.4 *Apparent Tensile Strength at Yield*— For pipe sizes above 3-in. (90-mm) nominal diameter, the Short-Term Pressurization Test, 6.2.1, may be replaced by the apparent ring