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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Specification for Polybutylene (PB) Plastic Hot- and Cold-Water Distribution Systems[1]

This standard is issued under the fixed designation D 3309; 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.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification covers requirements, test methods, and methods of marking for polybutylene plastic system components made in one standard dimension ratio and intended for 0.69 MPa (100 psi) water service up to and including 82°C (180°F). These components comprise pipe and tubing, socket-fusion fittings, compression fittings, mechanical fittings, and plastic-to-metal transition fittings. Requirements and test methods are included for hydrostatic sustained pressure strength, thermocycling resistance, joint strength, and dimensions and tolerances for pipe and socket fusion fittings. The components covered by this specification are intended for use in hot- and cold-water potable water service and distribution systems and such non-potable water applications as building services piping, water heating and cooling systems, fire sprinkler applications, and other miscellaneous applications involving the transport of water, ethylene glycol solutions, or other aqueous liquids shown not to adversely affect PB performance.

1.2 The values in SI units are the standard. The values stated in parentheses are for information only.

NOTE 1—Suggested hydrostatic design stresses and hydrostatic pressure ratings for pipe, tubing, and fittings are listed in Appendix X1. Design, assembly, and installation considerations are discussed in Appendix X2. An optional performance qualification and an in-plant quality control program are recommended in Appendix X3.

1.3 The following precautionary caveat pertains only to the test method portion, Section 7, of this specification: *This standard does not purport to address all of the safety problems, 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 618 Practice for Conditioning Plastics and Electrical Insulating Materials for Testing[2]

D 883 Terminology Relating to Plastics[2,3]

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 1600 Terminology Relating to Abbreviations, Acronyms, and Codes for Terms Relating to Plastics[2,3]

D 1708 Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens[4]

D 1784 Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds[4]

D 1898 Practice for Sampling of Plastics[4]

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

D 2581 Specification for Polybutylene (PB) Plastics Molding and Extrusion Materials[4]

D 2749 Symbols for Dimensions of Plastic Pipe Fittings[3]

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

D 3915 Specification for Poly(Vinyl Chloride) (PVC) and Related Plastics Pipe and Fitting Compounds[5]

D 4181 Specification for Acetal (POM) Molding and Extrusion Materials[5]

F 412 Terminology Relating to Plastic Piping Systems[3]

F 699 Practice for Accelerated Conditioning of Polybutylene Pipe and Tubing for Subsequent Quality Control Testing[3]

F 948 Test Method for Time-to-Failure of Plastic Piping Systems and Components Under Constant Internal Pressure With Flow[3]

2.2 *ANSI Standards:*

ANSI B36.10 Welded and Seamless Wrought Steel Pipe[7]

ANSI Z17.1 Preferred Numbers[7]

2.3 *AWWA Standard:*

Manual M-11 Steel Pipe Design and Insulation[8]

2.4 *Federal Standard:*

Fed Std. No. 123 Marking for Shipments (Civil Agencies)[9]

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[1] This specification is under the jurisdiction of ASTM Committee F-17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.61 on Water.

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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] *Annual Book of ASTM Standards*, Vol 08.03.

[6] *Annual Book of ASTM Standards*, Vol 15.07.

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

[8] Available from the American Water Works Association, 6666 W. Quincey Ave., Denver, CO 80235.

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

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TABLE 1 Outside Diameters, Wall Thicknesses, and Tolerances for PB 21 SDR 11, Plastic Pipe and Tubing[A]

Nominal Size	Average	Outside Diameter		Wall Thickness[C]	
		Tolerance on Average	Max Out-of-Round[B]	SDR 11	
				Min	Tolerance
Tubing					
⅛	0.250	±0.003	±0.003	0.040[D]	+0.007
3/16	0.312	±0.003	±0.004	0.062[D]	+0.010
¼	0.375	±0.003	±0.004	0.062[D]	+0.010
⅜	0.500	±0.003	±0.006	0.062[D]	+0.010
½	0.625	±0.004	±0.008	0.062[D]	+0.010
¾	0.875	±0.004	±0.008	0.080	+0.010
1	1.125	±0.005	±0.010	0.102	+0.010
1¼	1.375	±0.005	±0.010	0.125	+0.013
1½	1.625	±0.006	±0.012	0.148	+0.015
2	2.125	±0.006	±0.015	0.193	+0.019
Pipe					
¾	1.050	±0.004	±0.010	0.095	+0.021
1	1.315	±0.005	±0.010	0.119	+0.026
1¼	1.660	±0.005	±0.012	0.151	+0.026
1½	1.900	±0.006	±0.012	0.173	+0.026
2	2.375	±0.006	±0.012	0.216	+0.026

[A] All dimensions are in inches (1 in. = 25.4 mm).
[B] The maximum out-of-roundness apply to pipe or tubing as extruded.
[C] The minimum is the lowest wall thickness at any cross section. The maximum permitted wall thickness, at any cross section, is the minimum wall thickness plus the stated tolerance. All wall tolerances are on the plus side of the minimum requirement.
[D] For tubing sizes of ½ in. and below, wall thickness minimums are not a function of SDR.

2.5 *Military Standard:*
MIL-STD-129 Marking for Shipment and Storage[9]
2.6 *NSF Standard:*
Standard No. 14 for Plastic Piping Components and Related Materials[10]

3. Terminology

3.1 *Definitions:*

3.1.1 *General*—The terminology used in this specification is in accordance with Definitions D 883, Terminology F 412, Terminology D 1600, and Symbols D 2749. The abbreviation for polybutylene is PB. Plastic tubing denotes a particular diameter schedule of plastic pipe in which the outside diameter of the tubing is equal to the nominal size plus ⅛ in. Plastic pipe outside diameter schedule conforms to ANSI B36.10.

3.1.2 *polybutylene plastics*—plastics prepared by the polymerization of no less than 85 % butene-1 and no less than 95 weight % of total olefins.

3.1.3 *relation between standard dimension ratio, stress, and internal pressure*—The following expression, commonly known as the ISO equation, is used to relate standard dimension ratio, stress, and internal pressure for pipe and tubing:

$$2S/P = R - 1$$

or

$$2S/P = (D_o/t) - 1$$

where:
S = stress in circumferential or hoop direction, psi (MPa),
P = internal pressure, psi (MPa) gage,
D_o = average outside diameter, in.,
t = minimum wall thickness, in., and
R = standard dimension ratio, SDR.

3.1.4 *standard dimension ratio (SDR)*—a selected series of numbers in which the average outside diameter to minimum wall thickness dimension ratios are constant for all sizes of pipe and tubing in each standard dimension ratio, and which are the ANSI Z17.1 Preferred Number Series R 10 modified by +1. SDR fittings shall by definition be equivalent in minimum socket wall thickness to the minimum wall thickness of the corresponding SDR and size of pipe or tubing, and the minimum body wall thickness shall be 125 % of that value.

3.1.5 *standard material designation code*—The polybutylene material designation code shall consist of the abbreviation PB followed by two digits indicating the ASTM type and grade in Arabic numerals. A third and fourth digit shall be added to indicate the hydrostatic design stress for water at 23°C (73°F) in units of 100 psi.

4. Classification

4.1 *Pipe, Tubing, and Socket-Fusion Fittings*—This specification classifies PB 2110 pipe, tubing, and socket-fusion fittings by a single standard dimension ratio that shall be SDR 11 and by a maximum continuous use temperature that shall be 82°C (180°F), and by nominal pipe or tubing diameters from ⅛ in. through 2 in.

4.2 *Plastic-to-Metal Transition Fittings*—This specification classifies plastic-to-metal transition fittings intended for use in systems with PB 2110 tubing and pipe by a maximum use temperature that shall be 82°C (180°F) and by nominal sizes from ⅛ in. through 2 in. on the basis of resistance to burst pressure and to failure by thermocycling.

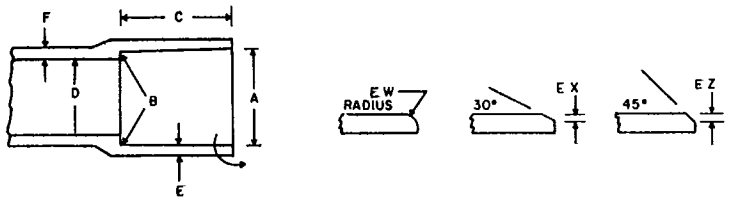
4.3 *Compression and Mechanical Plastic Fittings*—This specification classifies compression-type plastic fittings intended for use in systems with PB 2110 tubing by a maximum continuous use temperature that shall be 82°C (180°F) and by nominal sizes from ⅛ in. through 1 in. on the

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

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TABLE 2 Dimensions for Socket Fusion Fittings for PB 21, SDR 11.0 Pipe and Tubing[A,B]



Nominal Size	A Socket Entrance Diameter			B Socket Bottom Diameter			C Socket Length, min	D Inside Diameter, min	Wall Thickness min[D]		Entrance, min
	Average Diameter	Tolerance on Diameter	Max Out-of-Round[C]	Average Diameter	Tolerance on Diameter	Max Out-of-Round[C]			E	F	EW EX EZ
Tubing											
⅜	0.485	±0.005	±0.008	0.481	±0.005	±0.008	0.500	0.364	0.102	0.128	0.031
½	0.605	±0.005	±0.008	0.601	±0.005	±0.008	0.500	0.489	0.102	0.128	0.031
¾	0.845	±0.005	±0.008	0.839	±0.005	±0.008	0.625	0.715	0.102	0.128	0.031
1	1.095	±0.008	±0.010	1.087	±0.008	±0.010	0.625	0.921	0.102	0.128	0.031
1¼	1.340	±0.008	±0.010	1.332	±0.008	±0.010	0.687	1.125	0.125	0.156	0.031
1½	1.590	±0.008	±0.012	1.582	±0.008	±0.012	0.875	1.329	0.148	0.185	0.031
2	2.085	±0.010	±0.012	2.074	±0.010	±0.012	0.875	1.739	0.193	0.241	0.031
Pipe											
¾	1.020	±0.008	±0.012	1.012	±0.008	±0.010	0.625	0.920	0.102	0.128	0.031
1	1.275	±0.008	±0.012	1.267	±0.008	±0.010	0.687	1.100	0.119	0.149	0.031
1¼	1.620	±0.008	±0.012	1.612	±0.008	±0.012	0.875	1.300	0.151	0.189	0.031
1½	1.860	±0.010	±0.012	1.849	±0.010	±0.012	0.875	1.494	0.173	0.216	0.031
2	2.335	±0.010	±0.012	2.234	±0.010	±0.012	0.875	1.933	0.216	0.270	0.031

[A] All dimensions are in inches (1 in. = 25.4 mm).
[B] All sketches and designs of fittings are illustrative only.
[C] Maximum out-of-roundness applies to the average measured inside diameter.
[D] The minimum is the lowest wall thickness at any cross section.

basis of resistance to burst pressure and to failure by thermocycling.

5. Materials

5.1 *Basic Materials Description*—Polybutylene plastics used to make pipe, tubing, and fittings meeting the requirements of this specification are categorized by two criteria—namely, basic short-term properties, and long-term hydrostatic strength. Sections 5.1.1 and 5.1.2 respectively define these categories.

5.1.1 *Basic Short-Term Properties*—This specification covers pipe, tubing, and fittings made from plastic materials meeting the mechanical strength, melt characteristics, and density requirements of Type 2, Grade 1 material in Specification D 2581.

5.1.2 *Long-Term Hydrostatic PB Strength*—This specification covers pipe, tubing, and fittings that are made from polybutylene resins designated as PB 2110 and further have a long-term hydrostatic design stress of 500 psi (3.45 MPa) at 82°C (180°F). Pipe and tubing are also defined on the basis of long-term hydrostatic strength tests (Appendix X1). Fittings are so defined by hydrostatic sustained pressure tests on fitting assemblies required by this specification (see 6.5) based on the hydrostatic strength of the corresponding pipe or tubing.

NOTE 2—No hydrostatic design stress, as such, exists for fittings until such time as long-term hydrostatic strength test methods for fittings are developed.

5.1.3 Plastic fittings and components shall be made from either polybutylene meeting the mechanical strength, melt characteristics, and chemical resistance requirements of PB 21 in Specification D 2581, or acetal plastic meeting the requirements of Class 1, Grade 1 in Table 1 of Specification D 4181 or chlorinated poly(vinyl chloride) (CPVC) meeting the requirements of cell classification 23447-B in Specification D 1784 and D 3915 with applicable cells.

5.2 *Rework Material*—Clean rework material generated from the manufacturer's own production may be used by the same manufacturer provided the pipe, tubing, or fittings meet all the requirements of this specification.

6. Requirements for Pipe, Tubing, and Fittings

6.1 *Workmanship*—The pipe, tubing, and fittings shall be made from compounds that are homogeneous throughout and essentially uniform in color, opacity, density, and other properties. The inside and outside surfaces shall be semi-matte or glossy in appearance and free of sticky or tacky material. The pipe, tubing, and fitting walls shall be free of cracks, holes, blisters, voids, foreign inclusions, or other defects that are visible to the eye and that may affect the wall integrity.

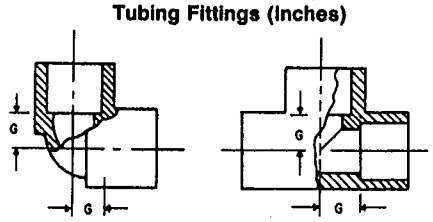
6.2 *Dimensions and Tolerances:*

6.2.1 *Pipe*—The outside diameters and wall thicknesses for pipe and tubing shall meet the requirements given in Table 1 when measured in accordance with Method D 2122. The maximum out-of-roundness requirements shown in Table 1 apply to the average measured diameter after rounding with a rounding tool recommended by the manufacturer. Calculated SDR-11 tubing wall thicknesses that fall below 0.062 in. (1.6 mm) shall be arbitrarily increased to that value.

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TABLE 3 Minimum Dimensions from Center to End of Sockets PB Socket Fusion Tees and 90° Elbows, SDR 11.0 PB Pipe and Tubing Fittings (Inches)



Nominal Size	G, min
Tubing	
⅜	0.359
½	0.382
¾	0.507
1	0.633
1¼	0.758
1½	0.884
2	1.134
Pipe	
¾	0.750
1	0.875
1¼	1.000
1½	1.250
2	1.500

6.2.2 *Socket-Fusion Fittings*—Fitting sockets inside diameters (waterways) and laying lengths shall meet the requirements given in Tables 2 and 3 when measured in accordance with Method D 2122. The out-of-roundness requirements shown in Table 2 apply to the average measured diameter. Calculated SDR 11 fitting wall thicknesses that fall below 0.102 in. (2.6 mm) for the fitting socket or 0.128 in. (3.2 mm) for the fitting body shall be arbitrarily increased to these values.

6.2.3 *Interference Fit*—The pipes and fitting dimensions and tolerances in Tables 1 and 2 provide for socket fusion joints having an interference fit based on the major diameter of pipe and tubing after rounding with a rounding tool recommended by the manufacturer.

6.3 *Plastic-to-Metal Transition Fittings, Mechanical Fittings and Compression Type Plastic Fittings*—Dimensions shall be compatible with the requirements of Table 1. Components shall be corrosion-resistant and assembled in accordance with the manufacturer's instructions.

6.4 *Hydrostatic Burst:*

6.4.1 Pipe, tubing, and fittings (tested as assemblies) shall meet the minimum hydrostatic burst requirements shown in Table 4 when tested in accordance with 7.6.

6.4.2 Socket-type joints heat fused according to the manufacturer's recommended procedure and conditioned in accordance with 7.1 shall meet the minimum hydrostatic burst requirement shown in Table 4 when tested in accordance with 7.6.

6.4.3 Plastic-to-metal transition fittings and compression-type plastic fittings assembled using the manufacturer's recommended procedure shall meet the minimum hydrostatic burst requirement shown in Table 4 when tested in accordance with 7.6.

6.5 *Hydrostatic Sustained Pressure Strength:*

6.5.1 Pipe, tubing, and fittings (tested as assemblies) shall meet the minimum hydrostatic sustained pressure strength requirements shown in Table 5 when tested in accordance with 7.4.

TABLE 4 Minimum Hydrostatic Burst Strength Requirements for PB 21 Component Joints[A]

Temperature, °C (°F)	Burst Pressure, MPa (psi)[B]
23 (73)	3.03 (440)
82 (180)	2.21 (320)

[A] PB 21 joint components shall include: 1. Nominal 1 in. PB 21 Heat fused joints after conditioning according to 7.1. 2. Nominal ½-in. compression-type plastic fittings. 3. Nominal ½-in. plastic-to-metal transition fitting.

[B] The fiber stress used to derive this test pressure is: 15.18 MPa (2200 psi) at 23°C (73°F) and 11.04 MPa (1600 psi) at 82°C (180°F).

6.5.2 Socket-type joints heat fused according to the manufacturer's recommended procedure and conditioned in accordance with 7.1 shall meet the requirements of 6.5.1 when tested in accordance with 7.4.

6.6 *Thermocycling*—Plastic-to-metal transition fittings and compression-type plastic fittings assembled using the manufacturers' recommended procedure shall not separate or leak when thermocycled 1000 times between the temperatures of 16°C (60°F) and 82°C (180°F) when tested in accordance with 7.5.

NOTE 3—Tests applicable to assemblies (6.4, 6.5, and 6.6) are intended to be performance qualification tests and not tests required of each joint.

6.7 *Excessive Temperature and Pressure Capability of Tubing and Pipe*—In the event of a heating system malfunction, polybutylene pipe and tubing shall have adequate strength to accommodate short-term conditions, 48 h of 99°C (210°F) and 150 psi (1.04 MPa), until repairs can be made. Pipe and tubing shall be tested in accordance with 7.7.

6.7.1 *Hydrostatic Burst Strength*—None of the test specimens shall fail as defined in Test Method D 1599 at a pressure less than that specified in Table 6.

6.7.2 *Hydrostatic Sustained Pressure*—None of the test specimens shall fail as defined in Test Method D 1598 in less than 1000 h at the pressure specified in Table 6.

6.8 *Elongation Value at Break*—The minimum pipe machine-direction elongation value at break shall exceed or equal an average of 125 % when samples are tested in accordance with 7.8.

7. Test Methods for Pipe, Tubing, and Fittings

7.1 *Conditioning*—Because of the crystalline transformation that takes place after polybutylene resins are cooled from the melt, it is necessary to delay physical testing until 10 days after pipe extrusion, molding of fittings, or socket fusion of joints. During this 10-day period the pipe fitting or assembly should be stored at temperatures between 4 and 38°C (40 and 100°F). The test specimens should be taken after 8 days and conditioned at 23 ± 2°C (70 to 77°F) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Methods D 618, for those tests where conditioning is required.

7.2 *Test Conditions*—Conduct the tests in the Standard Laboratory Atmosphere of 23 ± 2°C (70 to 77°F) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this specification.

7.3 *Sampling*—A sufficient quantity of pipe, tubing, or fittings, as agreed upon by the purchaser and the seller, shall be selected from each lot or shipment and tested to determine conformance with this specification (see Practice

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