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An American National Standard

Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems[1]

This standard is issued under the fixed designation F2389; 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 establishes requirements for polypropylene (PP) piping system components made to metric sizes and IPS schedule 80 sizes, and pressure rated for water service and distribution supply (see Appendix X1). Included are criteria for materials, workmanship, dimensions and tolerances, product tests, and marking for polypropylene (PP) piping system components such as pipe, fittings, valves, and manifolds.

1.2 The components governed by this specification shall be permitted for use in water service lines, hot-and-cold water distribution, hydronic heating, and irrigation systems.

1.3 The pipe and fittings produced under this specification shall be permitted to be used to transport industrial process fluids, effluents, slurries, municipal sewage, etc. The user shall consult the manufacturer to determine whether the material being transported is compatible with the polypropylene piping system and will not affect the service life beyond limits acceptable to the user.

1.4 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D1238 Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer

D1505 Test Method for Density of Plastics by the Density-Gradient Technique

D1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

D2749 Symbols for Dimensions of Plastic Pipe Fittings

D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

D4101 Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials

F412 Terminology Relating to Plastic Piping Systems

F2023 Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Pipe, Tubing and Systems to Hot Chlorinated Water

2.2 *International Organization for Standardization (ISO) Standards:*[3]

ISO 4065 Thermoplastics Pipes—Universal Wall Thickness Table

ISO 9080 Plastics Piping and Ducting Systems—Determination of the Long-Term Hydrostatic Strength of Thermoplastics Materials in Pipe Form by Extrapolation

ISO 9393–2 Thermoplastics valves for industrial applications - Pressure test methods and requirements - Part 2: Test conditions and basic requirements

ISO 12162 Thermoplastics materials for pipes and fittings for pressure applications -- Classification, designation and design coefficient

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.61 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 International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

***A Summary of Changes section appears at the end of this standard**

ISO 13760 Plastic Pipe for the Conveyance of Fluid Under Pressure – Miners Rule – Calculation Method for Cumulative Damage
ISO 15874 Plastics Piping Systems for Hot and Cold Water Installations—Polypropylene (PP)
ISO 15874-2 Plastics Piping Systems for Hot and Cold Water Installations—Polypropylene (PP)—Part 2: Pipes
ISO 15874-3 Plastics Piping Systems for Hot and Cold Water Installations—Polypropylene (PP)—Part 3: Fittings
ISO 15874-5 Plastics piping systems for hot and cold water installations — Polypropylene (PP) —Part 5: Fitness for purpose of the system
ISO/TS 15874-7 Plastics Piping Systems for Hot and Cold Water Installations—Polypropylene (PP)—Part 7: Guidance for the Assessment of Conformity

2.3 *NSF International Standards:*
NSF/ANSI 14 Plastics Piping System Components and Related Materials[4]
NSF/ANSI 61 Drinking Water System Components—Health Effects[4]

2.4 *CEN Standard:*
prEN 10226-1 Pipe Threads Where Pressure Tight Joints are Made on the Threads—Part 1: Designation, Dimensions and Tolerances[5]

2.5 *American Society of Mechanical Engineers (ASME) Standard:*
B1.20.1 Pipe Threads, General Purpose, Inch[6]

2.6 *Plastic Pipe Institute (PPI) Technical Report:*
TR-4 PPI Listing of Hydrostatic Design Basis (HDB), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials[7]

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions are in accordance with Terminology F412 and abbreviations are in accordance with Terminology D1600, unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *polypropylene random copolymer (PP-R) or polypropylene random copolymer with modified crystallinity and temperature resistance (PP-RCT), n*—a propylene plastic containing not more than 50% of another olefinic monomer (or monomers), having no functional group other than the olefinic group, and copolymerized with the propylene.

3.2.1.1 *Discussion*—Polypropylene materials are described in detail in ISO 15874. The performance of PP-R and PP-RCT is distinguished by the minimum reference curves in ISO 15874. Historically, PP-RCT has referred to a polypropylene random copolymer with modified crystallinity that delivers performance characteristics referenced in ISO 15874. However, recent developments make it possible to attain the PP-RCT performance requirements other than through modification of crystallinity.

3.2.1.2 *Discussion*—This term is also used for finished compound which comprises the PP-R or PP-RCT resin and additives such as colorants, UV inhibitors, and stabilizers. Polypropylene random copolymers containing more than one additional monomer are often referred to as "terpolymers."

3.2.2 *plastic-to-metal transition fittings, n*—a fitting designed to provide a means of connection between the PP piping system and metal piping systems such as steel pipe and copper tubing. The fittings include a means of taking into account the differences in thermal expansion of the materials and maintaining a pressure-tight seal over the intended use temperature range.

4. Classification

4.1 *General*—This specification covers PP piping systems made from PP materials (PP-R) in various dimension ratios and pressure ratings.

4.2 *Thermoplastic Pipe Series and Schedule*—This specification covers PP pipe made in schedule 80 IPS sizes and metric sizes in accordance with ISO 4065.

5. Materials and Manufacture

5.1 The pipe and fittings shall be polypropylene material of type PP-R or PP-RCT in accordance with Specification D4101. Clean rework material, of the same PP-R or PP-RCT resin generated from the manufacturer's own pipe or fitting production, shall be permitted to be used provided the pipe or fittings produced meet all requirements of this specification.

5.2 For pipe compound, the melt flow rate (MFR) shall not exceed 10.8 grain/10 min (0.7 g/10 min), when tested in accordance with Test Method D1238 using conditions of 4.76 lbm (2.16 kg) at 446 °F (230 °C).

5.3 The density of the unreinforced, natural color PP-R and PP-RCT material shall not exceed 56.9 lbm/ft^3 (912 kg/m^3), when tested in accordance with Test Method D1505 or Test Method D792.

5.4 *Minimum Required Strength (MRS)*—The PP-R material used in the pipe and fittings shall have an MRS value of 1160 psi (8.0 MPa) or 1450 psi (10.0 MPa) and the PP-RCT material used in the pipe and fittings shall have an minimum MRS value of 1624 psi (11,2 MPa) based on testing in accordance with ISO 9080 and classification of the lower confidence limit (σ_{LCL}) at 50 years in accordance with ISO 12162.

5.5 *Categorized Required Strength ($CRS_{0,t}$)*—The PP-R material used in the pipe and fittings shall have a minimum $CRS_{70\,°C,\ 50\ years}$ value of 457 psi (3.15 MPa) and the PP-RCT material used in the pipe and fittings shall have minimum $CRS_{70\,°C,\ 50\ years}$ value of 725 psi (5 MPa) in accordance with ISO 12162, based on testing in accordance with ISO 9080 and classification of the lower confidence limit (σLCL) at 158 °F (70 °C) and 50 years.

[4] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, http://www.nsf.org.
[5] Available from European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.
[6] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.
[7] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

NOTE 1—The CRS values required in 5.5 are a requirement of the standard. However, CRS values involving other temperatures and extrapolation times may be determined for design by following the methodology for the categorized required strength in ISO 12162 and ISO 9080 including the extrapolation time factors.

5.6 *Minimum Pressure Rating*—The minimum pressure rating of the pipe shall be 160 psi (1.1 MPa) at 73 °F (23 °C) and 100 psi (0.69 MPa) at 180 °F (82 °C) for hot-and-cold distribution and 160 psi (1.1 MPa) at 73 °F (23 °C) for cold water service.

5.7 *Threads*—Fittings shall be permitted to be threaded by use of metal inserts molded into the fitting.

5.7.1 Metal threads shall be constructed of brass or stainless steel inserts molded into the fitting.

5.7.2 Threads shall not be molded or fabricated directly into the polypropylene plastic.

5.8 The piping compound shall be permitted to include colorants, antioxidants, reinforcing materials and additives necessary for the finished product. The modified material and finished product shall meet all requirements of this specification.

NOTE 2—The Plastics Pipe Institute (PPI) publishes listings of minimum required strength (MRS) and categorized required strength ($CRS_{0,t}$) ratings for thermoplastic piping materials in Technical Report No. 4 (TR-4). ISO/TS 15874-7 provides guidance on evaluating the effect of additives on long-term strength of the pipe and fittings material.

5.9 *PEX Adapters*—The PEX fitting ends of PP to PEX transition fittings shall meet the material requirements of the corresponding PEX fitting standard.

6. Workmanship, Finish, and Appearance

6.1 The pipe and fittings shall be free of visible cracks, holes, foreign inclusions, blisters and other known injurious defects. The pipe and fittings shall be uniform in color, opacity, density and other physical properties.

7. Dimensions and Tolerances

7.1 *Pipe Dimensions*—Pipe dimensions shall meet the requirements in 7.1.1 and 7.1.2.

7.1.1 *Outside Diameters*—The outside diameters and tolerances shall be as shown in Table 1 (IPS Sch. 80), or Tables 2 and 3 (metric series), when measured in accordance with Test Method D2122. For diameters not shown in these tables, the tolerance shall be the same percentage of outside diameter as those for the closest listed diameter.

7.1.2 *Wall Thicknesses*—The wall thicknesses and tolerances shall be as shown in Table 1, or Tables 2 and 3, when measured in accordance with Test Method D2122. For wall thicknesses (DR's) not shown in these tables, the minimum wall thickness shall be as calculated using the DR and outside diameter, and the tolerance on the wall thickness shall be the same percentage of the calculated minimum wall thickness as for the closest listed minimum wall thickness.

7.1.3 *Threaded Pipe*—Pipe covered by this specification shall not be threaded.

7.2 *Fittings Dimensions*—Fittings dimensions shall meet the requirements in 7.2.1 through 7.2.6.

7.2.1 *Threads*—Taper threads for joining fittings shall comply with the requirements of ASME B1.20.1 for NPT metal thread inserts or prEN 10226-1 for metric threads. Threads used by the manufacturer to join component parts of a fitting together shall meet the manufacturer's specifications.

7.2.2 *Laying Lengths*—Laying lengths shall be in accordance with the manufacturer's specifications.

7.2.3 *Socket-fused Fittings*—Dimensions for socket-fused fittings shall be in accordance with Tables 4 and 5 (IPS Sch 80) or Tables 6 and 7 (metric series). Socket depth shall be measured from the face of the socket entrance to the face of the pipe stop at the socket bottom.

7.2.4 *Electrofusion Fittings*—Dimensions for electrofusion fittings shall be in accordance with manufacturer's specifications.

7.2.5 *Valves and Flanges*—Dimensions for valves and flanges shall be in accordance with the manufacturer's specifications.

7.2.6 *PEX Adapters*—The PEX fitting ends of PP to PEX transition fittings shall meet the dimensional requirements of the corresponding PEX fitting standard.

7.2.7 *Butt-fusion fittings*—Butt-fusion fittings for pipes in sizes larger than NPS-4 shall, at the ends of the fitting where butt-fusion joining is intended, comply with the diameter, out-of-roundness, and minimum wall thickness requirements for the piping intended to be joined to the fittings. Other fitting dimensions shall be in compliance with the manufacturer's specification.

8. Requirements

8.1 *Longitudinal Reversion*—When tested in accordance with ISO 15874-2, at the conditions given in Table 8, the mean relative change in pipe length shall not exceed 2 %.

8.2 *Melt Flow Rate (MFR) of Pipe and Fittings*—When tested in accordance with D1238, the MFR of specimens taken from the finished pipe or fittings shall be within 30 % of the MFR of the compound used to produce the pipe or fitting. Two specimens shall be tested, and both shall pass.

TABLE 1 IPS Schedule 80 OD and Wall Thickness

Nominal Pipe Size	Average Outside Diameter, OD, in.		Tolerance on OD, in.		Out-of-roundness (max–min)		Minimum Wall Thickness, in.		Tolerance on Wall Thickness, in.	
½	0.840	(21.34)	±0.004	(±0.10)	0.015	(0.38)	0.147	(3.73)	+0.020	(+0.51)
¾	1.050	(26.67)	±0.004	(±0.10)	0.020	(0.51)	0.154	(3.91)	+0.020	(+0.51)
1	1.315	(33.40)	±0.005	(±0.13)	0.025	(0.64)	0.179	(4.55)	+0.021	(+0.53)
1-½	1.900	(48.26)	±0.006	(±0.15)	0.030	(0.76)	0.200	(5.08)	+0.024	(+0.61)
2	2.375	(60.33)	±0.006	(±0.15)	0.035	(0.89)	0.218	(5.54)	+0.026	(+0.66)
3	3.500	(88.90)	±0.008	(±0.20)	0.040	(1.02)	0.300	(7.62)	+0.036	(+0.91)
4	4.500	(114.30)	±0.009	(±0.23)	0.050	(1.27)	0.337	(8.56)	+0.040	(+1.02)
6	6.625	(168.28)	±0.011	(±0.28)	0.050	(1.27)	0.432	(10.97)	+0.052	(+1.32)

TABLE 2 Metric Sizes OD

Nominal Size	Outside Diameter, OD					
	Minimum Average OD, in.		Maximum Average OD, in.		Maximum Out-of-roundness, in.	
16	0.630	(16.0)	0.642	(16.3)	0.016	(0.4)
20	0.787	(20.0)	0.799	(20.3)	0.016	(0.4)
25	0.984	(25.0)	0.996	(25.3)	0.016	(0.4)
32	1.260	(32.0)	1.272	(32.3)	0.020	(0.5)
40	1.575	(40.0)	1.591	(40.4)	0.020	(0.5)
50	1.969	(50.0)	1.988	(50.5)	0.024	(0.6)
63	2.480	(63.0)	2.504	(63.6)	0.024	(0.6)
75	2.953	(75.0)	2.980	(75.7)	0.039	(1.0)
90	3.543	(90.0)	3.579	(90.9)	0.039	(1.0)
110	4.331	(110.0)	4.370	(111.0)	0.039	(1.0)
125	4.921	(125.0)	4.969	(126.2)	0.051	(1.3)
140	5.512	(140.0)	5.563	(141.3)	...	...
160	6.299	(160.0)	6.358	(161.5)	...	...
200	7.874	(200.0)	7.945	(201.8)	...	...
250	9.842	(250.0)	9.941	(252.5)	...	...
280	11.023	(280.0)	11.091	(281.7)	...	...
315	12.401	(315.0)	12.500	(317.5)	...	...
355	13.976	(355.0)	14.063	(357.2)	...	...
400	15.748	(400.0)	15.843	(402.4)	...	...
450	17.717	(450.0)	17.823	(452.7)	...	...
500	19.685	(500.0)	19.803	(503.0)	...	...
560	22.047	(560.0)	22.142	(562.4)	...	...
630	24.803	(630.0)	24.953	(633.8)	...	...
710	27.953	(710.0)	28.205	(716.4)	...	...

8.3 *Thermal Stability and Oxidative Induction Time (OIT)*—Pipe and fittings shall meet the requirements of 8.3.1–thermal stability by hydrostatic testing, and 8.3.2–oxidative induction time.

8.3.1 When tested in accordance with Test Method D1598, pipe and fittings shall not fail at the pressure corresponding to the pipe circumferential stresses and times given in Table 9 for PP-R and PP-RCT. If an assembly fails at a joint, the fitting material shall be permitted to be retested in pipe form.

8.3.2 The oxidative induction time (OIT) shall be determined on pipe and fittings in accordance with Test Method D3895. Two specimens shall be tested and the average OIT of the two shall be at least 80 % of the OIT of the virgin material compound. For those materials which require final blending at the extruder (masterbatch/resin), the 80% OIT requirement shall be based on the OIT of the pipe sample which has also passed the hydrostatic testing of 8.3.1 or a pipe sample of the same formulation containing no rework.

NOTE 3—Initial qualification of changes to materials that have met the requirements of this section may be evaluated based on limited hydrostatic testing and comparison of OIT values.

8.4 *Hydrostatic Pressure Tests*—When tested in accordance with 9.1, at the hoop stresses and temperatures given in Table 10, assemblies of pipe and fittings shall not fail during the test period specified.

8.5 *Thermocycling*—Plastic-to-metal transition fittings, intended to be used at temperatures above 113 °F (45 °C) shall not separate or leak during or after being thermocycled 1000 times between the temperatures of 60 °F and 180 °F (16 °C and 82 °C). Transition fittings which meet the thermal cycling requirements of ISO 15874-5 for the intended application class are exempt from this requirement. Fittings shall be assembled with pipe per the manufacturer's instructions, and tested in accordance with 9.2.

8.6 *Oxidative Stability in Potable Chlorinated Water Applications*—PP piping intended for use in the transport of potable water shall meet the following requirements:

(1) Pipe labeled as CL-TD shall be tested in accordance with 9.3 and shall have a minimum extrapolated time to time failure of 50 years when tested in accordance with 9.3 and evaluated in accordance with 9.3.1.

(2) Pipe labeled as CL-R shall be tested in accordance with 9.3 and shall have a minimum extrapolated time to time failure of 50 years when tested in accordance with 9.3 and evaluated in accordance with 9.3.2.

9. Test Methods

9.1 *Hydrostatic Tests*—Test pipe and fitting assemblies in accordance with Test Method D1598, at the hoop stresses and temperatures given in Table 10. An assembly shall consist of at least 4 pipe specimens and 6 fitting joints. For testing valves, the assembly shall include at least 3 valves in the shut-off position (seat test) and 3 valves in the open or partially open position (shell test). Assemblies used in testing of manifolds shall include a minimum of 6 of each type of manifold connection.

9.1.1 Valves shall be tested in accordance with, and comply with the requirements of each of the following tests of ISO 9393-2.

9.1.1.1 Shell Test,

9.1.1.2 Long-term Behavior Test on Complete Valve, and

9.1.1.3 Seat and Packing Tests.

9.1.2 *Hydrostatic test of panels and other appurtenances*—Polypropylene radiant panels and other appurtenances shall be tested in accordance with Test Method D1598 at the conditions specified in Table 11. A minimum of three representative samples shall be tested.

TABLE 3 Metric Sizes Wall Thickness

Nominal Size	Minimum Wall Thickness																							
	DR = 17.6				DR = 17				DR = 11				DR = 9				DR = 7.4				DR = 6				DR = 5			
	Min Wall		Tolerance		Min Wall		Tolerance		Min Wall		Tolerance		Min Wall		Tolerance		Min Wall		Tolerance		Min Wall		Tolerance		Min Wall		Tolerance	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
16	...	...	...	...	...	...	...	...	0.071	(1.8)	+0.012	(+0.3)	0.071	(1.8)	+0.012	(+0.3)	0.087	(2.2)	+0.016	(+0.4)	0.106	(2.7)	+0.016	(+0.4)	0.130	(3.3)	+0.020	(+0.50)
20	...	...	...	...	...	...	...	...	0.075	(1.9)	+0.012	(+0.3)	0.091	(2.3)	+0.016	(+0.4)	0.110	(2.8)	+0.016	(+0.4)	0.134	(3.4)	+0.020	(+0.5)	0.161	(4.1)	+0.019	(+0.49)
25	...	...	...	...	...	...	...	...	0.091	(2.3)	+0.016	(+0.4)	0.110	(2.8)	+0.016	(+0.4)	0.138	(3.5)	+0.020	(+0.5)	0.165	(4.2)	+0.024	(+0.6)	0.201	(5.1)	+0.024	(+0.61)
32	0.071	(1.8)	+0.016	(+0.4)	0.075	(1.9)	+0.016	(+0.4)	0.114	(2.9)	+0.016	(+0.4)	0.142	(3.6)	+0.020	(+0.5)	0.173	(4.4)	+0.024	(+0.6)	0.213	(5.4)	+0.028	(+0.7)	0.256	(6.5)	+0.031	(+0.78)
40	0.091	(2.3)	+0.020	(+0.5)	0.094	(2.4)	+0.020	(+0.5)	0.146	(3.7)	+0.020	(+0.5)	0.177	(4.5)	+0.024	(+0.6)	0.217	(5.5)	+0.028	(+0.7)	0.264	(6.7)	+0.035	(+0.9)	0.319	(8.1)	+0.038	(+0.97)
50	0.114	(2.9)	+0.020	(+0.5)	0.118	(3.0)	+0.020	(+0.5)	0.181	(4.6)	+0.024	(+0.6)	0.220	(5.6)	+0.028	(+0.7)	0.272	(6.9)	+0.031	(+0.8)	0.327	(8.3)	+0.043	(+1.1)	0.398	(10.1)	+0.048	(+1.21)
63	0.142	(3.6)	+0.024	(+0.6)	0.150	(3.8)	+0.024	(+0.6)	0.228	(5.8)	+0.028	(+0.70)	0.280	(7.1)	+0.035	(+0.9)	0.339	(8.6)	+0.039	(+1.0)	0.413	(10.5)	+0.047	(+1.2)	0.500	(12.7)	+0.060	(+1.52)
75	0.169	(4.3)	+0.028	(+0.7)	0.177	(4.5)	+0.028	(+0.7)	0.268	(6.8)	+0.031	(+0.8)	0.331	(8.4)	+0.039	(+1.0)	0.406	(10.3)	+0.047	(+1.2)	0.492	(12.5)	+0.055	(+1.4)	0.594	(15.1)	+0.071	(+1.81)
90	0.201	(5.1)	+0.031	(+0.8)	0.213	(5.4)	+0.031	(+0.8)	0.323	(8.2)	+0.039	(+1.0)	0.398	(10.1)	+0.047	(+1.2)	0.484	(12.3)	+0.055	(+1.4)	0.591	(15.0)	+0.067	(+1.7)	0.713	(18.1)	+0.086	(+2.17)
110	0.248	(6.3)	+0.035	(+0.9)	0.260	(6.6)	+0.035	(+0.9)	0.394	(10.0)	+0.047	(+1.20)	0.484	(12.3)	+0.055	(+1.4)	0.594	(15.1)	+0.067	(+1.7)	0.720	(18.3)	+0.083	(+2.1)	0.870	(22.1)	+0.104	(+2.65)
125	0.280	(7.1)	+0.039	(+1.0)	0.291	(7.4)	+0.039	(+1.0)	0.449	(11.4)	+0.051	(+1.3)	0.551	(14.0)	+0.063	(+1.6)	0.673	(17.1)	+0.075	(+1.9)	0.819	(20.8)	+0.094	(+2.4)	0.988	(25.1)	+0.119	(+3.01)
140	0.315	(8.0)	+0.039	(+1.0)	0.327	(8.3)	+0.043	(+1.1)	0.500	(12.7)	+0.060	(+1.52)	0.618	(15.7)	+0.071	(+1.8)	0.756	(19.2)	+0.091	(+2.30)	0.917	(23.3)	+0.110	(+2.80)	1.106	(28.1)	+0.133	(+3.37)
160	0.358	(9.1)	+0.043	(+1.1)	0.374	(9.5)	+0.043	(+1.1)	0.575	(14.6)	+0.063	(+1.6)	0.705	(17.9)	+0.075	(+1.9)	0.862	(21.9)	+0.098	(+2.5)	1.047	(26.6)	+0.122	(+3.1)	1.264	(32.1)	+0.152	(+3.85)
200	0.449	(11.4)	+0.051	(+1.3)	0.469	(11.9)	+0.051	(+1.3)	0.717	(18.2)	+0.079	(+2.0)	0.882	(22.4)	+0.094	(+2.4)	1.079	(27.4)	+0.114	(+2.9)	1.307	(33.2)	+0.138	(+3.5)	1.575	(40.0)	+0.181	(+4.6)
250	0.559	(14.2)	+0.063	(+1.6)	0.583	(14.8)	+0.063	(+1.6)	0.894	(22.7)	+0.094	(+2.4)	1.098	(27.9)	+0.114	(+2.9)	1.346	(34.2)	+0.142	(+3.6)	1.642	(41.5)	+0.169	(+4.3)	1.968	(50.0)	+0.220	(+5.6)
280	0.626	(15.9)	+0.071	(+1.8)	0.653	(16.6)	+0.075	(+1.9)	1.000	(25.4)	+0.110	(+2.8)	1.232	(31.3)	+0.134	(+3.4)	1.508	(38.3)	+0.161	(+4.1)	...	...	...	...	...	...	...	...
315	0.705	(17.9)	+0.075	(+1.9)	0.736	(18.7)	+0.079	(+2.0)	1.126	(28.6)	+0.122	(+3.1)	1.386	(35.2)	+0.146	(+3.7)	...	...	...		...	...	...	...	...	...	...	...
355	0.791	(20.1)	+0.087	(+2.2)	0.831	(21.1)	+0.091	(+2.3)	1.268	(32.2)	+0.138	(+3.5)	1.563	(39.7)	+0.165	(+4.2)	...	...	...		...	...	...	...	...	...	...	...
400	0.894	(22.7)	+0.094	(+2.4)	0.933	(23.7)	+0.098	(+2.5)	1.429	(36.3)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
450	1.004	(25.5)	+0.106	(+2.7)	1.051	(26.7)	+0.110	(+2.8)	1.610	(40.9)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
500	1.118	(28.4)	+0.118	(+3.0)	1.169	(29.7)	+0.122	(+3.1)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
560	1.248	(31.7)	+0.130	(+3.3)	1.307	(33.2)	+0.138	(+3.5)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
630	1.406	(35.7)	+0.146	(+3.7)	1.472	(37.4)	+0.154	(+3.9)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
710	1.583	(40.2)	+0.165	(+4.2)	1.657	(42.1)	+0.173	(+4.4)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

TABLE 4 IPS Sch 80 Socket-weld Fittings

Nominal Size	Socket Entrance, A						Socket Bottom, B					
	Average, in.		Tolerance on Average, in.		Maximum Out-of-roundness, in.		Average, in.		Tolerance on Average, in.		Maximum Out-of-roundness, in.	
½	0.840	(21.34)	±0.010	(±0.25)	0.012	(0.30)	0.794	(20.17)	±0.005	(±0.13)	0.012	(0.30)
¾	1.050	(26.67)	±0.010	(±0.25)	0.012	(0.30)	1.000	(25.40)	±0.007	(±0.18)	0.012	(0.30)
1	1.311	(33.30)	±0.010	(±0.25)	0.016	(0.41)	1.258	(31.95)	±0.007	(±0.18)	0.012	(0.30)
1-½	1.898	(48.21)	±0.012	(±0.30)	0.016	(0.41)	1.830	(46.48)	±0.007	(±0.18)	0.015	(0.38)
2	2.383	(60.53)	±0.012	(±0.30)	0.016	(0.41)	2.308	(58.62)	±0.007	(±0.18)	0.015	(0.38)
3	3.513	(89.23)	±0.012	(±0.30)	0.040	(1.02)	3.427	(87.05)	±0.010	(±0.25)	0.020	(0.51)
4	4.522	(114.86)	±0.015	(±0.38)	0.040	(1.02)	4.417	(112.19)	±0.010	(±0.25)	0.020	(0.51)
6	6.656	(169.06)	±0.032	(±0.81)	0.050	(1.27)	6.512	(165.40)	±0.012	(±0.30)	0.040	(1.02)

TABLE 5 IPS Sch 80 Socket-weld Fittings

Nominal Size	Socket depth, C				Wall Thickness			
	Min, in.		Max, in.		Socket, E, Min, in.		Body, F, Min, in.	
½	0.835	(21.21)	0.865	(21.97)	0.147	(3.73)	0.185	(4.70)
¾	0.960	(24.38)	0.990	(25.15)	0.154	(3.91)	0.195	(4.95)
1	1.085	(27.56)	1.115	(28.32)	0.179	(4.55)	0.225	(5.72)
1-½	1.335	(33.91)	1.365	(34.67)	0.200	(5.08)	0.250	(6.35)
2	1.460	(37.08)	1.490	(37.85)	0.218	(5.54)	0.275	(6.99)
3	1.830	(46.48)	1.860	(47.24)	0.300	(7.62)	0.375	(9.53)
4	2.205	(56.01)	2.235	(56.77)	0.337	(8.56)	0.420	(10.67)
6	2.955	(75.06)	2.985	(75.82)	0.432	(11.0)	0.540	(13.72)

TABLE 6 Metric Series Socket-weld Fittings

Nominal Size	Socket Entrance, A						Socket Bottom, B					
	Minimum Average Diameter, in.		Maximum Average Diameter, in.		Maximum Out-of-roundness, in.		Minimum Average Diameter, in.		Maximum Average Diameter, in.		Maximum Out-of-roundness, in.	
16	0.598	(15.20)	0.610	(15.50)	0.016	(0.40)	0.594	(15.10)	0.606	(15.40)	0.016	(0.40)
20	0.756	(19.20)	0.768	(19.50)	0.016	(0.40)	0.748	(19.00)	0.760	(19.30)	0.016	(0.40)
25	0.953	(24.20)	0.965	(24.50)	0.016	(0.40)	0.941	(23.90)	0.957	(24.30)	0.016	(0.40)
32	1.224	(31.10)	1.240	(31.50)	0.020	(0.50)	1.217	(30.90)	1.232	(31.30)	0.020	(0.50)
40	1.535	(39.00)	1.551	(39.40)	0.020	(0.50)	1.528	(38.80)	1.543	(39.20)	0.020	(0.50)
50	1.925	(48.90)	1.945	(49.40)	0.024	(0.60)	1.917	(48.70)	1.937	(49.20)	0.024	(0.60)
63	2.437	(61.90)	2.461	(62.50)	0.024	(0.60)	2.425	(61.60)	2.445	(62.10)	0.024	(0.60)
75	2.890	(73.40)	2.941	(74.7)	0.039	(1.00)	2.858	(72.6)	2.898	(73.6)	0.039	(1.00)
90	3.472	(88.2)	3.531	(89.7)	0.039	(1.00)	3.441	(87.4)	3.480	(88.4)	0.039	(1.00)
110	4.252	(108.0)	4.319	(109.7)	0.039	(1.00)	4.213	(107.0)	4.260	(108.2)	0.039	(1.00)
125	4.819	(122.4)	4.906	(124.6)	0.039	(1.00)	4.783	(121.5)	4.843	(123.0)	0.039	(1.00)

TABLE 7 Metric Series Socket-weld Fittings

Nominal Size	Socket Depth, C				Wall Thickness			
	Min, in.		Max, in.		Socket, E, Min, in.		Body, F, Min, in.	
16	0.512	(13.0)	0.622	(15.8)	0.121	(3.06)	0.161	(4.08)
20	0.571	(14.5)	0.669	(17.0)	0.145	(3.69)	0.194	(4.92)
25	0.630	(16.0)	0.728	(18.5)	0.167	(4.25)	0.223	(5.67)
32	0.709	(18.0)	0.811	(20.6)	0.212	(5.38)	0.282	(7.17)
40	0.807	(20.5)	0.906	(23.0)	0.256	(6.50)	0.341	(8.67)
50	0.925	(23.5)	1.024	(26.0)	0.335	(8.50)	0.446	(11.33)
63	1.083	(27.5)	1.177	(29.9)	0.413	(10.50)	0.551	(14.00)
75	1.181	(30.0)	1.319	(33.5)	0.492	(12.50)	0.656	(16.67)
90	1.299	(33.0)	1.496	(38.0)	0.591	(15.00)	0.787	(20.00)
110	1.457	(37.0)	1.732	(44.0)	0.723	(18.38)	0.965	(24.50)
125	1.575	(40.0)	1.850	(47.0)	0.822	(20.88)	1.096	(27.83)

9.1.3 *Assembly Procedure*—The assemblies shall be made in accordance with the manufacturer's recommended joining procedures and equipment.

9.2 *Thermocycling Test Method for Transition Fittings:*

9.2.1 *Apparatus*—A nitrogen or air source capable of maintaining a nominal internal pressure of 100 ± 10 psi (690 ± 69 kPa) on the specimens is required. The immersion system shall consist of two water reservoirs controlled at 60 ± 3.6 °F (16 ± 2 °C) and 180 ± 3.6 °F (82 ± 2 °C). The specimens shall be cycled from one reservoir to the other or the hot and cold water shall be alternately cycled over the test specimens automatically and returned to the proper reservoir.

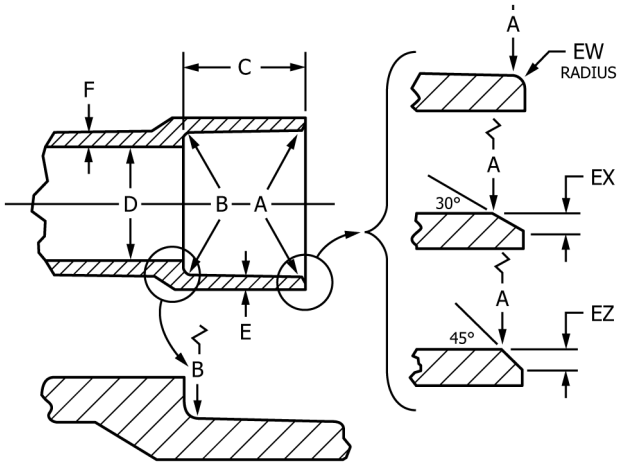

FIG. 1 Socket Dimension Symbols per D2749

TABLE 8 Conditions for Heat Reversion Test

Parameter	Type	Value
Oven Temperature	PP-R	275 ± 4 °F (135 ± 2 °C)
Exposure Time Based on Wall Thickness, *t*	*t* < 0.315 in. (8 mm)	60 min
	0.315 (8 mm) < *t* < 0.630 in. (16 mm)	120 min
	t > 0.630 in. (16 mm)	240 min

TABLE 9 Thermal Stability by Hydrostatic Test

Material	Hoop Stress, psi, (MPa)	Temperature, °F (°C)	Time, h
PP-R	275 (1.9)	230 (110)	8 760
PP-RCT	377 (2.6)	230 (110)	8 760

TABLE 10 Hydrostatic Test Conditions

Material	Hoop Stress, psi, (MPa)	Temperature, °F (°C)	Time, h
PP-R	2320 (16.0)	68 (20)	1
	510 (3.5)	203 (95)	1000
PP-RCT	2175 (15.0)	68 (20)	1
	551 (3.8)	203 (95)	1000

TABLE 11 Hydrostatic Test Conditions for Panels and Appurtenances

Test Pressure[A]	Test Temperature °F (°C)	Time, h
3.2 × PMA	68 (20)	1
1.5 × PMA	Max rated temperature	1000

[A]PMA is the maximum allowable operating pressure of the appurtenance or panel at the test temperature. The Test Pressure is a multiple of PMA, as shown in the table.

9.2.2 *Sampling and Specimen Preparation*—Select at random six specimens of the type and size of plastic-to-metal transition fittings to be tested. Assemble the fittings with suitable lengths of pipe or tubing and attach to a common manifold. Assemble strictly in accordance with the instructions of the fitting manufacturer. Close the specimen assembly with any suitable end closures that allow "free-end" mounting and will not leak under the thermocycling conditions, and connect the specimen assembly to the pressure source.

9.2.3 *Procedure*—Pressure the specimen assembly with nitrogen to 100 ± 10 psi (690 ± 69 kPa). Immerse in 60 ± 3.6 °F (16 ± 2 °C) water to determine if there are any initial leaks. All leaks shall be eliminated before the thermocycling test is started. Thermally cycle the specimen assembly between 60 ± 3.6°F (16 ± 2 °C) and 180 ± 3.6 °F (82 ± 2 °C) by means of immersion in water using the test cycle given in Table 12. For sizes greater than 1-½ in. (40 mm), shorter dwell times shall be permitted if it has been demonstrated that the shorter time is sufficient to achieve the test temperature at the internal surface of the fitting. Upon completion of the 1000 cycles, immerse the specimen assembly in 60 ± 3.6 °F (16 ± 2 °C) water to determine if there are any leaks.

9.2.4 *Interpretation of Results*—Any evidence of leakage at any one of the transition fittings or separation of any transition fitting from the pipe or tubing constitutes a failure of this test.

9.3 *Oxidative Stability in Potable Chlorinated Water Applications*—The test shall be conducted, and the extrapolated time-to-failure shall be determined in accordance with Test Method F2023. The test fluid shall be reverse-osmosis (RO) or deionized (DI) water prepared in accordance with 9.1.1 of Test Method F2023. The extrapolated time-to-failure shall be calculated in accordance with 13.3 of Test Method F2023 and as follows:

9.3.1 For a chlorine classification of CL-TD using the coefficients from Test Method F2023, 13.1 and using Miner's Rule, calculate the estimated time-to-failure for a hoop stress corresponding to a sustained pressure of 80 psig (551.7 kPa) for the highest DR of the product line being evaluated at temperature exposure conditions of 25% of the total time at 140°F (60 °C) and 75% of the total time at 73 °F (23 °C) in accordance with ISO 13760.

9.3.2 For a chlorine classification of CL-R using the coefficients from Test Method F2023, 13.1 and using Miner's Rule, calculate the estimated time-to-failure for a hoop stress corresponding to a sustained pressure of 80 psig (551.7 kPa) for the highest DR of the product line being evaluated at temperature exposure conditions of 100% of the total time at 140 °F (60°C) in accordance with ISO 13760.

9.3.3 *Significance*—The test need only be performed on representative pipe samples for the original validation of pipe made from a particular compound.

TABLE 12 Dwell Times for Transition Fittings Thermocyclic Test

Stage in Cycle	Fitting Nominal Size, IPS (metric)		
	½ to 1-½ (16 to 40)	2 to 3 (50 to 75)	4 to 6 (90 to 125)
Water immersion at 180°F (82°C), min	2 min	15 min	30 min
Air immersion at ambient, max	2 min	2 min	2 min
Water immersion at 16°C (60°F), min	2 min	15 min	30 min
Air immersion at ambient, max	2 min	2 min	2 min