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An American National Standard

# Standard Specification for Polyethylene of Raised Temperature (PE-RT) Systems for Non-Potable Water Applications[1]

This standard is issued under the fixed designation F2623; 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 polyethylene of raised temperature (PE-RT) systems for non-potable water applications. System components include PE-RT SDR 9 tubing, manifolds, fittings, valves and other appurtenances, and mechanical and fusion joining. PE-RT tubing is pressure rated for water at 73 °F (23 °C) and 180 °F (82 °C), and optionally 140 °F (60 °C). Included are requirements for materials, workmanship, dimensions and tolerances, product tests, and markings, and an optional barrier layer. Fittings include mechanical insert fittings and fusion fittings.



1.2 The text of this specification references notes, footnotes, and appendixes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the specification.

1.3 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.

1.3.1 Values in parentheses are appropriately rounded for accuracy and precision and are not exact equivalents.



1.4 The tubing systems produced under this specification are intended for use in the transport of non-potable water such as hydronic and irrigation systems.

1.4.1 PE-RT tubing containing an outside surface or mid-wall gas barrier layer or both is acceptable.

1.4.2 PE-RT systems under this standard are not intended for use in the transport of potable water. See Specification F2769 for PE-RT potable water distribution systems.

1.5 The following safety hazards caveat pertains only to the test methods 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, 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.*

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

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing
D1435 Practice for Outdoor Weathering of Plastics
D1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure
D1599 Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings
D1600 Terminology for Abbreviated Terms Relating to Plastics (Withdrawn 2024)[3]
D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings
D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications
D2683 Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
D3261 Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials
D3895 Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
F412 Terminology Relating to Plastic Piping Systems
F1055 Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing
F1281 Specification for Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe
F1282 Specification for Polyethylene/Aluminum/Polyethylene (PE-AL-PE) Composite Pressure Pipe
F1290 Practice for Electrofusion Joining Polyolefin Pipe and Fittings
F1807 Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps, for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing
F2080 Specification for Cold-Expansion Fittings with Metal Compression-Sleeves for Crosslinked Polyethylene (PEX) Pipe and SDR9 Polyethylene of Raised Temperature (PE-RT) Pipe
F2159 Specification for Plastic Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps for SDR9 Crosslinked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing
F2620 Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
F2735 Specification for Plastic Insert Fittings For SDR9 Cross-linked Polyethylene (PEX) and Polyethylene of Raised Temperature (PE-RT) Tubing
F2769 Specification for Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems
G155 Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials



2.2 *ANSI Standard:*

B36.10 Standards Dimensions of Steel Pipe (NTS)[4]

2.3 *Federal Standard:*

FED-STD-123 Marking for Shipment (Civil Agencies)[5]

2.4 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[5]

2.5 *PPI Standard:*[6]

PPI TR-3 Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe
PPI 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 or Pipe

2.6 *ISO Standard:*[7]

ISO 16871 Plastics piping and ducting systems—Plastics pipes and fittings—Method for exposure to direct (natural) weathering
ISO 17455 - Plastics piping systems — Multilayer pipes — Determination of the oxygen permeability of the barrier pipe

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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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[5] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

[6] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

[7] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

## 3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600, unless otherwise specified. The abbreviation for polyethylene of raised temperature is PE-RT. Plastic tubing denotes a particular diameter schedule of plastic pipe in which the outside diameter conforms to ANSI B36.10.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *barrier layer, n*—a very thin polymeric film within the tube wall or around the circumference of the tubing which provides a means for greatly reducing the transmission of oxygen from the atmosphere and into the fluid within the tube.

3.2.2 *fitting, n*—an appurtenance such as coupling, elbow or tee used to connect tubing or as an accessory to tubing.

3.2.3 *hydrostatic design stress (HDS)*—the estimated maximum tensile stress the material is capable of withstanding continuously with a high degree of certainty that failure of the tube will not occur. This stress is circumferential when internal hydrostatic water pressure is applied.

3.2.4 *manifold, n*—an appurtenance that has at least one inlet and multiple outlets.

3.2.5 *pressure rating (PR)*—the estimated maximum water pressure the tube is capable of withstanding continuously with a high degree of certainty that failure of the tube will not occur.

3.2.6 *relation between dimensions, hydrostatic design stress, and pressure rating*—the following expression, commonly known as the ISO equation,[8] is used in this specification to relate dimensions, hydrostatic design stress, and pressure rating:

$$2S/P = (D_O/t) - 1 \quad (1)$$

or

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



where:

$S$ = hydrostatic design stress, psi (or MPa) = Hydrostatic Design Basis × 0.63,
$P$ = pressure rating, psi (or MPa),
$D_O$ = average outside diameter, in. (or mm),
$t$ = wall thickness, in. (or mm), and
$R$ = standard dimension ratio, SDR.



3.2.7 *standard dimension ratio (SDR)*—the ratio of outside diameter to wall thickness. For PE-RT-tubing, it is calculated by dividing the average outside diameter of the tubing in inches or in millimeters by the minimum wall thickness in inches or millimeters. If the wall thickness calculated by this formula is less than 0.070 in. (1.78 mm) it shall be arbitrarily increased to 0.070 in. except for sizes NTS ⅛ and smaller. The SDR values shall be rounded to the nearest 0.5.

3.2.8 *standard thermoplastic material designated code*—the pipe material designation code shall consist of the abbreviation for the type of plastic (PE) followed by Arabic numerals which describe the short term properties in accordance with Specification D3350, the hydrostatic design stress for water at 73 °F (23 °C) in units of 100 psi with any decimal figures dropped. Where the hydrostatic design stress code contains less than two figures, a zero is used before the number.

3.2.9 *system components, n*—fittings and manifolds.

## 4. Classification

4.1 *Tubing*—This specification covers PE-RT tubing in one standard dimension ratio, 9.0, and nominal tubing sizes from NTS ⅛ through NTS 6 having pressure ratings based on water at 73 °F (23 °C) and 180 °F (82 °C) and optionally at 140 °F (60 °C), with a maximum continuous use temperature of 180 °F (82 °C). The pressure ratings decrease as the temperature is increased and is uniform for all nominal tubing sizes.

[8] ISO 161-1.

4.2 *System Components*—This specification covers system components, such as fittings and manifolds, for use in systems with PE-RT tubing on the basis of the requirements of this specification.

4.3 *Standard Thermoplastic Pipe Dimension Ratio (SDR)* —This specification covers PE-RT tubing in one standard dimension ratio (SDR 9) and nominal tubing sizes (NTS) from ⅛ in. through 6 in. with a maximum continuous use temperature that shall be 180 °F (82.2 °C). The pressure ratings are uniform for all nominal tubing sizes.

## 5. Materials and Manufacture

5.1 *PE-RT Tubing:*

5.1.1 The PE-RT compound used to make tubing shall have hydrostatic design basis (HDB) ratings at 73 °F (23 °C), 140 °F (60 °C) and 180 °F (82 °C) in accordance with Table 1 that are determined in accordance PPI TR-3.

5.1.1.1 Ratings at 140 °F (60 °C) that are interpolated in accordance with PPI TR-3 shall be acceptable.

5.1.1.2 Polyethylene compound shall comply with *Requirements For Polyethylene (PE) Materials To Qualify For A Higher Design Factor* in PPI TR-3, and shall have a 73 °F (23 °C) hydrostatic design stress (HDS) rating of 800 psi (5.52 MPa).

5.1.1.3 Polyethylene compound shall comply with Specification D3350 cell classification requirements in accordance with Table 2.

5.1.1.4 Polyethylene compound shall comply with Specification D3350 requirements for thermal stability, brittleness temperature and tensile elongation at break.



5.1.2 *Barrier Layer*—It is optional and acceptable for PE-RT tubing to incorporate a gas barrier layer in the mid-wall or outer wall or both, of non-PE-RT material for the purpose of reducing gas transmission through the tubing wall. A barrier layer incorporating a material to bond between PE-RT material and gas barrier layer material shall be acceptable.

5.1.2.1 The material used for an optional oxygen barrier layer shall be ethylene-vinyl alcohol copolymer (EVOH).

NOTE 1—Gas barrier layer material and bonding material if used, do not contribute to the internal pressure capacity of PE-RT tubing.



5.1.2.2 The EVOH material selected shall result in multilayer tubing that meets the adhesion and permeation requirements specified in A1.3.

5.2 *Rework Material*—Clean PE-RT material that complied with 5.1.1 through 5.1.1.4 when originally manufactured by the same manufacturer shall be acceptable as rework material when blended with new PE-RT compound that complies with 5.1.1 through 5.1.1.4. Rework material shall not contain barrier layer materials.

5.2.1 PE-RT tubing containing rework material and system components containing rework material shall meet the requirements of this specification.

5.3 *Fittings*—Fitting materials shall meet the applicable material requirements of at least one of the Specifications D2683, D3261, F1055, F1807, F2080, F2159, or F2735. Polyethylene material used in fusion fittings shall meet the requirements of 5.1.1 through 5.1.1.4.

**TABLE 1 Minimum Hydrostatic Design Basis at Different Temperatures**

| Rated Temperature | | Hydrostatic Design Basis | |
|---|---|---|---|
| °F | (°C) | psi | (MPa) |
| 73 | (23) | 1250 | (8.62) |
| 140 | (60) | 800 | (5.52) |
| 180 | (82) | 630 | (4.34) |

**TABLE 2 Required Specification D3350 Cell Classifications for PE-RT**

| Physical Property | Required Cell Classification |
|---|---|
| Density | 2, 3, or 4 |
| Melt index | 2, 3, 4, or 5 |
| Flexural modulus | 3 or 4 |
| Tensile strength | 2 or 3 |
| Slow crack growth resistance | 7 |
| Hydrostatic design basis | 3 or 4 |

## 6. Requirements

6.1 *Workmanship*—The tubing and fittings shall be homogeneous throughout and free of visible cracks, holes, foreign inclusions, or other defects. The tubing shall be as uniform as commercially practicable in color, opacity, density, and other physical properties. The walls of fittings and manifolds shall be free of cracks, holes, blisters, voids, foreign inclusions, or other defects that are visible to the naked eye and may affect fitting integrity. All sealing surfaces shall be smooth and free of foreign material.

6.2 *Dimensions and Tolerances:*

6.2.1 *Outside Diameters of Tubing*—The outside diameters and tolerances shall be as shown in Table 3, when measured in accordance with 7.4 and 7.4.1. Optional barrier layer(s) shall not increase the outside diameter beyond the Table 3 maximum outside diameter.

6.2.2 *Wall Thickness of Tubing*—The total wall thickness and tolerances shall be as shown in Table 4, when measured in accordance with 7.4 and 7.4.2.

6.2.2.1 *Layers*—PE-RT tubing that incorporates an EVOH oxygen barrier layer for the purposes of reducing the transmission rate of oxygen through the PE-RT wall and into the fluid medium shall comply with the dimensional, performance and marking requirements in accordance with Annex A1.

6.2.3 *Dimensions of Fittings*—The dimensions and tolerances of fittings shall meet the specific requirements contained in Specifications D2683, D3261, F1055, F1807, F2080, F2159, F2735, or other recognized specification.



6.3 *Sustained Pressure*—The tubing and system components, assembled using the system component manufacturer's instructions and tested as assemblies, shall not fail, balloon, burst, or weep as defined in Test Method D1598, at the test pressures given in Table 5 when tested in accordance with 7.5.

**TABLE 3 Outside Diameters and Tolerances for PE-RT Tubing**

| NTS, Nominal Tubing Size | Average Outside Diameter | | Tolerances for Average Diameter | | Out-of-Roundness[A] | |
|---|---|---|---|---|---|---|
| | in. | (mm) | in. | (mm) | in. | (mm) |
| ⅛ | 0.250 | (6.35) | ±0.003 | (±0.08) | 0.008 | (0.20) |
| ¼ | 0.375 | (9.52) | ±0.003 | (±0.08) | 0.008 | (0.20) |
| 5/16 | 0.430 | (10.92) | ±0.003 | (±0.08) | 0.008 | (0.20) |
| ⅜ | 0.500 | (12.70) | ±0.003 | (±0.08) | 0.012 | (0.32) |
| ½ | 0.625 | (15.88) | ±0.004 | (±0.10) | 0.016 | (0.40) |
| ⅝ | 0.750 | (19.05) | ±0.004 | (±0.10) | 0.016 | (0.40) |
| ¾ | 0.875 | (22.22) | ±0.004 | (±0.10) | 0.016 | (0.40) |
| 1 | 1.125 | (28.58) | ±0.005 | (±0.12) | 0.020 | (0.48) |
| 1¼ | 1.375 | (34.92) | ±0.005 | (±0.12) | 0.020 | (0.48) |
| 1½ | 1.625 | (41.28) | ±0.006 | (±0.16) | 0.024 | (0.60) |
| 2 | 2.125 | (53.98) | ±0.006 | (±0.16) | 0.030 | (0.76) |
| 2½ | 2.625 | (66.68) | ±0.007 | (±0.18) | 0.038 | (0.95) |
| 3 | 3.125 | (79.38) | ±0.008 | (±0.20) | 0.045 | (1.14) |
| 3½ | 3.625 | (92.08) | ±0.008 | (±0.20) | 0.046 | (1.16) |
| 4 | 4.125 | (104.78) | ±0.009 | (±0.23) | 0.052 | (1.32) |
| 4½ | 4.625 | (117.48) | ±0.009 | (±0.23) | 0.059 | (1.49) |
| 5 | 5.125 | (130.18) | ±0.010 | (±0.25) | 0.065 | (1.65) |
| 6 | 6.125 | (155.58) | ±0.011 | (±0.28) | 0.072 | (1.83) |

[A] The Out-of-Roundness specification applies only to tubing prior to coiling.

**TABLE 4 Wall Thickness and Tolerances for PE-RT SDR 9 Tubing[A]**

| NTS, Nominal Tubing | Minimum Wall Thickness | | Tolerance | |
|---|---|---|---|---|
| | in. | (mm) | in. | (mm) |
| ⅛ | 0.047[B] | (1.19)[B] | +0.007 | (+0.18) |
| ¼ | 0.062[B] | (1.57)[B] | +0.010 | (+0.25) |
| 5/16 | 0.064 | (1.63) | +0.010 | (+0.25) |
| ⅜ | 0.070[B] | (1.78)[B] | +0.010 | (+0.25) |
| ½ | 0.070[B] | (1.78)[B] | +0.010 | (+0.25) |
| ⅝ | 0.083 | (2.12) | +0.010 | (+0.25) |
| ¾ | 0.097 | (2.47) | +0.010 | (+0.25) |
| 1 | 0.125 | (3.18) | +0.013 | (+0.33) |
| 1¼ | 0.153 | (3.88) | +0.015 | (+0.38) |
| 1½ | 0.181 | (4.59) | +0.019 | (+0.48) |
| 2 | 0.236 | (6.00) | +0.024 | (+0.61) |
| 2½ | 0.292 | (7.41) | +0.030 | (+0.76) |
| 3 | 0.347 | (8.82) | +0.033 | (+0.84) |
| 3½ | 0.403 | (10.23) | +0.035 | (+0.89) |
| 4 | 0.458 | (11.64) | +0.040 | (+1.02) |
| 4½ | 0.514 | (13.05) | +0.045 | (+1.14) |
| 5 | 0.569 | (14.46) | +0.050 | (+1.27) |
| 6 | 0.681 | (17.29) | +0.060 | (+1.52) |

[A] The minimum is the lowest total wall thickness of PE-RT material in the tubing wall 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. The presence of optional barrier layer(s) shall not reduce the total thickness of PE-RT material in the tubing wall below the minimum, nor above the maximum (maximum = minimum + tolerance).
[B] For tubing nominal sizes of ½ and below, wall thickness minimums are not functions of SDR.



**TABLE 5 Minimum Sustained Water Pressure Test Condition for PE-RT SDR 9 Tubing and Systems**

| NTS, Nominal Tubing Size | Pressure Required for Test, psig[A] (MPa) | | | | | |
|---|---|---|---|---|---|---|
| | 73 °F | (23°C) | 140 °F (optional) | (60 °C) (optional) | 180°F | (82 °C) |
| ⅛ | 600 | (4.14) | 405 | (2.79) | 300 | (2.07) |
| ¼ | 515 | (3.55) | 350 | (2.41) | 260 | (1.79) |
| 5/16 | 455 | (3.14) | 310 | (2.14) | 230 | (1.59) |
| ⅜ | 425 | (2.93) | 285 | (1.97) | 215 | (1.48) |
| ½ | 330 | (2.28) | 220 | (1.52) | 165 | (1.14) |
| ⅝ and larger | 325 | (2.24) | 220 | (1.52) | 165 | (1.14) |



[A] The fiber stresses used to derive these test pressures are:
at 73 °F (23 °C) 1300 psi (8.96 MPa)
at 140 °F (60 °C) 880 psi (6.07 MPa)
at 180 °F (82 °C) 650 psi (4.48 MPa)

6.4 *Burst Pressure*—The tubing and system components, assembled using the system component manufacturer's instructions and tested as assemblies, shall meet the minimum burst pressures as given in Table 6 without failure, when determined in accordance with 7.6.

6.4.1 *Manifolds*—If the manifold has more than one connection size, the test pressure selected from Table 6 shall be based on the largest nominal tubing connection.

6.5 *Oxidative Resistance*—PE-RT tubing shall have a minimum extrapolated time-to-failure of 50 years when tested and evaluated in accordance with 7.7.

6.6 *Bent Tube*—PE-RT tubing, nominal sizes, up to and including NTS 1, can be installed bent by the technique described in Appendix X3 provided the following requirements are met. Bent tubing, with a radius of 6 times the outside diameter and