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Standard Specification for Polyethylene of Raised Temperature (PE-RT) SDR 9 Tubing[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) SDR 9 tubing that is outside diameter controlled, and pressure rated for water at 73°F (23°C), 140°F (60°C) and 180°F (82.2°C). Included are requirements for material, workmanship, dimensions and tolerances, product tests, and markings for PE-RT tubing.

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.

1.4 The tubing produced under this specification shall be permitted for use in general fluid transport, including hydronics and irrigations 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D618 Practice for Conditioning Plastics for Testing

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

D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

D2837 Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products

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

2.2 *ANSI Standard:*

B36.10 Standards Dimensions of Steel Pipe (NTS)[3]

2.3 *Federal Standard:*

FED-STD-123 Marking for Shipment (Civil Agencies)[4]

2.4 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[4]

2.5 *PPI Standard:*

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[5]

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 outside diameter of the tubing is equal to the nominal size plus ⅛ in. Plastic pipe outside diameter schedule conforms to ANSI B36.10.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *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

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

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

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

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

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tube will not occur. This stress is circumferential when internal hydrostatic water pressure is applied.

3.2.2 *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.

3.2.3 *relation between dimensions, hydrostatic design stress, and pressure rating*—the following expression, commonly known as the ISO equation,[6] 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),
P = pressure rating, psi (or MPa),
D_O = average outside diameter, in. (or mm),
T = minimum wall thickness, in. (or mm), and
R = standard dimension ratio, SDR.

3.2.4 *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 ⅛ in. and smaller. The SDR values shall be rounded to the nearest 0.5.

3.2.5 *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 73.4°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.

4. Tubing Classification

4.1 *General*—This specification covers one PE-RT tubing material in one standard dimension ratio, 9.0, and having pressure ratings for water at 73°F and 180°F and optionally at 140°F. The pressure ratings decrease as the temperature is increased.

4.2 *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

5.1 *General*—The plastic used to make tubing shall be virgin plastic or reworked plastic, as specified in 5.3, and shall have Plastics Pipe Institute (PPI) long-term hydrostatic design stress and pressure ratings at 73°F and 180°F. The ratings at 140°F are an optional standard.

5.2 *Barrier Layers*—PE-RT tubing may incorporate an optional interior wall, mid wall or outer wall layer or a combination of such layers of non-PE-RT material for the express purpose of providing gas barrier properties to the pipe. The tubing shall meet the minimum wall thickness requirements of this standard without using the barrier layer thickness in the determinations. PE-RT tubing with a barrier layer within the wall of the tubing (neither exterior layer nor interior layer) shall demonstrate a hydrostatic design stress (HDS) rating equivalent to that of PE-RT tubing without a barrier layer. This determination shall be made in accordance with policies no less restrictive than those of the PPI HSB and meet the requirements of this standard.

5.3 *Rework Material*—Clean rework material of the same commercial designation, generated from the manufacturer's own tubing production shall not be used unless the tubing produced meet all the requirements of this specification.

5.4 *Classification*—Polyethylene materials suitable for use in the manufacture of tubing under this specification shall be classified in accordance with Specification D3350 and as shown in Table 1. The material shall have minimum HDS and pressure ratings as per Table 2. The ratings at 140°F are optional.

5.5 *Tubing Material Designation*—The tubing meeting the requirements of this specification shall be designated PE-RT.

6. Requirements

6.1 *Workmanship*—The tubing 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.

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.

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

6.3 *Sustained Pressure*—The tubing 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.

6.4 *Burst Pressure*—The minimum burst pressure for PE-RT plastic tubing shall be as given in Table 6, when determined in accordance with 7.6.

TABLE 1 Required D3350 Cell Classifications for PE-RT

Physical Properties:	
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] ISO 161-1.

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TABLE 2 Minimum Hydrostatic Design Basis and Pressure Ratings for PE-RT SDR 9 Tubing for Water at Different Temperatures

Rated Temperature		Hydrostatic Design Basis		Pressure Rating for Water	
°F	°C	psi	(MPa)	psi	(MPa)
73.4	23	1250	(8.62)	160	(1.10)
140	60	800	(5.52)	100	(0.69)
180	82.2	630	(4.34)	80	(0.55)

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, up to and including 1 in. nominal diameter, 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 consisting of a continuous bend length inducing not less than 90° angle, shall meet the 180°F (82.2°C) minimum hydrostatic sustained pressure strength requirements shown in Table 5 when tested in accordance with 7.8. The bend length and bend angle is kept throughout the testing period by rigid secures immediately outside the bend. The minimum test duration shall be 1000 h without failure.

NOTE 1—PE-RT tubing, larger than 1 in. nominal diameter, is typically installed as main distribution lines and is installed in straight runs. Fittings are used when a change in direction of 90° or greater and a bend radius of less than 6 times the outside diameter is needed. The test procedures in 6.6 are intended to evaluate PE-RT tubing installed in tight bend applications in accordance with the procedure in Appendix X3. This application applies to tubing up to and including 1 in. nominal diameter only.

7. Test Methods

7.1 *Conditioning*—Condition the specimens at 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity for not less than 40 h prior to test in accordance with Procedure A of Practice D618, for those tests where conditioning is required. In cases of disagreement, the tolerances shall be ±1.8°F (±1°C) and ±2 % relative humidity.

7.2 *Test Conditions*—Conduct the test in the standard laboratory atmosphere of 73.4 ± 3.6°F (23 ± 2°C) and 50 ± 5 % relative humidity, unless otherwise specified in the test methods or in this specification. In cases of disagreement, the tolerances shall be ±1.8°F (±1°C) and ±2 % relative humidity.

7.3 *Sampling*—A sufficient quantity of tubing, as agreed upon by the purchaser and the seller, shall be selected and tested to determine conformance with this specification. In the case of no prior agreement, random samples selected by the testing laboratory shall be deemed adequate.

7.3.1 *Test Specimens*—Unless otherwise specified in this standard or as agreed upon by the purchaser and the seller, the quantity and size of the specimens to be tested shall be as specified by the test method referred to in this standard.

7.4 *Dimensions and Tolerances*—Use any length of tubing to determine the dimensions. Measure in accordance with Test Method D2122.

7.4.1 *Outside Diameter*—Measure the outside diameter of the tubing in accordance with Test Method D2122. The referee method of measurement is to be by circumferential wrap tape. The tolerance for out-of-roundness shall apply only to tubing prior to shipment. Averaging micrometer or vernier caliper measurements, four (4) maximum and minimum diameter measurements at any cross section, may be used for quality control checks if desired.

7.4.2 *Wall Thickness*—Make micrometer measurements of the wall thickness in accordance with Test Method D2122 to determine the maximum and minimum values. Measure the wall thickness at both ends of the tubing to the nearest 0.001 in. (0.025 mm).

7.5 *Sustained Pressure Test*—Select the test specimens at random. Test six specimens as per Test Method D1598 in water at 73°F (23°C) and 180°F (82.2°C) as shown in Table 5. If the optional 140°F rating is desired, perform an additional test at 140°F (60°C) in accordance with Table 5. Each specimen of tubing shall be at least five times the nominal diameter in length and not less than 12 in. (25 cm) or more than 3.0 ft (91 cm) between end closures. Maintain the specimens at the pressures indicated for the appropriate temperatures for a period of 1000 h. Failure of two of the six specimens tested at either temperature constitutes failure in the test. Failure of one of six specimens tested at either temperature is cause for retest of six additional specimens at that temperature. Failure of one of six specimens tested at either temperature in retest constitutes failure in the test. Failure of the tubing shall be defined in accordance with Test Method D1598.

7.6 *Burst Pressure*—Determine the sample complies with the minimum burst pressure requirements by testing at least five specimens in accordance with Test Method D1599 Method B. The pressure values are given in Table 6.

7.7 *Oxidative Resistance*—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 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.

7.7.1 *Significance*—The test need only be performed once and only once for the original validation of a compound tested in the form of a tube. A compound is defined as the PE-RT resin and the stabilization system. It shall not be required to perform plant or extrusion line verification testing.

7.8 *Bent Tube Test*—Determine in accordance with Test Method D1598, except for the following: Test at least six specimens, from randomly selected specimens assembled per the manufacturer's instructions with at least 5-pipe diameters between joints. Test temperature shall be 180°F (82 °C).

8. Retest and Rejection

8.1 If the results of any test(s) do not meet the requirements of this specification, the test(s) shall be conducted again only by agreement between the purchaser and seller. Under such agreement, minimum requirements shall not be lowered, changed, or modified, nor shall specification limits be changed.

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