



Designation: F3534/F3534M – 22

Standard Specification for MRS-Rated Metric- and Inch-Sized Crosslinked Polyethylene (PEX) Pressure Pipe for Gas Distribution Applications¹

This standard is issued under the fixed designation F3534/F3534M; 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 crosslinked polyethylene (PEX) pipe that is outside diameter controlled in metric pipe sizes (DN 16 to 1000) and inch pipe sizes (NPS 3 to 54), and pressure rated (see [Appendix X1](#)) using the MRS rating system. This Specification is intended for PEX pipe made by various processes, as long as the PEX pipe made by that process meets all the requirements of this Specification. Included are requirements and test methods for material, workmanship, UV protection, dimensions, hydrostatic sustained pressure, stabilizer functionality, bent-pipe hydrostatic pressure, chemical resistance, minimum operating temperature, degree of crosslinking, squeeze-off, and hydrostatic burst pressure. Requirements for pipe markings are also given. The pipe covered by this specification is intended for natural gas distribution.

1.2 This specification also includes requirements for qualifying joints made using polyethylene electrofusion fittings (such as Specification [F3373](#)) and PEX pipe. Fittings to be used with PEX pipe manufactured to this specification are in Specification [F2829/F2829M](#). Installation considerations are in [X3.2](#).

NOTE 1—NPS fittings should not be used for DN sized pipe, and DN sized fittings should not be used for NPS pipe.

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

1.4 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.4.1 For consistency with ISO 9080, MRS values are only in MPa and degrees Centigrade for conversion to the pipe

material designation code (for example PEX pipe with an MRS of 8 MPa is called a PEX 80).

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

- [D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents](#)
- [D618 Practice for Conditioning Plastics for Testing](#)
- [D792 Test Methods for Density and Specific Gravity \(Relative Density\) of Plastics by Displacement](#)
- [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](#)
- [D1599 Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings](#)
- [D1600 Terminology for Abbreviated Terms Relating to Plastics](#)
- [D1603 Test Method for Carbon Black Content in Olefin Plastics](#)
- [D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings](#)
- [D2290 Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe](#)
- [D2565 Practice for Xenon-Arc Exposure of Plastics Intended for Outdoor Applications](#)

¹ This specification is under the jurisdiction of ASTM Committee [F17](#) on Plastic Piping Systems and is the direct responsibility of Subcommittee [F17.60](#) on Gas.

Current edition approved Feb. 1, 2022. Published March 2022. DOI: 10.1520/F3534_F3534M-22

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.

- D2765** Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics
- D4218** Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
- D5596** Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
- F412** Terminology Relating to Plastic Piping Systems
- F2657** Test Method for Outdoor Weathering Exposure of Crosslinked Polyethylene (PEX) Tubing
- F2829/F2829M** Specification for Metric- and Inch-Sized Fittings for Crosslinked Polyethylene (PEX) Pipe
- F3203** Test Method for Determination of Gel Content of Crosslinked Polyethylene (PEX) Pipes and Tubing
- F3373** Specification for Polyethylene (PE) Electrofusion Fittings for Outside Diameter Controlled Crosslinked Polyethylene (PEX) Pipe

2.2 Federal Standard:³

FED-STD-123 Marking for Shipment (Civil Agencies)

2.3 Military Standard:³

MIL-STD-129 Marking for Shipment and Storage

2.4 ISO Standards:⁴

- ISO 1167** Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure — Part 1: General method
- ISO 3126** Plastics piping systems — Plastics components — Determination of dimensions
- ISO 9080** Plastics piping and ducting systems — Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation
- ISO 12162** Thermoplastics materials for pipes and fittings for pressure applications — Classification and designation — Overall service (design) coefficient
- ISO 13477** Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid crack propagation (RCP) — Small-scale steady-state test (S4 test)
- ISO 13760** Plastics pipes for the conveyance of fluids under pressure — Miner's rule ~ Calculation method for cumulative damage
- ISO 14531-1** Plastics pipes and fittings — Crosslinked polyethylene (PEX) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications — Part 1: Pipes
- ISO 18553** Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds

2.5 PPI Standards:⁵

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

PPI TR-4 HDB/HDS/SDB/PDB/MRS/CRS

Listed Materials, PPI Listing of Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Strength Design Basis (SDB), Pressure Design Basis (PDB), Minimum Required Strength (MRS), Categorized Required Strength (CRS) Ratings for Thermoplastic Piping Materials or Pipe

3. Terminology

3.1 Definitions—Unless otherwise specified, definitions, abbreviations and initials are in accordance with Terminology **F412** and Terminology **D1600**.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 categorized required strength (CRS) or CRS (θ, t), n —see ISO 12162 or PPI TR-4 for CRS definition.

3.2.1.1 Discussion—The MRS of a compound is determined before a CRS can be determined. CRS is used for a design time other than 50 years or a design temperature other than 20 °C. An example of the use of CRS is provided in **Appendix X2**.

3.2.2 design stress (σ_s), n —stress equal to the MRS or CRS divided by the overall design coefficient (C).

$$\sigma_s = MRS / C \text{ or } CRS / C \quad (1)$$

3.2.3 material designation, n —as used in this standard, the material designation for PEX pipe shall consist of the abbreviation for the type of plastic (PEX) followed by two or three Arabic digits, which are the MRS (in MPa only) times ten, as shown in **Table 1**.

3.2.4 maximum operating pressure (MOP), n —the estimated maximum pressure the pipe is capable of withstanding continuously with a high degree of certainty that failure of the pipe will not occur, as shown in the following equations that are used in this specification to relate dimensions, design stress, and maximum operating pressure.

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

TABLE 1 Material Designations for PEX Pipe

Material Designation	MRS (20 °C and 50 years) MPa
PEX 80	8.0
PEX 100	10.0

³ Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, <http://quicksearch.dla.mil>.

⁴ Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

$$MOP = 2\sigma_s / [(D_o / t) - 1], \text{ or} \quad (2)$$

$$MOP = 2\sigma_s / (R - 1)$$

For MOP at a temperature other than 20 °C or a time other than 50 years:

$$MOP = 2(CRS) / [(R - 1)(C)], \quad (3)$$

$$MOP = 2(CRS) / [(R - 1)(C_M \times C_A)] \quad (4)$$

where:

- σ_s = design stress, MPa,
- MOP = maximum operating pressure, MPa,
- D_o = average outside diameter, see Table 2 (mm) or Table 3 (in.),
- t = minimum wall thickness, see Table 4 (mm) or Table 5 (in.),
- R = standard dimension ratio (SDR) or dimension ratio (DR),
- MRS = minimum required strength, MPa,
- CRS = categorized required strength, MPa, and
- C = overall design coefficient – minimum of 2.0.

3.2.4.1 *Discussion*—MOP is sometimes referred to as PN or nominal pressure.

3.2.5 *minimum required strength (MRS), n*—see ISO 12162 or PPI TR-4 for MRS definition.

3.2.5.1 *Discussion*—MRS is determined only at 20 °C and 50 years. For a design temperature other than 20 °C or a design time other than 50 years, CRS is used in place of MRS, as discussed in 3.2.1.

TABLE 2 Outside Diameters and Tolerances for DN Size PEX Pipe

DN Size	Minimum outside diameter (mm)	Maximum outside diameter (mm)	Maximum of absolute out-of-roundness ^A (mm)
16	16.0	16.3	1.2
20	20.0	20.3	1.2
25	25.0	25.3	1.2
32	32.0	32.3	1.3
40	40.0	40.4	1.4
50	50.0	50.4	1.4
63	63.0	63.4	1.5
75	75.0	75.5	1.6
90	90.0	90.6	1.8
110	110.0	110.7	2.2
125	125.0	125.8	2.5
140	140.0	140.9	2.8
160	160.0	161.0	3.2
180	180.0	181.1	3.6
200	200.0	201.2	4.0
225	225.0	226.4	4.5
250	250.0	251.5	5.0
280	280.0	281.7	9.8
315	315.0	316.9	11.1
355	355.0	357.2	12.5
400	400.0	402.4	14.0
450	450.0	452.7	15.6
500	500.0	503.0	17.5
560	560.0	563.4	19.6
630	630.0	633.8	22.1
710	710.0	716.4	24.9
800	800.0	817.2	28.0
900	900.0	908.1	31.5
1000	1000.0	1009.0	35.0

^A Values are consistent with ISO 14531-1.

TABLE 3 Outside Diameters and Tolerances for NPS PEX Pipe

NPS	Average Outside Diameter in.	Tolerances for Average Diameter (±) in.	Maximum of absolute out-of-roundness ^A in.
3	3.500	0.016	0.07
4	4.500	0.020	0.09
5	5.563	0.025	0.11
6	6.625	0.030	0.13
8	8.625	0.039	0.17
10	10.750	0.048	0.22
12	12.750	0.057	0.26
14	14.000	0.063	0.28
16	16.000	0.072	0.40
18	18.000	0.081	0.54
20	20.000	0.090	0.60
22	22.000	0.099	0.66
24	24.000	0.108	0.72
26	26.000	0.117	0.78
28	28.000	0.126	0.98
30	30.000	0.135	1.05
32	32.000	0.144	1.12
34	34.000	0.153	1.19
36	36.000	0.162	1.26
42	42.000	0.189	1.47
48	48.000	0.216	1.68
54	54.000	0.243	1.89

^A Values are consistent with ISO 14531-1.

3.2.6 *nominal diameter, DN, adj*—a designation for SI unit outside diameter controlled pipe sizes.

3.2.7 *nominal pipe size, NPS, adj*—a designation for inch-pound unit outside diameter controlled pipe sizes.

3.2.8 *overall design coefficient (C), n*—a factor with a value greater than 1, which takes into consideration material properties (C_M) and application service conditions (C_A), as well as properties of the components of a piping system other than those represented in the lower predictive limit. The minimum overall design coefficient (C_{min}) for natural gas applications is 2.0, as specified in ISO 14531-1. The gas operator may add additional application coefficients, depending on the application, as shown below. See Appendix X1 for further discussion on design coefficients.

$$C = C_M \times C_A = 1.25 \times 1.6 \times C_{A1}, \text{ or}$$

$$C = 2.0 \times C_{A1} \times C_{A2} \text{ if there are multiple application coefficients} \quad (5)$$

Design coefficients are sometimes referred to as reduction factors.

3.2.8.1 *application design coefficient (C_A), n*—a factor that takes into account various aspects of the installation or the application that the plastic pipe is used for. For gas distribution, C_A is 1.6, which results in the minimum overall design coefficient of 2.0. Adding additional application coefficients is left to the design engineer to incorporate via appropriate design codes, national regulations or manufacturers recommendations, and is dependent on location of the pipeline, temperature, type of fluid being conveyed, and installation method.

3.2.8.2 *material design coefficient (C_M), n*—factor that takes into account the properties of the plastic material. For PEX, the material coefficient (C_M) is 1.25, as specified in ISO 14531-1.

TABLE 4 Minimum Wall Thicknesses for DN Size PEX Pipe

All dimensions in mm^A

DN Size	DR 6	DR 7.4	SDR 9	SDR 11	DR 13.6	DR 16.2	SDR 17
16	3.0	2.3	2.0	...	...	...	...
20	3.4	3.0	2.3	2.0	...	...	...
25	4.2	3.5	3.0	2.3	2.0	...	...
32	5.4	4.4	3.6	3.0	2.4	2.0	2.0
40	6.7	5.5	4.5	3.7	3.0	2.5	2.4
50	8.3	6.9	5.6	4.6	3.7	3.1	2.9
63	10.5	8.6	7.1	5.8	4.7	3.9	3.7
75	12.5	10.3	8.4	6.8	5.6	4.6	4.4
90	15.0	12.3	10.1	8.2	6.7	5.6	5.3
110	18.3	15.1	12.3	10.0	8.1	6.8	6.5
125	20.8	17.1	14.0	11.4	9.2	7.7	7.4
140	23.3	19.2	15.7	12.7	10.3	8.7	8.2
160	26.6	21.9	17.9	14.6	11.8	9.9	9.4
180	29.9	24.6	20.1	16.4	13.3	11.1	10.6
200	33.2	27.4	22.4	18.2	14.7	12.4	11.8
225	37.4	30.8	25.2	20.5	16.6	13.9	13.2
250	41.5	34.2	27.9	22.7	18.4	15.5	14.7
280	46.5	38.3	31.3	25.4	20.6	17.3	16.5
315	52.3	43.1	35.2	28.6	23.2	19.5	18.5
355	59.0	48.5	39.7	32.2	26.1	21.9	20.9
400	...	54.7	44.7	36.3	29.4	24.7	23.5
450	...	61.5	50.3	40.9	33.1	27.8	26.5
500	...	...	55.8	45.4	36.8	30.9	29.4
560	...	...	62.5	50.8	41.2	34.6	32.9
630	...	...	70.3	57.2	46.3	38.9	37.0
710	...	...	79.3	64.5	52.2	43.9	41.8
800	...	...	89.3	72.6	58.8	49.4	47.0
900	...	...	...	81.7	66.2	56.6	52.9
1000	...	...	...	90.2	72.5	61.8	58.8

^A Small pipe diameters have minimum wall thicknesses values greater than the calculated value based on DR or SDR.

TABLE 5 Minimum Wall Thicknesses for NPS PEX Pipe

All dimensions in inches^A

NPS	DR 7.3	DR 8.3	SDR 9	SDR 11	DR 13.5	DR 15.5	SDR 17	SDR 21
3	0.479	0.422	0.389	0.318	0.259	0.226	0.206	0.167
4	0.616	0.542	0.500	0.409	0.333	0.290	0.265	0.214
5	0.762	0.670	0.618	0.506	0.412	0.359	0.327	0.265
6	0.908	0.798	0.736	0.602	0.491	0.427	0.390	0.315
8	1.182	1.039	0.958	0.784	0.639	0.556	0.507	0.411
10	1.473	1.295	1.194	0.977	0.796	0.694	0.632	0.512
12	1.747	1.536	1.417	1.159	0.944	0.823	0.750	0.607
14	1.918	1.687	1.556	1.273	1.037	0.903	0.824	0.667
16	2.192	1.928	1.778	1.455	1.185	1.032	0.941	0.762
18	2.466	2.169	2.000	1.636	1.333	1.161	1.059	0.857
20	...	2.409	2.222	1.818	1.481	1.290	1.176	0.952
22	...	...	2.444	2.000	1.630	1.419	1.294	1.048
24	...	...	2.667	2.182	1.778	1.548	1.412	1.143
26	...	...	...	2.364	1.926	1.677	1.529	1.238
28	...	...	...	2.545	2.074	1.806	1.647	1.333
30	...	...	...	2.727	2.222	1.935	1.765	1.429
32	...	...	...	2.909	2.370	2.065	1.882	1.524
34	...	...	...	3.091	2.519	2.194	2.000	1.619
36	...	...	...	3.273	2.667	2.323	2.118	1.714
42	...	...	...	...	...	2.710	2.471	2.000
48	...	...	...	...	...	3.097	2.824	2.286
54	...	...	...	...	...	...	3.176	2.571

^A Small pipe diameters have minimum wall thicknesses values greater than the calculated value based on DR or SDR.

4. Pipe Classification

4.1 *General*—This specification covers two PEX ISO classifications – PE-X 80 with an 8.0 MPa MRS and PE-X 100 with a 10.0 MPa MRS. The maximum operating pressure (MOP) for PEX pipe is based on the MRS or CRS and shall be determined in accordance with the equations in 3.2.4.

NOTE 2—The CRS for PEX pipe is only determined after the MRS is established.

4.2 *Operating Temperature Range*—The determination of the minimum operating temperature shall be in accordance with 6.10. The maximum operating temperature is based on the maximum temperature at which a CRS can be determined by the