Summary of Substantive Changes
between the 2015a and 2017 editions of
ASTM F876 "Crosslinked Polyethylene (PEX) Tubing

Presented to the IAPMO Standards Review Committee on July 9, 2018

General: The changes to this standard should not have an impact on currently listed products. The substantive changes are:

- Expanded the scope to include additional examples of the intended use of products covered by the standard (see Section 1.1).
- Clarified the requirements for workmanship and added a minimum coiling diameter allowance for PEX pipe (see Section 5)
- Revised the test temperatures to reduce the precision and added a note to explain the significance of the chlorine ratings (Section 7)
- Removed the inch and millimeter specifications for the NTS designations. (see Tables 2 and 3)

Section 1, Scope: Expanded the scope to include additional examples of the intended use of products covered by the standard as follows:

1. Scope

1.1 This specification covers crosslinked polyethylene (PEX) tubing that incorporates an optional polymeric inner, middle or outer layer and that is outside diameter controlled, made in nominal SDR9 tubing dimension ratios except where noted, and pressure rated for water at three temperatures (see Appendix X1). Included are requirements and test methods for material, workmanship, dimensions, burst pressure, hydrostatic sustained pressure, excessive temperature and pressure, environmental stress cracking, stabilizer functionality, bent-tube hydrostatic pressure, oxidative stability in potable chlorinated water, and degree of crosslinking. Requirements for tubing markings are also given. The components covered by this specification are intended for use in, but not limited to, residential and commercial, hot- and cold-potable water distribution systems, reclaimed water, fire protection, municipal water service lines, radiant heating and cooling systems, hydronic distribution systems, snow and ice melting systems, geothermal ground loops, district heating, turf conditioning, compressed air distribution and building services pipe, provided that the PEX tubing covered herein complies with applicable code requirements.

1.4 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.

1.5 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.

Section 2, Referenced Documents: PPI TR-3 was moved from footnote 10 to be included in the list of referenced standards as follows:
PPI TR-3 - 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) Ratings, and Categorized Required Strength (CRS) for Thermoplastic Piping Materials or Pipe

Section 3, Terminology: Clarified the terminology as follows:

3.2 Definitions of Terms Specific to This Standard:
3.2.1 crosslinked polyethylene—a polyethylene material ~~which~~ that has undergone a change in molecular structure ~~using a chemical or a physical~~ through processing whereby a majority of the polymer chains are chemically linked.

3.2.7 ~~standard~~ thermoplastic tubing materials designation code—The tubing material designation code shall consist of the abbreviation for the type of plastic (PEX) followed by four Arabic ~~digits~~ numerals – two to ~~that~~ describe the short-term properties, in accordance with ~~applicable~~ the ASTM standards being referenced, and two to designate the hydrostatic design stress when tested in water at 73°F (23°C) in units of 100 psi, with any decimal figures dropped. ~~and as shown in~~ See Table ~~2~~1~~.~~ and ~~See~~ Fig. 1.

3.2.7.3 Discussion—PEX tubing is not designed for outdoor use. Data from short-term exposure testing in accordance with this test method can be used to judge the relative performance of PEX tubing stored outdoors for short periods of time prior to installation completely shielded from sunlight.

Section 5, Materials: AZO compounds are no longer in commercial use for PEX crosslinking and were removed throughout the standard as follows:
5.2 Basic Materials—PEX tubing shall be made from polyethylene compounds which have been crosslinked by peroxides, ~~Azo compounds,~~ or silane compounds in extrusion, or by electron beam after extrusion, or by other means such that the tubing meets the performance requirements of Section 6. For the use temperatures that the tubing will be marked for, the materials, procedure for mixing, and the process for crosslinking shall result in a product with long term hydrostatic stress ratings equal to or better than those shown in Table ~~3~~4, when determined in accordance with procedures no less restrictive than those of PPI TR-3 Tubing incorporating an optional layer shall also meet the requirement of PPI TR-3~~10~~ See Appendix X1 for additional information on PPI hydrostatic stress ratings.
NOTE 2—Tubing produced by crosslinking by peroxides, ~~AZO compounds,~~ or silane compounds in extrusion, or by electron beam after extrusion have met the requirements of Section 6. There are several other processes for producing crosslinked polyethylene tubing. However, each process must be established as meeting the requirements of this specification.
~~10PPI Technical Report TR-3, Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials.~~

Section 6, Requirements: Clarified the requirements for workmanship and added a minimum coiling diameter allowance for PEX pipe as follows:

6.1 Workmanship—The tubing shall be ~~homogeneous~~ uniform in appearance and consistent throughout. The walls shall be free of ~~visible~~ cracks, holes, blisters, voids, foreign inclusion, or other defects that are visible to the naked eye and that affect the wall integrity. The ~~pipe~~ tubing shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

6.3.4 Coil diameters - PEX tubing may be supplied in either straight lengths or coils with a minimum coiling diameter based on a tubing bend radius of 10 times the outside diameter.

6.8 Degree of Crosslinking—When tested in accordance with 7.9, the degree of crosslinking for PEX tubing material shall be within the range from 65 to 89 % inclusive. Depending on the process used, the following minimum percentage crosslinking values shall be achieved: 70 % by peroxides, ~~65 % by Azo compounds,~~ 65 % by electron beam, or 65 % by silane compounds.

6.9 Stabilizer Functionality —~~Stabilizer Functionality shall be~~ There shall be no loss of pressure in the tubing, when tested in accordance with 7.10.

Section 7, Test Methods: Revised the test temperatures to reduce the precision and added a note to explain the significance of the chlorine ratings as follows:

7. Test Methods

7.1 Conditioning—Condition the specimens at 73~~.4~~ ± 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~~ ± 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.

7.6 Hydrostatic Sustained Pressure Test—Select the test specimens at random. Test individually with water at the three controlled temperatures and under the pressures given in Table 5, 18 specimens of tubing, each specimen at least ten times the nominal diameter in length, but not less than 10 in. (25.4 cm) or more than 3 ft (91.4 cm) between end closures and containing the permanent marking on the tubing. Test six specimens at each temperature. Condition the specimens for at least 2 h to within ± 4~~3.6~~°F (±2°C) of the specified test temperatures. Maintain the specimens at the pressures indicated for the appropriate temperatures for a period of 1000 h. Hold the pressure as closely as possible, but within ± 10 psi (±0.070 MPa). Maintain the test temperatures within ± 4~~3.6~~°F (±2°C) of the specified temperature. Test in accordance with Test Method D1598 except maintain the pressure at the values given in Table 5 for 1000 h. Failure of two of the six specimens tested at ~~either~~ any given temperature constitutes failure in the test. Failure of one of six specimens tested at ~~either~~ any given temperature is cause for retest of six additional specimens at that temperature. Failure of one of six specimens tested at ~~either~~ any given temperature in retest constitutes failure in the test. Failure of the tubing shall be defined in accordance with Test Method D1598, namely:

7.9 Degree of Crosslinking—Place a tubing sample in a lathe with automatic feeding. Shave a strip that consists of the full wall thickness. The strip thickness shall be ~~approximately~~ 0.004 +/- 0.002 in. (0.1 +/- 0.05 mm) which is obtained by setting the lathe feeding accordingly. Test the specimens in accordance with Test

Methods D2765, Method B, with the only deviation: test specimen preparation. For the purpose of this specification, degree of crosslinking (V) is defined as 100 % minus extract percent equals V.
NOTE 7—This method provides a test method for measuring the average degree of crosslinking over the tube wall thickness. That, however, does not mean that the degree of crosslinking is allowed to vary outside the limits for the grade in question at any part of the tubing. In case of disagreement, strips of the same thickness, 0.004 +/- 0.002 in. (0.1 +/- 0.05 mm), can be taken in tangential, axial, or radial direction at any angle section or wall thickness depth, or both, etc. to measure the degree of crosslinking.

7.11.1 For a chlorine resistance cell of "1" using the coefficients from Test Method F2023, 13.1 and using Miners Rule, calculate the estimated time to-failure for a hoop stress corresponding to a sustained internal pressure of 80 psig (550~~1.7~~ kPa) for the DR of the tested specimens 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.
7.11.2 For a chlorine resistance cell of "3" using the coefficients from Test Method F2023, 13.1, and using Miners Rule, calculate the estimated time to-failure for a hoop stress corresponding to a sustained internal pressure of 80 psig (550~~1.7~~ kPa) for the DR of the tested specimens at temperature exposure conditions of 50 % of the total time at 140°F (60°C) and 50% of the total time at 73°F (23°C) in accordance with ISO 13760.
7.11.3 For a chlorine resistance cell of "5", using the coefficients from Test Method F2023, 13.1, calculate the estimated time-to-failure at a hoop stress corresponding to a sustained internal pressure of 80 psig (550~~1.7~~ kPa) for the DR of the tested specimens at temperature of 100% of the time at 140°F (60°C)
7.11.4 Significance—The test need only be performed on representative ~~pipe~~ tubing samples for the original validation of ~~pipe~~ tubing made from a particular compound.

NOTE 8 - ~~The conditions described in Test Method F2023, 13.3 only apply to intermittent service such as might be found in normal residential use. This does not validate the use of PEX tubing in continuous recirculation applications.~~ The extrapolated times-to-failure calculated in 7.11.1, 7.11.2 and 7.11.3 apply to a maximum end-use temperature of 140°F (60°C) and a maximum end-use pressure of 80 psig (550 kPa), which are typical maximum conditions in residential plumbing applications. These extrapolations do not validate the use of PEX tubing in applications with temperatures or pressures beyond these values. For operating conditions beyond 140°F and 80 psig users should contact the PEX tubing manufacturer to determine whether such conditions are approved for use.

Table 1 Thermoplastic Tubing Material Designation Code Cells for SDR9 PEX: The title of this table was changed as follows:

TABLE ~~2~~1 Thermoplastic Tubing Material Designation Code Cells for SDR9 PEX

Table 2, Outside Diameters and Tolerances for SDR9 PEX Tubing: Removed the mm reference to nominal tubing size as follows:

TABLE ~~4~~2 Outside Diameters and Tolerances for SDR9 PEX Tubing

Nominal Tubing Size		Average Outside Diameter		Tolerances for Average Diameter		Out-of-Roundness[A]	
~~in.~~	~~mm~~	in.	(mm)	in.	(mm)	in.	(mm)
1/8	~~3~~	0.250	(6.35)	±0.003	(±0.08)	0.008	(0.20)
1/4	~~7~~	0.375	(9.52)	±0.003	(±0.08)	0.008	(0.20)

5/16	~~8~~	0.430	(10.92)	±0.003	(±0.08)	0.008	(0.20)
3/8	~~10~~	0.500	(12.70)	±0.003	(±0.08)	0.012	(0.32)
1/2	~~13~~	0.625	(15.88)	±0.004	(±0.10)	0.016	(0.40)
5/8	~~16~~	0.750	(19.05)	±0.004	(±0.10)	0.016	(0.40)
3/4	~~19~~	0.875	(22.22)	±0.004	(±0.10)	0.016	(0.40)
1	~~25~~	1.125	(28.58)	±0.005	(±0.12)	0.020	(0.48)
1 1/4	~~32~~	1.375	(34.92)	±0.005	(±0.12)	0.020	(0.48)
1 1/2	~~38~~	1.625	(41.28)	±0.006	(±0.16)	0.024	(0.60)
2	~~51~~	2.125	(53.98)	±0.006	(±0.16)	0.030	(0.76)
2 1/2	~~64~~	2.625	(66.68)	±0.007	(±0.18)	0.038	(0.95)
3	~~76~~	3.125	(79.38)	±0.008	(±0.20)	0.045	(1.14)
3 1/2	~~89~~	3.625	(92.08)	±0.008	(±0.20)	0.046	(1.16)
4	~~102~~	4.125	(104.78)	±0.009	(±0.23)	0.052	(1.32)
4 1/2	~~114~~	4.625	(117.48)	±0.009	(±0.23)	0.059	(1.49)
5	~~127~~	5.125	(130.18)	±0.010	(±0.25)	0.065	(1.65)
6	~~152~~	6.125	(155.58)	±0.011	(±0.28)	0.072	(1.83)

Table 3 Wall Thickness and Tolerances for SDR9 PEX Tubing: Removed the mm reference to nominal tubing size as follows:

TABLE ~~1~~3 Wall Thickness and Tolerances for ~~Nominal~~ SDR9 PEX ~~SDR 9 Plastic~~PEX Tubing[A]

Nominal Tubing Size		Minimum Wall Thickness		Tolerance	
~~in.~~	~~mm~~	in.	(mm)	in.	(mm)
1/8	~~3~~	0.047B	(1.19)[B]	+0.007	(+0.18)
1/4	~~7~~	0.062B	(1.57)[B]	+0.010	(+0.25)
5/16	~~8~~	0.064**B**	(1.63)[B]	+0.010	(+0.25)
3/8	~~10~~	0.070B	(1.78)[B]	+0.010	(+0.25)
1/2	~~13~~	0.070B	(1.78)[B]	+0.010	(+0.25)
5/8	~~16~~	0.083	(2.12)	+0.010	(+0.25)
3/4	~~19~~	0.097	(2.47)	+0.010	(+0.25)
1	~~25~~	0.125	(3.18)	+0.013	(+0.33)
1 1/4	~~32~~	0.153	(3.88)	+0.015	(+0.38)
1 1/2	~~38~~	0.181	(4.59)	+0.019	(+0.48)
2	~~51~~	0.236	(6.00)	+0.024	(+0.61)
2 1/2	~~64~~	0.292	(7.41)	+0.030	(+0.76)
3	~~76~~	0.347	(8.82)	+0.033	(+0.84)
3 1/2	~~89~~	0.403	(10.23)	+0.035	(+0.89)
4	~~102~~	0.458	(11.64)	+0.040	(+1.02)
4 1/2	~~114~~	0.514	(13.05)	+0.045	(+1.14)
5	~~127~~	0.569	(14.46)	+0.050	(+1.27)
6	~~152~~	0.681	(17.29)	+0.060	(+1.52)

[A] The minimum is the lowest wall thickness of the pipe 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.

[B] For nominal tubing sizes of 1/2 ~~in.~~ and below, wall thickness minimums are not functions of SDR.

Table 4 Hydrostatic Design Stresses and Pressure Ratings for SDR9 PEX Tubing for Water at Different Temperatures: Reduced the precision of the test temperatures as follows:

TABLE ~~3~~4 Hydrostatic Design Stresses and Pressure Ratings for SDR9 PEX ~~SDR 9~~ Tubing for Water at Different Temperatures

Rated Temperature		*Hydrostatic Design Stress*		*Pressure Rating for Water*	
°F	*°C*	*psi*	*(MPa)*	*psi*	*(MPa)*
73~~.4~~	*23*	*630*	*(4.34)*	*160*	*(1.10)*
180	*82~~.2~~*	*400*	*(2.76)*	*100*	*(0.69)*
200	*93~~.3~~*	*315*	*(2.17)*	*80*	*(0.55)*