Designation: F2805 – 16

Standard Specification for Multilayer Thermoplastic And Flexible Steel Pipe And Connections[1]

This standard is issued under the fixed designation F2805; 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 requirements and test methods for materials, dimensions, workmanship, markings for factory manufactured multilayer flexible steel pipe with thermoplastic inner and outer layers and end connections (Fig. 1). It covers nominal sizes 2 in. through 8 in. (50 mm through 200 mm). Flexible steel pipes are multilayered pipe products manufactured in long continuous lengths and reeled for storage, transport and installation. The multilayer thermoplastic and flexible steel pipe governed by this standard are intended for use for the transport of crude oil, natural gas, hazardous chemicals, industrial chemicals and water.[2]

1.2 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 *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:*[3]

A109/A109M Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled

A312/A312M Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

A333/A333M Specification for Seamless and Welded Steel Pipe for Low-Temperature Service and Other Applications with Required Notch Toughness

A506 Specification for Alloy and Structural Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled

A519 Specification for Seamless Carbon and Alloy Steel Mechanical Tubing

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

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

D2765 Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

F412 Terminology Relating to Plastic Piping Systems

2.2 *ASME Standard:*[4]

B16.5 Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.68 on Energy Piping Systems.

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[2] The multilayer thermoplastic and flexible steel pipe and connections described in this standard is covered by patents (FlexSteel Pipeline Technologies, 500 Dallas Street Suite 500, Houston, TX 77002, USA). Interested parties are invited to submit information regarding the identification of acceptable alternatives to this patented item to the Committee on Standards, ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959. Your comments will receive careful consideration at a meeting of the responsible technical committee which you may attend.

[3] 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.

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

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

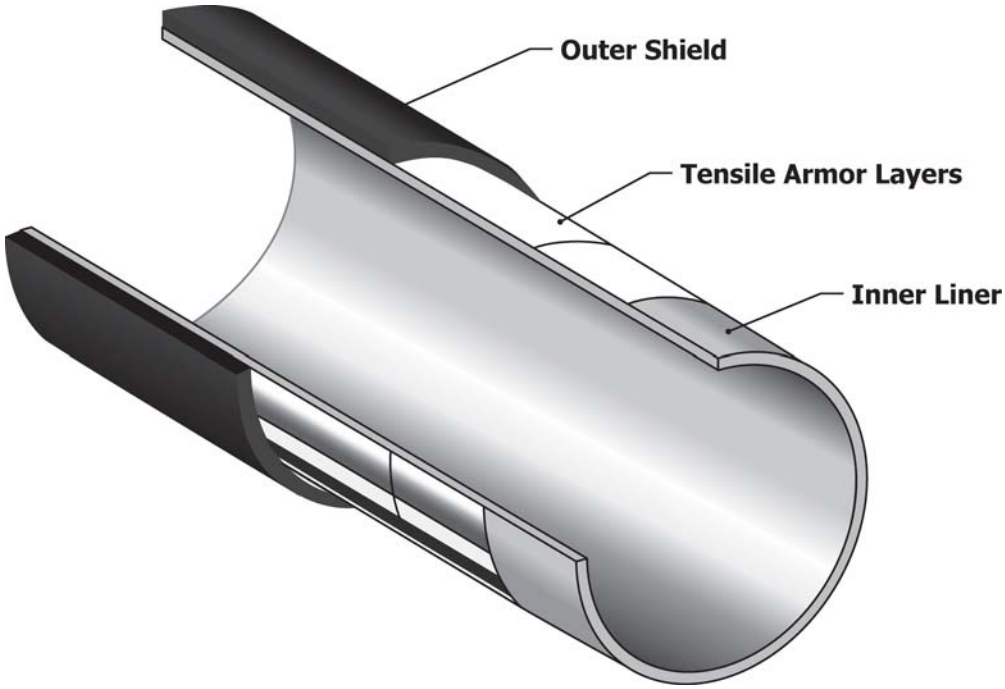

FIG. 1 Cutaway of Flexible Steel Pipe

2.3 *ANSI Standard:*[5]

B 16.5 Pipe, Flanges, and Flanged Fittings

2.4 *API Standards:*[6]

17B Recommended Practice for Flexible Pipe

17J Specification for Unbonded Flexible Pipe

2.5 *ISO Standards:*[7]

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

2.6 *PPI Standards:*[8]

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

TR-19 Thermoplastics Piping for the Transport of Chemicals

2.7 *BSI Standards:*[9]

EN 10210 Hot Finished Structural Hollow Sections of Non-Alloy and Fine Grain Steels

EN 10297 Seamless Circular Steel Tubes for Mechanical and General Engineering Purposes

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

[6] Available from American Petroleum Institute (API), 1220 L. St., NW, Washington, DC 20005-4070, http://www.api.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.

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

[9] Available from British Standards Institute (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., http://www.bsi-global.com.

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *coupling, n*—specific type of fitting developed for joining one section of spoolable pipe to another.

3.2.2 *design pressure, n*—the minimum or maximum pressure, inclusive of operating pressure, surge pressure including shut-in pressure where applicable, vacuum conditions and static pressure head.

3.2.3 *design temperature, n*—highest temperature at which the product has been determined by qualification testing to be suitable at the nominal pressure rating

3.2.4 *end connection, n*—connects the pipe ends with adjacent pipe or other parts of the system.

3.2.5 *factor, design (Fd), n*—number less than or equal to 1 that takes into consideration the manufacturing and testing variables including normal variations in the material, manufacture, dimensions, good handling and installation techniques, and the precision and bias of the test methods.

3.2.6 *factors, service (Sn), n*—group of operating factors less than or equal to 1 which considers the application or use, and may include, environment (fluids), cycling loading, and temperatures.

3.2.7 *inner sheath layer, n*—pipe lining made from extruded thermoplastic compound.

3.2.8 *maximum operating pressure (MOP), n*—pressure obtained by multiplying the MPR by application related service factors

3.2.9 *maximum pressure rating (MPR), n*—the estimated maximum internal hydrostatic pressure that can be applied continuously to a pipe with a high degree of certainty that failure will not occur.

3.2.10 *nominal pressure rating (NPR), n*—pressure rating of the pipe as defined by the manufacturer and does not exceed the MPR.

3.2.11 *outer sheath layer, n*—external extruded thermoplastic coating applied to resist mechanical damage and to provide the underlying layers of the pipe protection from the environment.

3.2.12 *product family, n*—group of pipe products being a range of sizes and pressure ratings manufactured with the same material types, production process and process controls and pipe construction.

3.2.13 *product family representative (PFR), n*—product variant chosen for full qualification.

3.2.14 *product variant (PV), n*—member of a product family with a specific pressure rating and diameter.

3.2.15 *qualified procedure*—procedure subjected to sufficient testing to show that the procedure produces consistently reliable results and has been demonstrated to meet the specified requirements for its intended purpose.

3.2.16 *tensile armor layer, n*—hoop and structural reinforcement helically wrapped over the inner sheath layer. The steel layers are not bonded.

3.2.17 *traceability, n*—ability to track the history, application or location of a material or component by means of recorded identifications

4. Materials

4.1 *Polyethylene Materials*—Polyethylene compounds used in the manufacture of these products shall have a minimum cell classification of 444474 in accordance with Specification D3350 (PE4710 as defined in PPI TR-4) or PE100 in accordance with ISO 9080. Addition of pigments or stabilizers to natural polyethylene compounds during extrusion is permitted.

4.2 *Crosslinked Polyethylene Materials*—Crosslinked polyethylene compounds used in the manufacture of these products shall be made from polyethylene compounds which have been crosslinked by peroxides, azo compounds or silane compounds in extrusion or by other means such that the inner sheath layer and/or the outer sheath layer meets the following performance requirements:

4.2.1 *Density*—When determined in accordance with Test Method D1505 or D792, the crosslinked polyethylene material shall have a minimum density of 0.033 lb/in^3 (0.926 g/cm^3).

4.2.2 *Degree of Crosslinking*—When tested in accordance with Test Method D2765, Method B, the degree of crosslinking for the PEX material shall be within the range of 65% to 89% inclusive.

4.3 *Long Term Hydrostatic Strength*— Polyethylene and crosslinked polyethylene compounds used in the manufacture of these products shall have Hydrostatic Design Basis (HDB) listings in PPI TR-4.

4.4 *Rework materials*—Reground or reprocessed thermoplastic materials are not permitted to be used.

4.5 *Steel Materials:*

4.5.1 Steel tensile armor layers shall consist of steel strip manufactured in accordance with Specification A506 or Specification A109/A109M with a number 3 edge and number 1 or 2 finish.

4.5.2 Steel in end connections shall meet the requirements of Specification A312/A312M, Specification A333/A333M, Specification A519, EN 10210, or EN 10297 (Fig. 2). Specialty steel grades requested by the purchaser must meet the same minimum performance requirements.

4.5.3 Flanges which are incorporated within the design of end connections shall meet the requirements of ASME B 16.5.

4.6 The manufacturer shall have procedures for ensuring that materials are received in a condition that is suitable for processing, including receiving inspection to discover damage or contamination from shipping and verification of appropriate material properties and shall include measurable physical, mechanical, chemical, and performance characteristics and tolerances.

5. Requirements

5.1 *Workmanship*—The inside and outside surfaces of the pipe shall be semi-matte or glossy in appearance and free of chalking, sticky or tacky materials. The pipe surfaces shall be free of cracks, holes, blisters, voids, foreign inclusions or other defects that are visible to the naked eye.

5.2 *Multilayer Pipe Dimensions*—Pipe Dimensions shall comply with Table 1, Table 2 and Table 3, when measured in accordance with Test Method D2122.

5.3 *Design Pressure*—The pipe shall have the design pressures listed in Table 2 and Table 3.

NOTE 1—The typical multilayer pipe construction is a three layer structure consisting of an extruded thermoplastic inner liner or pipe, helically wrapped layers of steel strips, and an extruded thermoplastic outer layer or sheath.

5.4 *Outside Diameter*—The outside diameter of the applicable pipe layer shall be as shown in Table 1, Table 2 or Table 3 when measured in accordance with Section 7.

5.5 *Pipe Wall Thickness*—The wall thickness of the applicable pipe layer shall be as shown in Table 1, Table 2 or Table 3 when measured in accordance with Section 7.

5.6 *Laying Length*—The pipe may be sold in any laying length agreeable to the user.

6. Quality Assurance Tests

6.1 *Factory Acceptance Test*—Prior to shipment, the continuous length of pipe shall be pressure tested in accordance with manufacturer's documented procedures as detailed in 7.3.

6.2 *Retest and Rejection*—Retesting in the event of a test failure shall be conducted to the same test procedures or requirements.

7. Test Methods

7.1 *Outside Diameter*—The outside diameter of each completed layer shall be measured and recorded according to

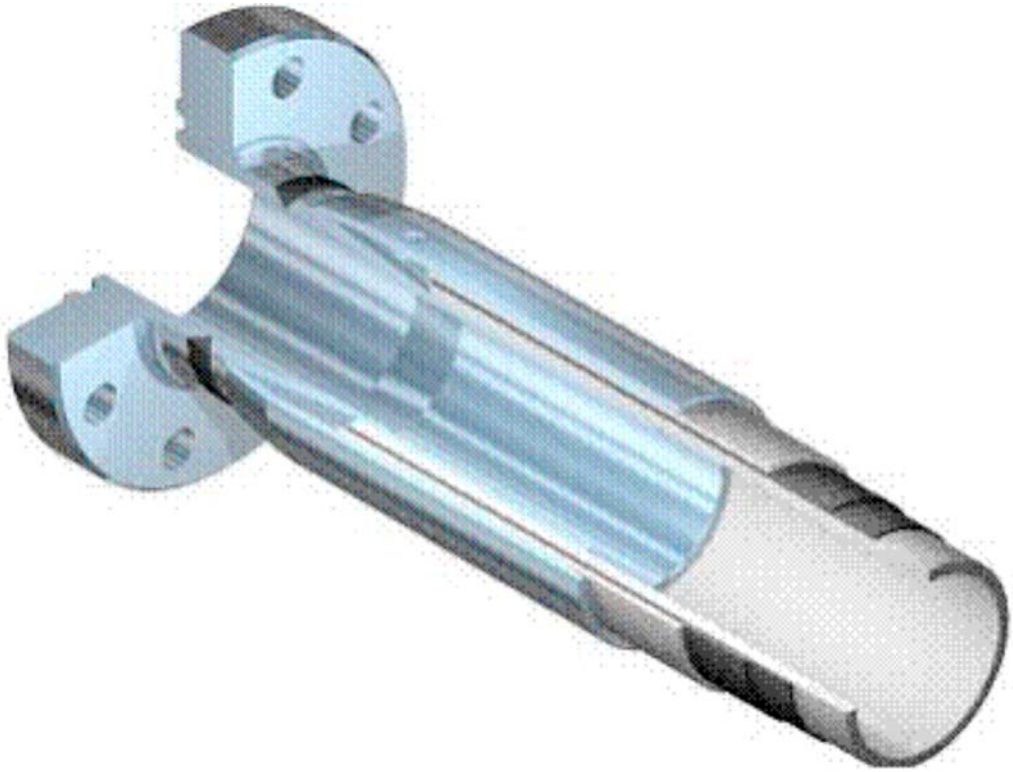

FIG. 2 Typical End Connection

TABLE 1 Inner Sheath Layer Wall Thickness Range and Outside Diameter Range

Nominal Pipe Size in. (mm)	Minimum Wall Thickness, in. (mm)	Maximum Wall Thickness, in. (mm)	Minimum Outside Diameter, in. (mm)	Maximum Outside Diameter, in. (mm)
2 (50)	0.098 (2.5)	0.197 (5)	2.14 (54.3)	2.33 (59.3)
3 (75)	0.098 (2.5)	0.236 (6)	3.02 (76.6)	3.29 (83.6)
4 (100)	0.098 (2.5)	0.276 (7)	3.87 (98.2)	4.22 (107.2)
5.5 (140)	0.138 (3.5)	0.433 (11)	5.43 (137.8)	6.02 (152.8)
6 (150)	0.138 (3.5)	0.433 (11)	5.88 (149.2)	6.47 (164.2)
7 (175)	0.138 (3.5)	0.433 (11)	6.78 (172.1)	7.37 (187.1)
8 (200)	0.138 (3.5)	0.630 (16)	7.90 (200.7)	8.88 (225.7)

manufacturer's procedures. The outside pipe diameter of each completed layer shall be measured at a frequency of every 30 ft (10 m) for the first 150 ft (50 m) and according to manufacturer's procedures thereafter.

7.2 *Wall Thickness*—The thickness of the extruded polymer layers shall be checked by means of a calibrated ultrasonic thickness instrument, with an absolute accuracy of at least 50 T (2 mil). The extruded layer wall thickness shall be measured at a frequency of every 30 feet (10 m) for the first 150 ft (50 m) and according to manufacturer's procedures thereafter.

7.3 *Pressure Testing*—Unless otherwise specified by the purchaser, the pipe shall be tested for a minimum of 8 hours at 1.3 times the stated design pressure.

NOTE 2—A pipeline system is typically commissioned after completion by filling it with water and conducting a pressure test. Flexible steel pipe behavior when hydrotested is somewhat different from the behavior of rigid steel pipes. The layers are un-bonded and upon initial pressurization undergo a stabilization process referred to as conditioning. After conditioning, the pipe is held at the test pressure for a period of time.

8. Test Reports and Certification

8.1 Upon request of the purchaser, the manufacturer shall provide certification that the product was manufactured and tested in accordance with this specification. This certification shall be furnished at the time of shipment.

8.2 When test reports are requested by the purchaser, the manufacturer shall report the results of tests required by this specification as well as any additional tests required by the purchaser.

9. Marking

9.1 *Quality of Marking*—The marking shall be applied to the pipe in such a manner that it remains legible (easily read) after installation and inspection. It shall be spaced at intervals of not more than 10 ft. (3.0 m).

9.2 *Markings*—Each length of pipe in compliance with this specification shall be clearly marked by the manufacturer with the following information: this designation, (ASTM F2805),

TABLE 2 Inner Sheath Layer Wall Thickness Range and Outside Diameter Range

Nominal Pipe Size, in. (mm)	Design Pressure, psi (kPa)	Minimum Outside Diameter, in. (mm)	Maximum Outside Diameter, in. (mm)
2 (50)	750 (5,171)	2.18 (55.5)	2.41 (61.2)
2 (50)	1,000 (6,895)	2.22 (56.5)	2.46 (62.5)
2 (50)	1,500 (10,342)	2.23 (56.7)	2.49 (63.1)
2 (50)	2,250 (15,513)	2.28 (57.9)	2.54 (64.6)
2 (50)	3,000 (20,684)	2.31 (58.7)	2.59 (65.8)
3 (75)	750 (5,171)	3.09 (78.5)	3.40 (86.5)
3 (75)	1,000 (6,895)	3.11 (79.1)	3.44 (87.5)
3 (75)	1,500 (10,342)	3.16 (80.3)	3.50 (88.9)
3 (75)	2,250 (15,513)	3.21 (81.5)	3.58 (90.9)
3 (75)	3,000 (20,684)	3.25 (82.5)	3.62 (92.0)
4 (100)	750 (5,171)	3.96 (100.7)	4.37 (111.1)
4 (100)	1,000 (6,895)	3.99 (101.3)	4.41 (111.9)
4 (100)	1,500 (10,342)	4.02 (102.1)	4.49 (114.1)
4 (100)	2,250 (15,513)	4.13 (104.9)	4.61 (117.0)
4 (100)	3,000 (20,684)	4.15 (105.3)	4.65 (118.2)
5.5 (140)	750 (5,171)	5.55 (140.9)	6.23 (158.3)
5.5 (140)	1,000 (6,895)	5.57 (141.5)	6.28 (159.5)
5.5 (140)	1,500 (10,342)	5.62 (142.7)	6.34 (161.1)
5.5 (140)	2,250 (15,513)	5.66 (143.7)	6.45 (163.8)
6 (150)	750 (5,171)	6.00 (152.3)	6.67 (169.4)
6 (150)	1,000 (6,895)	6.03 (153.1)	6.73 (170.9)
6 (150)	1,500 (10,342)	6.13 (155.7)	6.85 (174.0)
6 (150)	2,250 (15,513)	6.18 (157.0)	6.91 (175.4)
7 (175)	750 (5,171)	6.90 (175.1)	7.57 (192.2)
7 (175)	1,000 (6,895)	6.93 (176.0)	7.65 (194.2)
7 (175)	1,500 (10,342)	7.03 (178.6)	7.76 (197.1)
7 (175)	2,250 (15,513)	7.08 (179.8)	7.81 (198.5)
8 (200)	750 (5,171)	8.02 (203.7)	9.16 (232.8)
8 (200)	1,000 (6,895)	8.05 (204.5)	9.28 (235.8)
8 (200)	1,500 (10,342)	8.16 (207.2)	9.35 (237.5)
8 (200)	2,250 (15,513)	8.20 (208.4)	9.44 (239.9)

TABLE 3 Outer Sheath Layer Wall Thickness Range and Outside Diameter Range

Nominal Pipe Size, in. (mm)	Design Pressure, psi (kPa)	Minimum Wall Thickness, in. (mm)	Maximum Wall Thickness, in. (mm)	Minimum Outside Diameter, in. (mm)	Maximum Outside Diameter, in. (mm)
2 (50)	750 (5,171)	0.098 (2.5)	0.276 (7.0)	2.38 (60.5)	2.96 (75.2)
2 (50)	1,000 (6,895)	0.098 (2.5)	0.276 (7.0)	2.42 (61.5)	3.01 (76.5)
2 (50)	1,500 (10,342)	0.098 (2.5)	0.276 (7.0)	2.43 (61.7)	3.04 (77.1)
2 (50)	2,250 (15,513)	0.098 (2.5)	0.276 (7.0)	2.48 (62.9)	3.09 (78.6)
2 (50)	3,000 (20,684)	0.098 (2.5)	0.276 (7.0)	2.51 (63.7)	3.14 (79.8)
3 (75)	750 (5,171)	0.098 (2.5)	0.276 (7.0)	3.29 (83.5)	3.96 (100.5)
3 (75)	1,000 (6,895)	0.098 (2.5)	0.276 (7.0)	3.31 (84.1)	4.00 (101.5)
3 (75)	1,500 (10,342)	0.098 (2.5)	0.276 (7.0)	3.36 (85.3)	4.05 (102.9)
3 (75)	2,250 (15,513)	0.098 (2.5)	0.276 (7.0)	3.41 (86.5)	4.13 (104.9)
3 (75)	3,000 (20,684)	0.098 (2.5)	0.276 (7.0)	3.45 (87.5)	4.17 (106.0)
4 (100)	750 (5,171)	0.098 (2.5)	0.276 (7.0)	4.16 (105.7)	4.92 (125.1)
4 (100)	1,000 (6,895)	0.098 (2.5)	0.276 (7.0)	4.18 (106.3)	4.96 (125.9)
4 (100)	1,500 (10,342)	0.098 (2.5)	0.276 (7.0)	4.22 (107.1)	5.04 (128.1)
4 (100)	2,250 (15,513)	0.098 (2.5)	0.276 (7.0)	4.33 (109.9)	5.16 (131.0)
4 (100)	3,000 (20,684)	0.098 (2.5)	0.276 (7.0)	4.34 (110.3)	5.20 (132.2)
5.5 (140)	750 (5,171)	0.098 (2.5)	0.276 (7.0)	5.74 (145.9)	6.78 (172.3)
5.5 (140)	1,000 (6,895)	0.098 (2.5)	0.276 (7.0)	5.77 (146.5)	6.83 (173.5)
5.5 (140)	1,500 (10,342)	0.098 (2.5)	0.276 (7.0)	5.81 (147.7)	6.90 (175.1)
5.5 (140)	2,250 (15,513)	0.098 (2.5)	0.276 (7.0)	5.85 (148.7)	7.00 (177.8)
6 (150)	750 (5,171)	0.098 (2.5)	0.295 (7.5)	6.19 (157.3)	7.25 (184.1)
6 (150)	1,000 (6,895)	0.098 (2.5)	0.295 (7.5)	6.22 (158.1)	7.32 (185.9)
6 (150)	1,500 (10,342)	0.098 (2.5)	0.295 (7.5)	6.33 (160.7)	7.44 (189.0)
6 (150)	2,250 (15,513)	0.098 (2.5)	0.344 (8.75)	6.38 (162.0)	7.60 (192.9)
7 (175)	750 (5,171)	0.098 (2.5)	0.295 (7.5)	7.09 (180.1)	8.16 (207.2)
7 (175)	1,000 (6,895)	0.098 (2.5)	0.295 (7.5)	7.12 (181.0)	8.24 (209.2)
7 (175)	1,500 (10,342)	0.098 (2.5)	0.295 (7.5)	7.23 (183.6)	8.35 (212.0)
7 (175)	2,250 (15,513)	0.098 (2.5)	0.344 (8.75)	7.28 (184.8)	8.50 (216.0)
8 (200)	750 (5,171)	0.098 (2.5)	0.354 (9.0)	8.22 (208.7)	9.75 (247.8)
8 (200)	1,000 (6,895)	0.098 (2.5)	0.354 (9.0)	8.25 (209.5)	9.87 (250.8)
8 (200)	1,500 (10,342)	0.098 (2.5)	0.354 (9.0)	8.35 (212.2)	9.94 (252.4)
8 (200)	2,250 (15,513)	0.098 (2.5)	0.354 (9.0)	8.40 (213.4)	10.15 (257.9)

the nominal pipe size, the pressure rating, the Minimum Bend Radius (MBR), the manufacturer's name, trade name, or

trademark, and the manufacturer's pipe serial number or other designation traceable to the manufacturing facility and process.

10. End Connections

10.1 The assembly of the end connections shall be in accordance with the manufacturer's recommendations. End connections shall not reduce or impair the overall integrity or function of the pipe. The manufacturer shall have test results on file to demonstrate that end connections installed in accordance with the manufacturer's instructions, shall not leak when tested along with the multilayer pipe in accordance with 10.6.

10.2 Connections shall be of steel construction meeting the materials requirements given in 4.5.2.

10.3 Flanges shall meet the requirements of ANSI B16.5 for the applicable class.

10.4 The connection assemblies shall meet the performance requirements of this specification.

10.5 Only connections and couplers supplied or recommended by the pipe manufacturer shall be used.

10.6 *End Connection Qualification*—To ensure that the pipe end connection interface does not leak over the design life, an accelerated life test shall be conducted on a product variant from each pressure rating or size group. The variant selected shall be either the largest diameter in a pressure rating group or the highest pressure rating in a given size group. Qualification components shall be assembled in accordance with manufacturer's documented procedures. The manufacturer shall subject test samples with end connections to a constant pressure survival test at the pipe design pressure. The test temperature shall be at the design temperature plus the listed temperature shift and test duration shown in Table 4. For each end connection type to be qualified, at least 2 end connections shall be tested. The length of the sample between the end connections shall be at least 6 times the nominal pipe diameter. All samples shall survive without leakage for the full test period.

11. Packaging

11.1 All pipe, unless otherwise specified, shall be spooled onto reels for commercial shipment.

12. Handling

12.1 All pipe shall be handled in accordance with manufacturer's procedures.

13. Quality Assurance

13.1 When the product is marked with the designation, F2805, the manufacturer affirms that the product was manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

14. Keywords

14.1 alloy steel; carbon steel; cold rolled steel strip; flexible; multilayer; polyethylene; spoolable; steel; steel strip; thermoplastic

TABLE 4 End Connection Qualification Testing Requirements

Shift Above Design Temperature, °F (°C)	Test Duration, h
35 (20)	1100
45 (25)	312

APPENDIXES

(Nonmandatory Information)

X1. DESIGN

X1.1 API 17J Section 5 requires that for a given application, appropriate combined load cases be selected, the maximum applied loads be determined, and the stress and strain in each layer of the pipe be determined. The loads are verified as being acceptable by comparing the resulting calculated stresses and strains to the maximum allowable utilizations specified in API 17J. For offshore applications, the tensile, hydrostatic, installation and other loads are carefully determined and analyzed for each project. For onshore applications, the loads are largely from internal pressure and are easily evaluated. Engineering design is usually based on yield strength, which is most commonly defined as the tensile strength at 0.2% offset. For conservatism and better consistency with the types of steel used in flexible steel pipes, API 17J strength analysis uses a structural strength σ_s that is similar to the yield strength, and is typically considered to be 0.90 of the steel ultimate tensile strength (UTS). API 17J specifies the maximum allowable material utilization, essentially the reciprocal of a design factor, and maximum allowable strains for polymer layers. The maximum stress fraction is the maximum allowed ratio between the actual stress and the UTSeff. The pipe is rarely used with the combined load cases typical of subsea installation and operation; thus individual loads can be considered separately. In general, the pipes share essentially a single design, and similar design factors. Thus, a single analysis suffices to meet API 17J analysis requirements for all of the pipes.

X1.2 *Load Cases*—The major operating load case is recurrent operation with internal pressure: API 17J, allows up to 0.67 of yield strength. This load case is used to determine the pressure rating for the pipe. For extreme or abnormal operations, the maximum tensile armor stress factor 0.85 of yield strength.

X1.2.1 *Hydrostatic pressure test case*—API 17J allows a maximum tensile armor stress factor of 0.91 of yield strength. The factory structural capacity test pressure is performed at 1.3

* Design Pressure as required for hydro testing by API 17J for static flowlines. Field hydrotest pressure for liquid flowlines is commonly performed at 1.25 * Design Pressure

X2. TEMPERATURE LIMITATIONS

X2.1 The polyethylene and crosslinked polyethylene materials provide service for temperatures over the nominal range of -40ºF (40ºC) to 200 ºF (93.3ºC) depending on fluid properties, size, and maximum pressure. The purchaser should contact the manufacturer for recommendations regarding specific applications.

X3. CHEMICAL RESISTANCE

X3.1 *Conveyed Product Compatibility with Thermoplastic Materials*—The ability of the thermoplastic material in a flexible steel pipe to resist the effects of the conveyed fluid over the design life is a primary concern in verifying the suitability for a specified application. Pipe grade polyethylene (PE) is typically usable to a maximum of 140ºF (60ºC) in oil and gas service. This compatibility limitation is imposed for use in unreinforced plastic pipes to control the loss of structural properties that accompanies the swelling of the PE resulting from plasticization. In reinforced flexible pipe service, the structural properties of the PE are secondary because the steel layers resist the internal pressure. Crosslinked polyethylene (PEX) is typically usable to a maximum of 200ºF (93.3°C). PPI TR-19 or similar documents may be utilized to determine fluid compatibility. The manufacturer should be consulted for any specific questions regarding compatibility. If the conveyed fluid contains high partial pressure of CO_2 gas the polyethylene or crosslinked polyethylene material shall be shown, by testing, to not blister or degrade during rapid depressurization from the maximum pressure and temperature. The test method described in API 17J may be used as a guideline for this testing.

X3.2 *Conveyed Product Compatibility with Steel*—The steel tensile strips in the pipe annulus are protected from the bore fluids by the inner liner. Small quantities of certain molecules can permeate through the PE or PEX inner liner into the pipe annulus. The effect of permeated H_2O, H_2S, and CO_2 on the carbon steels should be considered in the design of the flexible pipe.

X3.3 *Venting of Permeated Gases*—The pipe design should consider the effect the permeated gases and fluids and provide a system for venting of the gases to prevent rupture of the outer sheath.

X3.4 *Minimum Bend Radius (MBR)*—Care during handling is required to assure the pipe does not exceed the minimum bend radius (MBR). Applying a moment to a flexible steel pipe causes it to deflect to a radius defined by the applied load and the pipe stiffness (EI).

X4. PIPE QUALIFICATION TESTING

X4.1 Product variants should be qualified in accordance with the methodologies established in API RP 17B, Par 9.0 Prototype Testing. See Table X4.1.

TABLE X4.1 Typical MBR Values

Pipe Size, ft. (mm)	MBR, ft (m)
2 (50)	2.2 (0.67)
3 (75)	2.9 (0.88)
4 (100)	3.6 (1.110)
5.5 (140)	4.9 (1.49)
6 (150)	5.3 (1.622)
7 (175)	6.0 (1.83)
8 (200)	6.9 (2.11)

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F2805–11) that may impact the use of this standard.

(1) Scope, 1.1— Statement on the reinforcing elements.
(2) Addition of a new footnote.
(3) Renumbering of existing footnotes.
(4) Add a reference to an ASME standard.
(5) Renumbering of referenced standards.
(6) New definitions added:
3.2.1 *coupling, n—*
3.2.2 *design pressure, n—*
3.2.3 *design temperature, n—*
3.2.4 *end connection, n—*
3.2.5 *factor, design (Fd), n —*
3.2.6 *factors, service (Sn), n —*
3.2.8 *maximum operating pressure, n—*
3.2.9 *nominal pressure rating, n—*
3.2.10 *outer sheath layer, n —*
3.2.15 *qualified procedure, n—*
3.2.17 *traceability, n—*
(7) New wording added to the Materials Section– 4.5.3 Flanges and 4.6 statement added on manufacturers responsibilities.
(8) Revision of Note 1 in Section 5 Requirements.
(9) Revision of Section 9 Marking.
(10) Revision of Note 3 in Section 10 to make the requirements mandatory.