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An American National Standard

Standard Specification for Reinforced Polyethylene Composite Pipe For The Transport Of Oil And Gas And Hazardous Liquids[1]

This standard is issued under the fixed designation F2896; 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, and markings for on-site manufactured multilayer reinforced polyethylene composite pipe. It covers nominal sizes 6 in. through 36 in. (150 mm through 915 mm). These multilayered reinforced polyethylene composite pipe products[2] are assembled and installed in various lengths, including long continuous lengths. These products are intended for the transport of crude oil, natural gas and hazardous liquids in the rehabilitation of existing pipelines and for new pipelines.

NOTE 1—Hazardous liquids are those liquids defined by the U.S. Department of Transportation in 49 CFR 195.2.

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]

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

A519 Specification for Seamless Carbon and Alloy Steel Mechanical Tubing

D624 Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers

D638 Test Method for Tensile Properties of Plastics

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

D1000 Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications

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

D1693 Test Method for Environmental Stress-Cracking of Ethylene Plastics

D2122 Test Method for Determining Dimensions of Thermoplastic Pipe and Fittings

D2256/D2256M Test Method for Tensile Properties of Yarns by the Single-Strand Method

D2513 Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings

D2774 Practice for Underground Installation of Thermoplastic Pressure Piping

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

D2992 Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings

D3850 Test Method for Rapid Thermal Degradation of Solid Electrical Insulating Materials By Thermogravimetric Method (TGA)

D5035 Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)

F412 Terminology Relating to Plastic Piping Systems

F585 Guide for Insertion of Flexible Polyethylene Pipe Into Existing Sewers

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.11 on Composite.

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[2] The reinforced polyethylene composite pipe product described in this standard is covered by patents. Interested parties are invited to submit information regarding the identification of an alternative(s) to this patented item to the ASTM International Headquarters. 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.

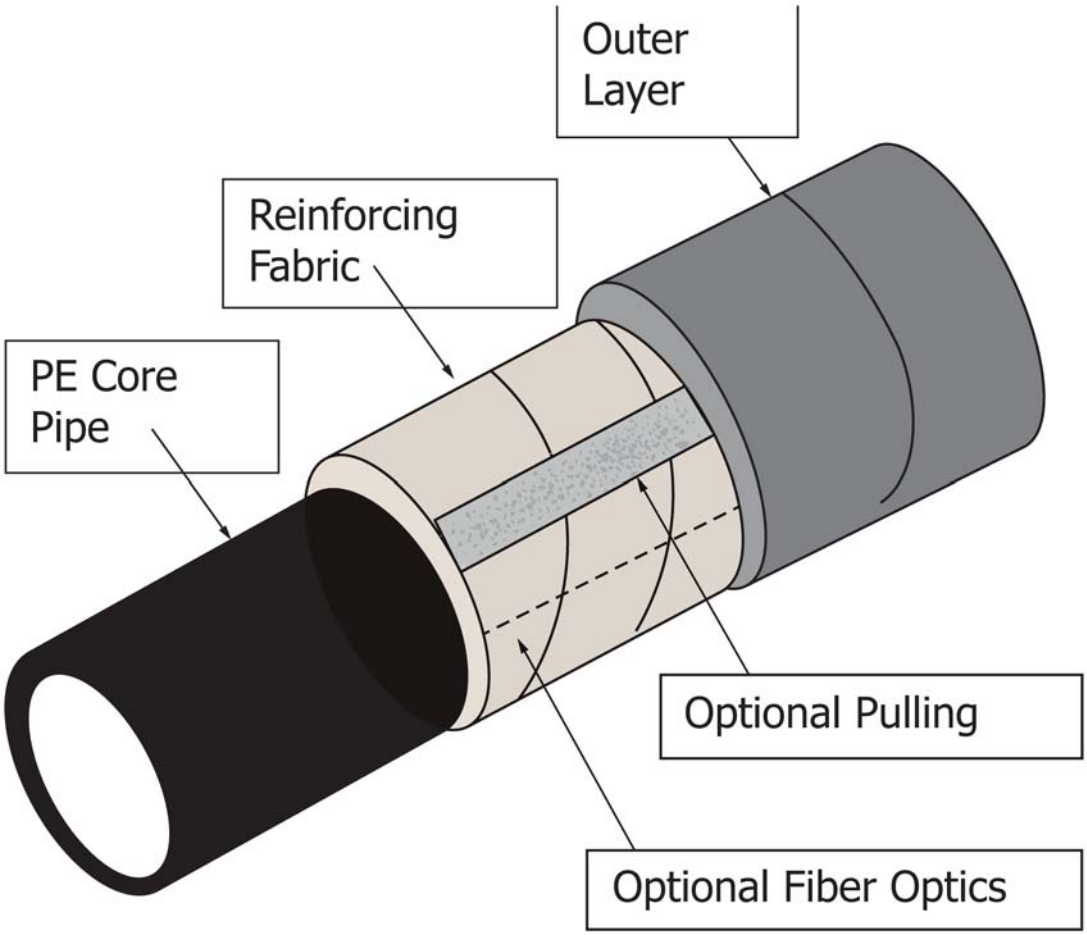

FIG. 1 Typical Construction of Reinforced Polyethylene Composite Pipe

F1249 Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor
F1606 Practice for Rehabilitation of Existing Sewers and Conduits with Deformed Polyethylene (PE) Liner
F1668 Guide for Construction Procedures for Buried Plastic Pipe
F2619/F2619M Specification for High-Density Polyethylene (PE) Line Pipe
F2620 Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
G14 Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)

2.2 *ANSI Standards:*[4]
B 16.5 Pipe, Flanges, and Flanged Fittings

2.3 *API Standards:*[5]
17 J Unbonded Flexible Pipe – Unbonded Flexible Pipe

2.4 *PPI Standards:*[6]
TR-3/2010 HDB/HDS/PDB/SDB/MRS Policies – Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe5

2.5 *Other Documents:*[7]
49 CFR 195 Code of Federal Regulations - Transportation of Hazardous Liquids by Pipeline

3. Terminology

3.1 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 *Reinforced Polyethylene Composite Pipe (RPCP), n*—Polyethylene piping helically wrapped with non-metallic reinforcing materials and then overwrapped with an outer protective layer (Fig. 1).

3.2.2 *core pipe, n*—the inner liner or polyethylene pipe

3.2.2.1 *Discussion*—The typical reinforced polyethylene composite pipe to be described in this standard is a multilayer pipe construction consisting of a polyethylene liner or core pipe, co-helically wrapped with multiple layers (counter

[4] Available from Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[5] Available from American Petroleum Institute (API), 1220 L. St., NW, Washington, DC 20005-4070, http://www.api.org.
[6] Available from Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.
[7] Available online from the Department of Transportation at http://setonresourcecenter.com/transportation/49CFR/172_101tb.pdf

TABLE 1 Physical Properties of Polyamide Reinforcing Fibers

Fiber Properties	Test Method	Units	Minimum Value
Specific Density	D792	lb/in^3 (g/cm^3)	0.052 (1.44)
Tensile Strength at Break	D2256/D2256M	psi	424,000 (2921)
Elongation at Break	D2256/D2256M	%	2.4
Specific Tensile Strength	D2256/D2256M	in. (cm)	815,000 (2,070,100)
Decomposition Temperature	D3850	°F (°C)	800 (427)

wound in pairs) (of non-metallic reinforcing material, and then wrapped with an outer polyethylene or other thermoplastic protective layer. The polyethylene core pipe is heat fusion joined to make long continuous lengths of pipe. Longitudinal direction reinforcing materials may be applied to reinforce the pipe linearly to increase the strength in sliplining installations. The polyethylene liner pipe may either be manufactured on-site or shipped to the site and fusion joined on-site prior to being wrapped with the reinforcing materials. These products are constructed from individual pipe lengths of the polyethylene core pipe and not from coiled polyethylene pipe. See Fig. 1.

3.2.3 *on-site, adj*—accomplished or located at the site of a particular activity or concern.

3.2.4 *pressure class, n*—The maximum allowable operating pressure.

4. Ordering Information

4.1 *General*—The reinforced polyethylene multilayer composite pipe meeting the requirements of this specification are classified by pressure design basis.

NOTE 2—Fig. 1 is meant to be representative of the reinforced polyethylene PE composite pipes described in this standard.

5. Materials

5.1 *Polyethylene Pipe Materials :*

5.1.1 *Polyethylene*—Polyethylene shall be PE4710 pipe in accordance with Specification F2619/F2619M or Specification D2513.

5.2 *Reinforcement Materials:*

5.2.1 *Polyamide reinforcing fibers*—Polyamide reinforcing fibers used in the assembly of the Reinforced Polyethylene Composite Pipe shall have the minimum properties as shown in Table 1. Polyamide reinforcing fabrics shall have the minimum properties as shown in Table 2.

5.2.2 *Ultra high molecular weight polyethylene (UHMW) reinforcing fibers*—Polyethylene reinforcing fibers used in the assembly of the Reinforced Polyethylene Composite Pipe shall have the minimum properties as shown in Table 3. UHMW Polyethylene reinforcing fabrics shall have the minimum properties as shown in Table 4.

5.2.3 *Polyester fibers*—Polyester reinforcing fibers used in the assembly of the Reinforced Polyethylene Composite Pipe shall have the minimum properties as shown in Table 5. Polyester reinforcing fabrics shall have the minimum properties as shown in Table 6.

5.3 *Non-Structural Materials:*

5.3.1 *Polyester fibers*—Polyester non-structural fibers used in the assembly of the Reinforced Polyethylene Composite Pipe shall have the minimum properties as shown in Table 7. Polyester fibers used in the polyester pulling tapes shall have the minimum properties as shown in Table 5. Polyester tapes shall have the minimum properties as shown in Table 6.

5.3.2 *Polyamide fibers*—Polyamide fibers used in the polyamide pulling tapes shall have the minimum properties as shown in Table 1. Polyamide tapes shall have the minimum properties as shown in Table 2.

NOTE 3—Non-structural reinforcing pulling tapes provide increased longitudinal strength during installation, including sliplining installations.

5.4 *External protective coating materials:*

5.4.1 *Polyethylene tape*— Polyethylene coating materials used in the assembly of the Reinforced Polyethylene Composite Pipe shall have the minimum properties as shown in Table 8.

5.4.2 *Polyethylene/Butyl rubber tape*—Polyethylene/Butyl rubber coating materials used in the assembly of the Reinforced Polyethylene Composite Pipe shall have the minimum properties as shown in Table 9.

5.5 *Rework materials*—Excluding the core pipe, reground or reprocessed polyethylene or other thermoplastic materials are not permitted to be used. Reinforcing materials shall not be recovered and reused.

5.6 *Steel End Connections*—Steel materials in end connections shall meet the requirements of Specifications A312/A312M, A333/A333M or A519. Specialty steel grades requested by the purchaser must meet the same minimum performance requirements.

6. Requirements

6.1 *Workmanship*—The polyethylene core pipe shall be inspected for defects and damage prior to wrapping with the reinforcing materials. The reinforcing layers shall be applied uniformly and be free from irregularities and visible defects. If defects or damages are found the material is to be rejected.

6.2 *Core Pipe Dimensions*—Polyethylene core pipe shall comply with the requirements listed in Specification F2619/F2619M or Specification D2513.

6.3 *Fabric Wrap*—The fabric wrap shall be overlapped and the fabric wrap angle is the natural wrap angle of 55°. The fabric warp angle shall be calibrated and controlled to within a tolerance of ± 2 degrees of the design wrap angle. The fabric wrap angle shall be measured and confirmed to ± 2 degrees of the design wrap angle every 300 feet (100m).

6.4 *Multilayer Pipe Dimensions*—Pipe Dimensions shall comply with Table 10 and Table 11, when measured in accordance with Test Method D2122.

NOTE 4—As these piping products are generally assembled on site, the conditioning requirements that are specified in Test Method D2122

TABLE 2 Physical Properties of Polyamide Reinforcing Fabrics

Fiber Properties	Test Method	Units	Minimum Value
Tensile Strength at Break	D5035	Lbs/inch (N/cm)	2,500 (4380)

TABLE 3 Physical Properties of UHMW Polyethylene Reinforcing Fibers

Fiber Properties	Test Method	Units	Minimum Value
Specific Density	D792	lb/in^3 (g/cm^3)	0.035 (0.97)
Tensile Strength at Break	D2256/D2256M	psi	316,000 (2177)
Elongation at Break	D2256/D2256M	%	2.9
Decomposition Temperature	D3850	°F (°C)	300 (149)

TABLE 4 Physical Properties of UHMW Polyethylene Reinforcing Fabrics

Fiber Properties	Units	Test Method	Minimum Value
Tensile Strength at Break	D5035	Lbs/inch (N/cm)	2,500 (4380)

TABLE 5 Physical Properties of Polyester Reinforcing Fibers

Property	Test Method	Units	Minimum Value
Specific Density	D792	lb/in^3 (g/cm^3)	0.051 (1.41)
Tensile Strength at Break	D2256/D2256M	psi	400,000 (2756)
Elongation at Break	D2256/D2256M	%	3.8

TABLE 6 Physical Properties of Polyester Reinforcing Fabrics

Fiber Properties	Test Method	Units	Minimum Value
Tensile Strength at Break	D5035	Lbs/inch (N/cm)	2,500 (4380)

TABLE 7 Physical Properties of Polyester Non-Reinforcing Fibers

Property	Test Method	Units	Minimum Value
Specific Density	D792	lb/in^3 (g/cm^3)	0.051 (1.41)
Breakload (1000 denier fiber)	D2256/D2256M	g/denier	8.6
Elongation at Break	D2256/D2256M	%	10.6

TABLE 8 Physical Properties of Polyethylene protective tape

Tape Properties	Test Method	Units	Minimum Value
Tensile Strength at Break	D1000	lbs/in	25
Elongation at Break	D1000	%	20
Impact Resistance	G14	in-lbs (Nm)	45 (5.0)
Water Vapor Transmission Rate, (100°F, 100% RH)	F1249	g/in^2/24hr,	0.03
Water Vapor Transmission Rate, (100°F, 100% RH)	F1249	g/m^2	0.5

TABLE 9 Physical Properties of polyethylene/butyl rubber protective tape

Tape Properties	Test Method	Units	Minimum Value
Tensile Strength at Break	D638	lb/in2, (kg/cm2)	1320 (92.8)
Tear Strength	D624	lb/in, (kg/cm)	300 (53.7)
Elongation at Break	D638	%	20
Environmental Stress Crack Resistance	D1693, Condition C	Hrs	>500, no cracking

obviously cannot be applied. Other than conditioning, the measurement requirements of Test Method D2122 are to be followed in measuring the pipe dimensions.

6.5 *Pressure Design Basis (PDB)*—: The multilayer reinforced polyethylene composite pipe shall have an established pressure design basis at 73°F (23°C) as listed in Table 10 and Table 11 and as per the requirements of Test Method D2837. For higher temperature service applications, PDB values for those temperatures shall be provided based on Test Method D2837 analysis or by interpolation using higher temperature PDB values as described in PPI TR-3/2010. The PDB shall be established for a minimum of one diameter of composite pipe in each of the diameter ranges as follows; 6 to 16 inch, >16 to 24 inch, and >24 to 36 inch. The pressure design basis of other pipe sizes within the same pressure class having the same

TABLE 10 Dimensions for Pressure Class 750 psi (5.17 MPa) Pipe

Nominal Pipe Size	PDB, psi (MPa)	Minimum Inside Diameter, in. (mm)	Minimum Outside Diameter, in. (mm)
6	2000 (13.79)	6.095 (154.81)	7.07 (179.58)
8	2000 (13.79)	8.074 (205.08)	9.099 (231.11)
10	2000 (13.79)	10.062 (255.58)	11.340 (288.04)
12	2000 (13.79)	11.935 (303.15)	13.335 (388.71)
14	2000 (13.79)	13.104 (332.84)	14.610 (371.09)
16	2000 (13.79)	14.977 (380.42)	16.623 (422.22)
18	2000 (13.79)	16.685 (423.79)	18.700 (474.98)
20	2000 (13.79)	18.721 (475.51)	20.647 (524.43)
22	2000 (13.79)	20.255 (514.48)	22.710 (576.83)
24	2000 (13.79)	22.460 (570.48)	24.770 (629.16)
26	2000 (13.79)	23.914 (607.43)	26.780 (680.21)
28	2000 (13.79)	26.20 (655.48)	28.798 (731.47)
30	2000 (13.79)	27.617 (701.46)	30.820 (782.83)
32	2000 (13.79)	29.950 (760.73)	32.941 (836.70)
34	2000 (13.79)	31.345 (796.16)	34.950 (887.73)
36	2000 (13.79)	33.695 (855.85)	36.925 (937.90)

TABLE 11 Dimensions for Pressure Class 1500 psi (10.34 MPa) Pipe

Nominal Pipe Size	PDB, psi (MPa)	Minimum Inside Diameter, in. (mm)	Minimum Outside Diameter, in. (mm)
6	4000 (27.58)	6.095 (154.81)	7.186 (182.52)
8	4000 (27.58)	8.074 (205.08)	9.161 (232.69)
10	4000 (27.58)	10.062 (255.58)	11.491 (291.87)
12	4000 (27.58)	11.935 (303.15)	13.454 (341.73)
14	4000 (27.58)	13.104 (332.84)	14.941 (379.50)
16	4000 (27.58)	14.977 (380.42)	16.918 (429.72)
18	4000 (27.58)	16.685 (423.79)	19.035 (483.49)
20	4000 (27.58)	18.721 (475.51)	21.151 (537.24)
22	4000 (27.58)	20.255 (514.48)	23.250 (590.55)
24	4000 (27.58)	22.460 (570.48)	25.350 (643.89)
26	4000 (27.58)	23.914 (607.43)	27.450 (697.23)
28	4000 (27.58)	26.20 (655.48)	29.550 (750.57)
30	4000 (27.58)	27.617 (701.46)	31.632 (803.46)
32	4000 (27.58)	29.950 (760.73)	33.501 (850.93)
34	4000 (27.58)	31.345 (796.16)	25.593 (904.06)
36	4000 (27.58)	33.695 (855.85)	37.685 (957.20)

materials of construction, reinforcement configuration shall be confirmed through testing in accordance with 9.5. Changes in the reinforcing materials or changes in layer construction require that the PDB be established for the new construction.

6.6 *Special Sizes*—Inside and outside diameters not specified in Table 10 or Table 11 are acceptable by agreement between the manufacturer and the purchaser.

6.7 *Reconfirmation of PDB*— Changes to the composite pipe construction with the same PDB and with the same materials of construction shall be confirmed through testing in accordance with 9.5.

6.8 *Long Term Cyclic Hydrostatic Pressure*—Multilayer reinforced polyethylene composite pipe shall be qualified, where intended for cyclic pressure service, to have a long term cyclic hydrostatic pressure design basis at the maximum service temperature as per the requirements of 9.3.

6.9 *Outside Diameter*— The outside diameter of the applicable pipe layer shall be as shown in Table 9 or Table 10, when measured in accordance with Section 9.

6.10 *Pipe Wall Thickness*— The wall thickness of the applicable pipe layer shall be as shown in Table 9 or Table 10, when measured in accordance with Section 9.

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

NOTE 5—As the pipe is assembled on site, it is intended for either sliplining for pipeline rehabilitation or direct burial in long continuous lengths that will be produced per the specific requirements of each project.

6.12 *Short-Term Pressure Test Requirements*— Pipe samples tested per Test Method D1599 shall exceed minimum burst strength as shown in Table 12 to meet the requirements of this standard.

NOTE 6—Short term hydraulic to failure per Test Method D1599 can be dangerous due to the amount of energy released when the pipe fails. Care must be taken to conduct these tests safely.

7. Joining of the Core Pipe

7.1 *Heat Fusion:*

7.1.1 Heat fusion joints for polyethylene pipes shall be made in accordance with Practice F2620 and the manufacturer's written procedure. PE butt fusion joining shall be between pipes having the same SDR or DR.

7.1.2 The internal beads resulting from fusion joining shall be removed prior to the wrapping of the core pipe with the reinforcing materials.

NOTE 7—The internal beads resulting from fusion joining may be

TABLE 12 Minimum Quick Burst Requirements

Pipe Pressure Class	Minimum Burst Strength, psi
750 psi	2400
1500 psi	4800

removed prior to the wrapping of the core pipe with the reinforcing materials.

8. Quality Assurance Tests

8.1 *Acceptance Test*—Prior to acceptance, the continuous length of pipe shall be pressure tested in accordance with manufacturer's documented procedures as detailed in 9.2.

8.2 A sample of the multilayer composite pipe shall be manufactured at the beginning of a production run and at the end of a production run and tested to failure as per 9.4 and shall meet the requirements of 6.12.

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

9. Test Methods

9.1 *Outside Diameter*—The outside diameter of each completed layer shall be measured and recorded according to manufacturer's procedures. The outside pipe diameter of each completed layer shall be measured at a minimum frequency of every 300 feet (100 m).

9.2 *Long-term-Static Hydrostatic Pressure*—Determine in accordance with Test Method D2837, following Test Method D1598 at ambient temperatures and at the maximum service temperature.

9.3 *Long-Term Cyclic Hydrostatic Pressure*—Determine in accordance with Procedure A of D2992.

9.4 *Short-Term Burst Test*—The pipe sample shall be tested to failure as per D1599.

9.5 *Confirmation of Pressure Design Basis (PDB)*—The pressure design basis of composite pipe shall be confirmed by testing per 9.2, where applicable, to establish that the PDB classification is equal to or greater than the established value. The minimum levels of data required are, E-2 per Part A of PPI TR-3/2010 at 73°F and E-2 at the highest other testing temperature, if any, a minimum of 2,000 hours on test and analyzed per Test Method D2837 or Practice D2992 at the highest temperature for which the PDB was established.

9.6 *Qualification Testing of the Installed Pipeline/On-Site Pressure Testing*—Unless otherwise specified by the purchaser, the assembled pipe shall be tested for a minimum of 4 hours at 1.25 times the stated operating pressure of the system.

NOTE 8—A pipeline system is typically commissioned after completion by filling it with water and conducting a pressure test. Reinforced polyethylene composite 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.

NOTE 9—As the qualification testing of the installed pipeline shall exceed the maximum operating pressure (MOP), significant pressures are being applied for the first time to the new pipeline. Catastrophic failure of the pipe or the end connections or separation of the end connections can and will cause high pressure release and/or material failures. Extreme caution is required during this testing.

10. Test Reports and Certification

10.1 Upon request of the purchaser, the manufacturer shall provide certification that the product was manufactured and tested in accordance with this specification.

10.2 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.

11. Marking

11.1 *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 2 ft. (0.65 m).

11.2 *Markings*—Each length of pipe in compliance with this specification shall be clearly marked by the producer with the following information: this designation, (ASTM F2896), the nominal pipe size, the pressure rating, the manufacturer's name, and trade name, or trademark, a description of the construction including identification of the core pipe and the reinforcement material and the date of manufacture. Where being used for cyclic pressure service, such pipe shall be marked to indicate that it has been tested and qualified for cyclic pressure service.

12. End Connections

12.1 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 in accordance with section 12.4.

12.2 Connections shall be of steel construction meeting the materials requirements given in section 5.6.

12.3 The connection assemblies shall meet the performance requirements of this specification. Only connections and couplers supplied or recommended by the pipe manufacturer shall be used.

12.4 To ensure that the pipe end connection interface does not leak, each pressure class shall be tested once per year. The manufacturer shall test samples with end connections per section 6.12. At least 2 end connections shall be tested.

13. Handling

13.1 All pipes shall be handled in accordance with manufacturer's procedures.

14. Quality Assurance

14.1 When the product is marked with the designation, F2896, 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.

15. Keywords

15.1 composite; crude oil; hazardous liquids; multilayer; natural gas; pipe; polyethylene; reinforced; thermoplastic

ANNEXES

(Mandatory Information)

A1. END CONNECTION AND JOINING QUALIFICATION

A1.1 *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 test at the pipe design pressure and at a test temperature of 176°F (80°C) or higher. The pipe and end connections shall be tested for >1000 hours without failure to qualify the end connections and joining procedure.

A1.2 For each end connection type to be qualified, at least 2 end connections shall be tested on the reinforced polyethylene composite piping product. 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.

A2. INSTALLATION PROCEDURES

A2.1 *Direct Burial of Reinforced Polyethylene Composite Pipe*— Direct burial of reinforced polyethylene composite pipe shall follow the requirements of D2774 Standard Practice for Underground Installation of Thermoplastic Pressure Piping or F1668 Standard Guide for Construction Procedures for Buried Plastic Pipe, where applicable.

A2.2 *Sliplining with Reinforced Polyethylene Composite Pipe*— Sliplining of existing pressure pipelines with reinforced polyethylene composite pipe shall follow the requirements of F585 Standard Practice for Insertion of Flexible Polyethylene Pipe into Existing Sewers, as applicable.

A2.3 *Renewal of Pipelines with Deformed Reinforced Polyethylene Composite Pipe*— Installation of deformed ("C" shaped) reinforced polyethylene composite pipe into pipelines shall follow the requirements of F1606, Standard Practice for Rehabilitation of Existing Sewers and Conduits with Deformed Polyethylene (PE) Liner, as applicable.

APPENDIXES

(Nonmandatory Information)

X1. PRESSURE DESIGN BASIS, PRESSURE DESIGN CATEGORIES, SERVICE FACTOR [DESIGN FACTOR]

X1.1 Pressure Design Basis (PDB)

X1.1.1 The pressure design basis for multilayer reinforced polyethylene thermoplastic composite pipe is the estimated long term hydrostatic strength as obtained in accordance with Test Methods D2837 or D2992 at the temperature tested.

X1.2 Pressure Design Basis Categories

X1.2.1 The pressure design basis category is obtained from Table 2 in D2837 using the estimated long term hydrostatic pressure at the tested temperature as the calculated value. For values not listed in Table 2 in Test Method D2837 the categories listed in Table X1.1 are provided shall be used.

X1.3 Service Factor [Design Factor] (F)

X1.3.1 The service factor, or design factor, is a number less than 1.0, which takes into consideration the variables and degrees of safety involved in the design of the multilayer reinforced polyethylene thermoplastic composite piping system. It is selected for the application based on two general groups of conditions. The first group considers the manufacturing and testing variables, specifically the normal variations in the materials, manufacturing, dimensions, good handling practices, and in the evaluation methodologies in this specification. The second group considers the application or use of the piping product, specifically the installation procedures, environment, temperature, any other hazards involved, the estimated service life, and the degree of reliability selected.

NOTE X1.1—It is not the intent of this standard to provide service or design factors. The service or design factor should be selected by the design engineer with guidance from the composite pipe manufacturer after fully evaluating the service conditions and the engineering properties of the specific composite piping product under considerations.

X1.4 Pressure Rating

X1.4.1 The pressure rating is the estimated maximum pressure that the medium in the pipe can exert continuously with a high degree of certainty that failure of the pipe will not occur.

X1.4.2 The pressure rating is obtained by multiplying the pressure design basis as determined by Test Methods D2837 or D2992 by the service or design factor.

$$PR = PDB\ x\ F \qquad \text{(X1.1)}$$

TABLE X1.1 Pressure Design Basis Categories

Range of Calculated LTHS Values		Pressure Design Basis values	
Psi	(MPa)	Psi	(MPA)
1200 to <1530	(8.27 to <10.55)	1250	(8.62)
1530 to <1920	(10.55 to <13.24)	1600	(11.03)
1920 to <2400	(13.24 to <16.55)	2000	(13.79)
2400 to <3020	(16.55 to <20.82)	2500	(17.24)
3020 to <3830	(20.82 to <26.41)	3150	(21.72)
3830 to <4800	(26.41 to <33.09)	4000	(27.58)
4800 to <6040	(33.09 to <41.62)	5000	(34.47)
6040 to <6810	(41.62 to <46.92)	6300	(43.41)

X2. TEMPERATURE LIMITATIONS

X2.1 Core pipe polyethylene materials provide service for temperatures over the nominal range of -40°F (40°C) to 140 ºF (60.0 °C) 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 Polyethylene Materials*— The ability of the polyethylene material in a composite 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 140°F (60°C) 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 composite pipe service, the structural properties of the PE are secondary because the reinforcing layers resist the internal pressure. The manufacturer should be consulted for any specific questions regarding compatibility. If the conveyed fluid contains high partial pressure of CO2 gas the 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 17 J shall be used as a guideline for this testing.

X3.2 *Conveyed Product Compatibility with the reinforcing materials*—The reinforcing materials are generally protected from the bore fluids by the core pipe. Small quantities of certain molecules can permeate through the PE liner pipe into the pipe annulus. The effect of permeated H_2O, H_2S, CO_2 and hydrocarbons on the reinforcements should be considered in the design of the composite pipe.

REFERENCES

(1) 1. US Patent #5,551,484 – Pipe Liner and Monitoring System, Issued September 3, 1996

(2) US Patent #6,634,388 – Annular Fluid Manipulation in Lined Tubular Systems – Licensed Safety Liner, Issued October 21, 2003

(3) US Patent #7,258,141 – Pipe Liner Apparatus and Method, Issued August 21, 2007

(4) US Patent #7,374,127 – System and Methods for Making Pipe Liners, Issued May 20, 2008

(5) "The Development and Validation of a High Strength, Self Monitoring, Composite, Tight Fit Liner for Offshore Pipelines and Risers," K. Bethel, S.C. Catha, A. Ekelund, J. Gallagher, K./R. Charbonneau, M.F. Kanninen, I. Mandich, R. Stonesifer and W.D. Stringfellow, Fourth International Conference on Composite Materials for Offshore Operations, Houston, TX, October 4-6, 2005.

(6) "Smart Pipe: An Innovative New Trenchless Technology for Rehabilitating High Pressure Gas/Liquid Pipelines," K. Bethel, S.C. Catha, A. Ekelund, M.F. Kanninen, and R. Stonesifer, 6th Pipeline Technology Conference, Hannover, Germany, April 4-6, 2011