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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~~ 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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:*[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

[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 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.

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

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
D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials
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
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]
15S Spoolable Reinforced Plastic Line Pipe
17 J Unbonded Flexible Pipe – Unbonded Flexible Pipe
2.4 *PPI Standards:*[6]
~~TR-3/2010~~TR-3 HDB/HDS/PDB/SDB/MRS Policies – – Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Hydrostatic Design ~~Stress~~Stresses (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), ~~and~~ Minimum Required ~~Strength~~Ballot (MRS) Ratings and Categorized Required Strength (CRS) for Thermoplastic Piping Materials or ~~Pipe5~~Pipe
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 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

[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

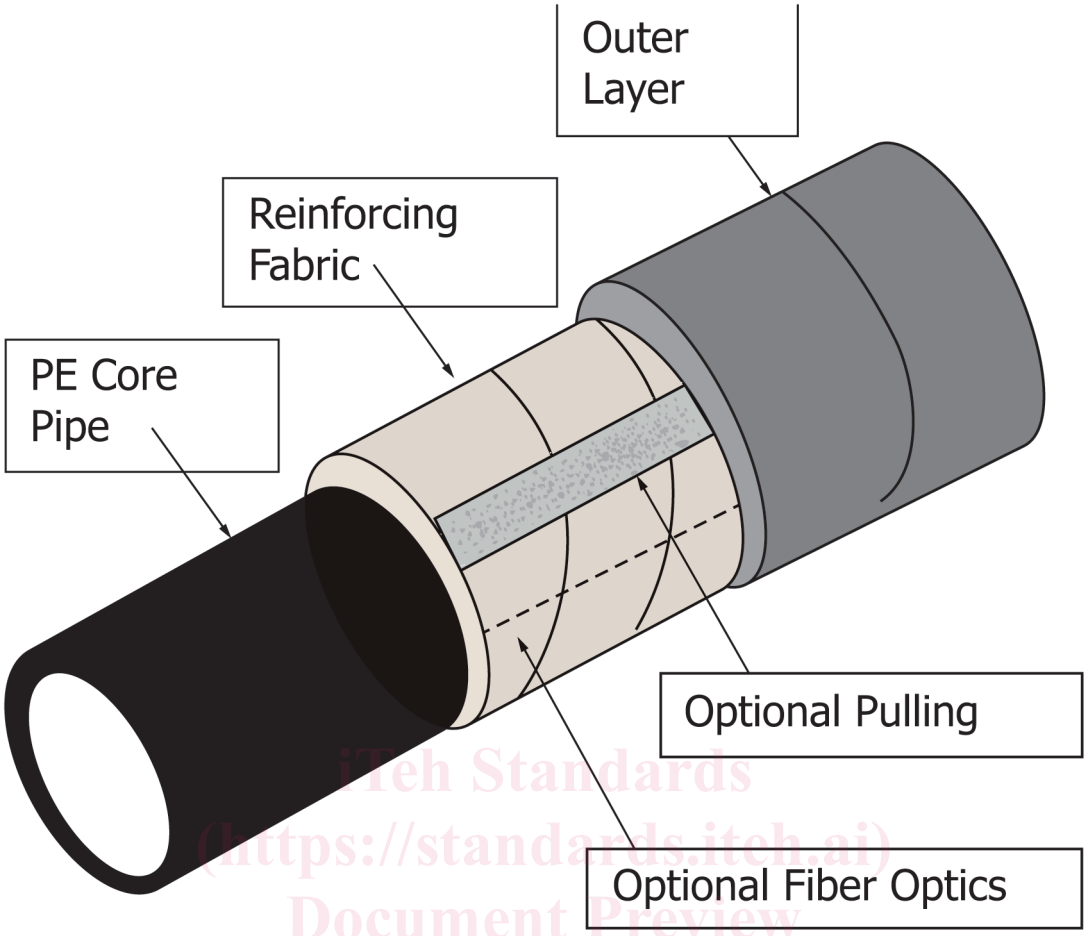

FIG. 1 Typical Construction of Reinforced Polyethylene Composite Pipe

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:*

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)

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:*~~ *Cover Materials:*

5.4.1 *Polyethylene* ~~*tape*—~~*Cover Materials*—Polyethylene coating materials used in the assembly of the Reinforced Polyethylene Composite Pipe shall have the minimum properties as shown in Table 8. The UV resistance of the polyethylene cover materials shall be Code C or Code E as defined in Specification D3350.

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~~ Reprocessed materials shall not be ~~recovered and reused.~~used.

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.

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/in^2/24hr,	0.03
~~Water Vapor Transmission Rate, (100°F, 100% RH)~~	~~F1249~~	~~g/m^2~~	~~0.5~~
Water Vapor Transmission Rate, (100 °F, 100 % RH)	F1249	g/m^2	0.5

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 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

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

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)

design basis at ~~73°F (23°C)~~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 or Practice D2992 analysis or by interpolation using higher temperature PDB values as described in PPI ~~TR-3/2010.~~TR-3. The PDB shall be established for a minimum of one diameter of composite pipe in each of the diameter ranges as follows; 6 inch to 16 inch, >16 inch to 24 inch, and >24 to 36 inch. The pressure design basis of other pipe sizes within the same pressure class having the same 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.

TABLE 12 Minimum Quick Burst Requirements

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

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 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 Practice D2992.