Designation: D 3754 – 01

An American National Standard

Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer and Industrial Pressure Pipe[1]

This standard is issued under the fixed designation D 3754; 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 machine-made fiberglass pipe, 8 in. (200 mm) through 144 in. (3700 mm), for use in pressure systems for conveying sanitary sewage, storm water, and many industrial wastes, and corrosive fluids. Both glass-fiber-reinforced thermosetting-resin pipe (RTRP) and glass-fiber-reinforced polymer mortar pipe (RPMP) are fiberglass pipes. This standard is suited primarily for pipes to be installed in buried applications, although it may be used to the extent applicable for other installations such as, but not limited to, sliplining and rehabilitation of existing pipelines. Pipe covered by this specification is intended to operate at internal gage pressures of 250 psi (1.72 MPa) or less.

NOTE 1—For the purposes of this standard, polymer does not include natural polymers.

1.2 The values given in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information purposes only.

NOTE 2—There is no similar or equivalent ISO standard.

1.3 The following precautionary caveat pertains only to the test method portion, Section 8, 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates[2]

C 581 Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service[3]

D 638 Test Method for Tensile Properties of Plastics[4]

D 695 Test Method for Compressive Properties of Rigid Plastics[4]

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[4]

D 883 Terminology Relating to Plastics[4]

D 1600 Terminology for Abbreviated Terms Relating to Plastics[4]

D 2290 Test Method for Apparent Hoop Tensile Strength of Plastic or Reinforced Plastic Pipe by Split Disk Method[5]

D 2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading[3]

D 2584 Test Method for Ignition Loss of Cured Reinforced Resins[6]

D 2992 Practice for Obtaining Hydrostatic or Pressure Design Basis for "Fiberglass'' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings[3]

D 3567 Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings[3]

D 3681 Test Method for Chemical Resistance of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe in a Deflected Condition[3]

D 3892 Practice for Packaging/Packing of Plastics[7]

D 4161 Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals[3]

F 412 Terminology Relating to Plastic Piping Systems[3]

F 477 Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe[3]

2.2 *ISO Standard:*

[1] This specification is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.23 on Reinforced Plastic Piping Systems and Chemical Equipment.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 08.04.

[4] *Annual Book of ASTM Standards*, Vol 08.01.

[5] *Annual Book of ASTM Standards*, Vol 15.03.

[6] *Annual Book of ASTM Standards*, Vol 08.02.

[7] *Annual Book of ASTM Standards*, Vol 08.03.

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

ISO 1172 Textile Glass Reinforced Plastics—Determination of Loss on Ignition[8]

2.3 *AWWA Standard:*

AWWA C-950 Glass-Fiber Reinforced Thermosetting Resin Pressure Pipe[9]

3. Terminology

3.1 *Definitions:*

3.1.1 *General*—Definitions are in accordance with Terminology D 883 or Terminology F 412 and abbreviations with Terminology D 1600, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *fiberglass pipe*—a tubular product containing glass fiber reinforcements embedded in or surrounded by cured thermosetting resin. The composite structure may contain aggregate, granular or platelet fillers, thixotropic agents, pigments, or dyes. Thermoplastic or thermosetting liners or coatings may be included.

3.2.2 *reinforced thermosetting resin pipe*—a fiberglass pipe without aggregate.

3.2.3 *reinforced polymer mortar pipe*—a fiberglass pipe with aggregate.

3.2.4 *industrial pipe*—pipe designed for internal, or external environments, or both, commonly encountered in industrial piping systems used for many process solutions or effluents.

3.2.5 *qualification test*—one or more tests used to prove the design of a product. Not a routine quality control test.

3.2.6 *liner*—a resin layer, with or without filler or reinforcement, or both, forming the interior surface of the pipe.

3.2.7 *surface layer*—a resin layer, with or without filler or reinforcement, or both, applied to the exterior surface of the pipe structural wall.

[8] Available from American National Standards Institute (ANSI), 11 West 42nd Street, 13th Floor, New York, NY 10036.

[9] Available from the American Water Works Association, 6666 West Quincey Ave., Denver, CO 80235.

4. Classification

4.1 *General*—This specification covers fiberglass sewer and industrial pressure pipe defined by raw materials in the structural wall (type) and liner, surface layer material (grade), operating pressure (class), and pipe stiffness. Table 1 lists the types, liners, grades, classes, and stiffnesses that are covered.

NOTE 3—All possible combinations of types, liners, grades, classes, and stiffness may not be commercially available. Additional types, liners, grades, and stiffnesses may be added as they become commercially available. The purchaser should determine for himself or consult with the manufacturer for the proper class, type, liner, grade, and stiffness of pipe to be used under the installation and operating conditions that will exist for the project in which the pipe is to be used.

4.2 *Designation Requirements*—The pipe materials designation code shall consist of the standard designation, ASTM D 3754, followed by type, liner, and grade in arabic numerals, class by the letter C with two or three arabic numerals, and pipe stiffness by a capital letter. Table 1 presents a summary of the designation requirements. Thus a complete material code shall consist of ASTM D 3754, three numerals, C...and two or three numerals, and a capital letter.

NOTE 4—Examples of the designation codes are as follows: (*1*) ASTM D 3754-1-1-3-C50-A for glass-fiber-reinforced aggregate and polyester resin mortar pipe with a reinforced thermoset liner and an unreinforced polyester resin and sand surface layer, for operation at 50 psi (345 kPa), and having a minimum pipe stiffness of 9 psi (62 kPa). (*2*) ASTM D 3754-4-2-6-C200-C for glass-fiber-reinforced epoxy resin pipe with an unreinforced thermoset liner, no surface layer, for operation at 200 psi (1380 kPa) and having a minimum pipe stiffness of 36 psi (248 kPa).

NOTE 5—Although the "Form and Style for ASTM Standards" manual requires that the type classification be roman numerals, it is recognized that few companies have stencil-cutting equipment for this style of type, and it is therefore acceptable to mark the product type in arabic numbers.

5. Materials and Manufacture

5.1 *General*—The resins, reinforcements, colorants, fillers, and other materials, when combined as a composite structure, shall produce a pipe that shall meet the performance requirements of this specification.

TABLE 1 General Designation Requirements for Fiberglass Pressure Pipe

Designation	Property	Cell Limits[A]								
1	Type	1 glass-fiber-reinforced thermosetting polyester[B] resin mortar (RPMP polyester)[B]	2 glass-fiber-reinforced thermosetting polyester[B] resin (RTRP polyester)[B]	3 glass-fiber-reinforced thermosetting epoxy resin mortar (RPMP epoxy)	4 glass-fiber-reinforced thermosetting epoxy resin (RTRP epoxy)					
2	Liner	1 reinforced thermoset liner	2 non-reinforced thermoset liner	3 thermoplastic liner	4 no liner					
3	Grade	1 Polyester resin surface layer—reinforced[B]	2 polyester[B] resin surface layer—nonreinforced[B]	3 polyester[B] resin and sand surface layer nonreinforced	4 epoxy resin surface layer—reinforced	5 epoxy resin surface layer—nonreinforced	6 No surface layer			
4	Class[C]	C50	C75	C100	C125	C150	C175	C200	C225	C250
5	Pipe Stiffness psi (kPa)	A 9 (62)	B 18 (124)	C 36 (248)	D 72 (496)[ABC]					

[A] The cell-type format provides the means of identification and specification of piping materials. This cell-type format, however, is subject to misapplication since unobtainable property combinations can be selected if the user is not familiar with commercially available products. The manufacturer should be consulted.

[B] For the purposes of this standard, polyester includes vinyl ester resin.

[C] Based on operating pressure in psig (numerals).

5.2 *Wall Composition*—The basic structural wall composition shall consist of a thermosetting resin, glass-fiber reinforcement, and, if used, an aggregate filler.

5.2.1 *Resin*—A thermosetting polyester or epoxy resin, with or without filler.

5.2.2 *Aggregate*—A siliceous sand conforming to the requirements of Specification C 33, except that the requirements for gradation shall not apply.

5.2.3 *Reinforcement*—A commercial grade of glass fiber with a sizing compatible with the resin used.

5.3 *Liner and Surface Layers*—A liner or surface layer, or both, when incorporated into or onto the pipe shall meet the chemical and structural requirements of this specification.

5.4 *Joints*—The pipe shall have a joining system that shall provide for fluid tightness for the intended service condition.

5.4.1 *Unrestrained*—Pipe joints capable of withstanding internal pressure but not longitudinal forces.

5.4.1.1 *Coupling or Bell-and-Spigot Gasket Joints*, with a groove either on the spigot or in the bell to retain an elastomeric gasket that shall be the sole element of the joint to provide watertightness. For typical joint detail see Fig. 1.

5.4.1.2 *Mechanical Couplings*.

5.4.2 *Restrained*—Pipe joints capable of withstanding internal pressure and longitudinal forces.

5.4.2.1 Joints similar to those in 5.4.1.1 with supplemental restraining elements.

5.4.2.2 *Butt Joint*, with laminated overlay.

5.4.2.3 *Bell-and-Spigot*, with laminated overlay.

5.4.2.4 *Bell-and-Spigot*, adhesive bonded.

5.4.2.5 *Flanged*.

5.4.2.6 *Mechanical*.

NOTE 6—Other types of joints may be added as they become commercially available.

5.5 *Gaskets*—Elastomeric gaskets, when used with this pipe, shall conform to the requirements of Specification F 477, except that composition of the elastomer shall be as agreed upon between the purchaser and the supplier for the particular exposure to oily or aggressive-chemical environments.

6. Requirements

6.1 *Workmanship*:

6.1.1 Each pipe shall be free from all defects including indentations, delaminations, bubbles, pinholes, cracks, pits, blisters, foreign inclusions, and resin-starved areas that due to their nature, degree, or extent, detrimentally affect the strength and serviceability of the pipe. The pipe shall be as uniform as commercially practicable in color, opacity, density, and other physical properties.

6.1.2 The inside surface of each pipe shall be free of bulges, dents, ridges, or other defects that result in a variation of inside diameter of more than ⅛ in. (3.2 mm) from that obtained on adjacent unaffected portions of the surface. No glass-fiber reinforcement shall penetrate the interior surface of the pipe wall.

6.1.3 Joint sealing surfaces shall be free of dents, gouges, or other surface irregularities that will affect the integrity of the joints.

6.2 *Dimensions*:

6.2.1 *Pipe Diameters*—The pipe shall be supplied in the nominal diameters shown in Table 2 or Table 3. The pipe diameter tolerances shall be as shown in Table 2 or Table 3, when measured in accordance with 8.1.1.

6.2.2 *Lengths*—The pipe shall be supplied in nominal lengths of 10, 20, 30, 40, and 60 ft (3.05, 6.10, 9.15, 12.19, and 18.29 m). The actual laying length shall be the nominal length ±2 in. (±51 mm), when measured in accordance with 8.1.2. At least 90 % of the total footage of any one size and class, excluding special-order lengths, shall be furnished in the nominal lengths specified by the purchaser. Random lengths, if furnished, shall not vary from the nominal lengths by more than 5 ft (1.53 m), or 25 %, whichever is less.

6.2.3 *Wall Thickness*—The average wall thickness of the pipe shall not be less than the nominal wall thickness published in the manufacturer's literature current at the time of purchase, and the minimum wall thickness at any point shall not be less than 87.5 % of the nominal wall thickness when measured in accordance with 8.1.3.

6.2.4 *Squareness of Pipe Ends*—All points around each end of a pipe unit shall fall within ±¼in. (6.4 mm) or ±0.5 % of the nominal diameter of the pipe, whichever is greater, to a plane perpendicular to the longitudinal axis of the pipe, when measured in accordance with 8.1.4.

6.3 *Chemical Requirements*:

6.3.1 *Sanitary Sewer Service* :

6.3.1.1 *Long-Term*—Pipe specimens, when tested in accordance with 8.2.1 shall be capable of being deflected, without failure, at the 50 year strain level given in Table 4 when exposed to 1.0 *N* sulfuric acid.

NOTE 7—See Appendix X1 for derivation of the minimum sanitary sewer pipe chemical requirements given in Table 4.

6.3.1.2 *Control Requirements*—Test pipe specimens periodically in accordance with 8.2.1.3, following the procedure of 8.2.1.4, or alternatively, the procedure of 8.2.1.5.

6.3.1.3 When the procedure of 8.2.1.4 is used, the following three criteria must be met: a) the average failure time at each strain level must fall at or above the lower 95 % confidence limit of the originally determined regression line, b) no specimen-failure times may be sooner than the lower 95 % prediction limit of the originally determined regression line, and c) one-third or more of the specimen failure times must be on or above the originally determined regression line.

NOTE 8—Determine the lower 95 % confidence limit and the lower 95 % prediction limit in accordance with to Annex A2.

6.3.1.4 When the alternative method of 8.2.1.5 is used, failure shall not occur in any specimen.

6.3.2 *Industrial Service*—The resin component of the liner or of the surface layer, or both, shall be a commercial-grade

FIG. 1 Typical Joints

TABLE 2 Nominal Inside Diameters (ID) and Tolerances Inside Diameter Control Pipe

Nominal Diameter,[A] in.	Tolerances, in.	Nominal Metric Diameter,[B] mm	ID Range,[B] mm		Tolerance[B] on Declared ID, mm
			Minimum	Maximum	
8	±0.25	200	196	204	±1.5
10	±0.25	250	246	255	±1.5
12	±0.25	300	296	306	±1.8
14	±0.25	400	396	408	±2.4
15	±0.25	500	496	510	±3.0
16	±0.25	600	595	612	±3.6
18	±0.25	700	695	714	±4.2
20	±0.25	800	795	816	±4.2
21	±0.25	900	895	918	±4.2
24	±0.25	1000	995	1020	±5.0
27	±0.27	1200	1195	1220	±5.0
30	±0.30	1400	1395	1420	±5.0
33	±0.33	1600	1595	1620	±5.0
36	±0.36	1800	1795	1820	±5.0
39	±0.39	2000	1995	2020	±5.0
42	±0.42	(2200)	2195	2220	±6.0
45	±0.45	2400	2395	2420	±6.0
48	±0.48	(2600)	2595	2620	±6.0
51	±0.51	2800	2795	2820	±6.0
54	±0.54	(3000)	2995	3020	±6.0
60	±0.60	3200	3195	3220	±7.0
66	±0.66	(3400)	3395	3420	±7.0
72	±0.72	3600	3595	3620	±7.0
78	±0.78	(3800)	3795	3820	±7.0
84	±0.84	4000	3995	4020	±7.0
90	±0.90	. . .	. . .	. . .	. . .
96	±0.96	. . .	. . .	. . .	. . .
102	±1.00	. . .	. . .	. . .	. . .
108	±1.00	. . .	. . .	. . .	. . .
114	±1.00	. . .	. . .	. . .	. . .
120	±1.00	. . .	. . .	. . .	. . .
132	±1.00	. . .	. . .	. . .	. . .
144	±1.00	. . .	. . .	. . .	. . .

[A] Inside diameters other than those shown shall be permitted by agreement between purchaser and supplier.
[B] Values are taken from International Standards Organization documents. Parentheses indicate non-preferred diameters.

corrosion-resistant thermoset that has either been evaluated in a laminate by test, in accordance with 8.2.2, or that has been determined by previous documented service to be acceptable for the service conditions. Where service conditions have not been evaluated, a suitable resin may also be selected by agreement between the manufacturer and purchaser.

NOTE 9—The results obtained by this test shall serve as a guide only in the selection of a pipe material for a specific service application. The purchaser is cautioned to evaluate all of the various factors that may enter into the serviceability of a pipe material when subjected to chemical environment, including chemical resistance in the strained condition.

6.4 *Soundness*—Unless otherwise agreed upon between purchaser and supplier, test each length of pipe up to 54 in. (1370 mm) diameter hydrostatically without leakage or cracking, at the internal hydrostatic proof pressures specified for the applicable class in Table 5 when tested in accordance with 8.3. For sizes over 54 in., the frequency of hydrostatic leak tests shall be as agreed upon by purchaser and supplier.

6.5 *Hydrostatic Design Basis*:

6.5.1 *Long-Term Hydrostatic Pressure*—The pressure classes shall be based on long-term hydrostatic pressure data obtained in accordance with 8.4 and categorized in accordance with Table 6. Pressure classes are based on extrapolated strengths at 50 years. For pipe subjected to longitudinal loads or circumferential bending, the effect of these conditions on the hydrostatic design pressure classification of the pipe must be considered.

6.5.2 *Control Requirements*—Test pipe specimens periodically in accordance with the reconfirmation procedures described in Practice D 2992.

NOTE 10—Hydrostatic design basis (HDB—extrapolated value at 50 years) determined in accordance with Procedure A of Practice D 2992, may be substituted for the Procedure B evaluation required by 8.4. It is generally accepted that the Procedure A value multiplied by 3 is equivalent to the Procedure B value.

6.6 *Stiffness*—Each length of pipe shall have sufficient strength to exhibit the minimum pipe stiffness ($F/\Delta y$) specified in Table 7 when tested in accordance with 8.5. At deflection level A per Table 8, there shall be no visible damage in the test specimen evidenced by surface cracks. At deflection level B per Table 8, there shall be no indication of structural damage as evidenced by interlaminar separation, separation of the liner or surface layer (if incorporated) from the structural wall, tensile failure of the glass-fiber reinforcement, fracture, or buckling of the pipe wall.

NOTE 11—This is a visual observation (made with the unaided eye) for quality control purposes only, and should not be considered a simulated service test. Table 8 values are based on an in-use long-term deflection limit of 5 % and provide an appropriate uniform safety margin for all pipe stiffnesses. Since the pipe-stiffness values ($F/\Delta y$) shown in Table 7 vary, the percent deflection of the pipe under a given set of installation conditions will not be constant for all pipes. To avoid possible misapplication, take care to analyze all conditions that might affect performance of the installed pipe.

TABLE 3 Nominal Outside Diameters (OD) and Tolerances

Outside Diameter Control Pipe				
Nominal Pipe Size, in.	Steel Pipe Equiv. (IPS) OD's, in.	Tolerance, in.	Cast Iron Pipe Equiv. OD's, in.	Tolerance, in.
8	8.625	+0.086 −0.040	9.05	
10	10.750	+0.108 −0.048	11.10	±0.06
12	12.750	+0.128 −0.056	13.20	
14	14.000	+0.140 −0.062	15.30	
16	16.000	+0.160 −0.070	17.40	+0.05 −0.08
18	...	...	19.50	
20	...	...	21.60	
24	...	...	25.80	
30	...	...	32.00	
36	...	...	38.30	
42	...	...	44.50	+0.08
48	...	...	50.80	−0.06
54	...	...	57.56	
60	...	...	61.61	

Metric Pipe Size, mm	D.I. Pipe Equiv, mm	Tolerance, mm		Int'l OD, mm	Tolerance, mm	
200	222	−3.0			+2.0	
250	274	−3.1			+2.1	
300	326	−3.3			+2.3	
350	378	−3.4			+2.4	
400	429	−3.5			+2.5	
500	532	−3.8			+2.8	
600	635	−4.0			+3.0	
700	738	−4.3			+3.3	
800	842	−4.5	+1.0	1.02 × nominal plus 4	+3.5	−2.0
900	945	−4.8			+3.8	
1000	1048	−5.0			+4.0	
1100	1152	−5.3			+4.3	
1200	1255	−5.5			+4.5	
1400	1462	−6.0			+5.0	
1600	1668	−7.4			+5.5	
1800	1875	−8.2			+6.0	
2000	2082	−9.0			+6.5	
2200 to 4000	...	...			increase (+) tol. 0.5 each 200 mm	

TABLE 4 Minimum Sanitary Sewer Pipe Chemical Requirements

ϵ_{scv}

Pipe Stiffness, psi (kPa)	Minimum Strain					
	6 min	10 h	100 h	1 000	10 000	50 years
9 (62)	0.97 (*t/de*)	0.84 (*t/d*)	0.78 (*t/d*)	0.73 (*t/d*)	0.68 (*t/d*)	0.60 (*t/d*)
18 (124)	0.85 (*t/d*)	0.72 (*t/d*)	0.66 (*t/d*)	0.61 (*t/d*)	0.56 (*t/d*)	0.49 (*t/d*)
36 (248)	0.71 (*t/d*)	0.60 (*t/d*)	0.55 (*t/d*)	0.51 (*t/d*)	0.47 (*t/d*)	0.41 (*t/d*)
72 (496)	0.56 (*t/d*)	0.48 (*t/d*)	0.44 (*t/d*)	0.41 (*t/d*)	0.38 (*t/d*)	0.34 (*t/d*)

Where: *t* and *d* are the nominal total wall thickness and the mean diameter (inside diameter plus *t*) as determined in accordance with 8.1.

6.6.1 For other pipe stiffness levels, appropriate values for Level A and Level B deflections (Table 8) may be computed as follows:

$$\text{Level A at new PS} = \left(\frac{72}{\text{new PS}}\right)^{0.33} (9) \quad (1)$$

$$\text{Level B at new PS} = \text{new Level A} \div 0.6$$

6.6.2 Since products may have use limits of other than 5 % long-term deflection, Level A and Level B deflections (Table 8)

TABLE 5 Hydrostatic-Pressure Test

Class	Hydrostatic Proof Pressure, gage, psi (kPa)
C50	100 (689)
C75	150 (1034)
C100	200 (1379)
C125	250 (1723)
C150	300 (2068)
C175	350 (2412)
C200	400 (2757)
C225	450 (3102)
C250	500 (3445)

TABLE 6 Long-Term Hydrostatic Pressure Categories

Class	Minimum Calculated Values of Long-Term Hydrostatic Pressure. gage, psi (kPa)
C50	90 (621)
C75	135 (931)
C100	180 (1241)
C125	225 (1551)
C150	270 (1862)
C175	315 (2172)
C200	360 (2482)
C225	405 (2792)
C250	450 (3103)

TABLE 7 Minimum Stiffness at 5 % Deflection

Nominal Diameter, in.	Pipe Stiffness, psi (kPa)			
	Designation			
	A	B	C	D
8	. . .	. . .	36 (248)	72 (496)
10	. . .	18 (124)	36 (248)	72 (496)
12 and greater	9 (62)	18 (124)	36 (248)	72 (496)

TABLE 8 Ring Deflection Without Damage or Structural Failure

	Nominal Pipe Stiffness, psi			
	9	18	36	72
Level A	18 %	15 %	12 %	9 %
Level B	30 %	25 %	20 %	15 %

may be proportionally adjusted to maintain equivalent in-use safety margins. For example, a 4 % long-term limiting deflection would result in a 20 % reduction of Level A and Level B deflections, while a 6 % limiting deflection would result in a 20 % increase in Level A and Level B deflection values. However, minimum values for Level A and Level B deflections shall be equivalent to strains of 0.6 and 1.0 % respectively (as computed by Eq X1.1 in Appendix X1).

6.7 *Hoop-Tensile Strength*—All pipe manufactured under this specification shall meet or exceed the hoop-tensile strength shown for each size and class in Table 9 and Table 10, when tested in accordance with 8.6.

6.7.1 *Alternative Requirements*—When agreed upon by the purchaser and the supplier, the minimum hoop tensile strength shall be as determined in accordance with 8.6.1.

6.8 *Joint Tightness*—The pipe joint shall meet the performance requirements of the applicable section of Specification D 4161. Restrained rigid joints (5.4.2.2, 5.4.2.3, 5.4.2.4, and 5.4.2.5) shall be exempt from angular deflection requirements.

6.9 *Longitudinal Strength:* :

6.9.1 *Beam Strength*—For pipe sizes up to 27 in. (686 mm), the pipe shall withstand, without failure, the beam loads specified in Table 11, when tested in accordance with 8.7.1. For pipe sizes larger than 27 in., and alternatively for smaller sizes, adequate beam strength is demonstrated by tensile and compression tests conducted in accordance with 8.7.2 and 8.7.3 respectively, for pipe wall specimens oriented in the longitudinal direction, using the minimum tensile and compression strengths specified in Table 11.

TABLE 9 Minimum Hoop Tensile Strength of Pipe Wall Inch-Pound Units

Nominal Diameter in.	Hoop Tensile Strength, lbf/in. Width								
	C50	C75	C100	C125	C150	C175	C200	C225	C250
8	800	1 200	1 600	2 000	2 400	2 800	3 200	3 600	4 000
10	1 000	1 500	2 000	2 500	3 000	3 500	4 000	4 500	5 000
12	1 200	1 800	2 400	3 000	3 600	4 200	4 800	5 400	6 000
14	1 400	2 100	2 800	3 500	4 200	4 900	5 600	6 300	7 000
15	1 500	2 250	3 000	3 750	4 500	5 250	6 000	6 750	7 500
16	1 600	2 400	3 200	4 000	4 800	5 600	6 400	7 200	8 000
18	1 800	2 700	3 600	4 500	5 400	6 300	7 200	8 100	9 000
20	2 000	3 000	4 000	5 000	6 000	7 000	8 000	9 000	10 000
21	2 100	3 150	4 200	5 250	6 300	7 350	8 400	9 450	10 500
24	2 400	3 600	4 800	6 000	7 200	8 400	9 600	10 800	12 000
27	2 700	4 050	5 400	6 750	8 100	9 450	10 800	12 150	13 500
30	3 000	4 500	6 000	7 500	9 000	10 500	12 000	13 500	15 000
33	3 300	4 950	6 600	8 250	9 900	11 450	13 200	14 850	16 500
36	3 600	5 400	7 200	9 000	10 800	12 600	14 400	16 200	18 000
39	3 900	5 850	7 800	9 750	11 700	13 650	15 600	17 550	19 500
42	4 200	6 300	8 400	10 500	12 600	14 700	16 800	18 900	21 000
45	4 500	6 750	9 000	11 250	13 500	15 750	18 000	20 250	22 500
48	4 800	7 200	9 600	12 000	14 400	16 800	19 200	21 600	24 000
54	5 400	8 100	10 800	13 500	16 200	18 900	21 600	24 300	27 000
60	6 000	9 000	12 000	15 000	18 000	21 000	24 000	27 000	30 000
66	6 600	9 900	13 200	16 500	19 800	23 100	26 400	29 700	33 000
72	7 200	10 800	14 400	18 000	21 600	25 200	28 800	32 400	36 000
78	7 800	11 700	15 600	19 500	23 400	27 300	31 200	35 100	39 000
84	8 400	12 600	16 800	21 000	25 200	29 400	33 600	37 800	42 000
90	9 000	13 500	18 000	22 500	27 000	31 500	36 000	40 500	45 000
96	9 600	14 400	19 200	24 000	28 800	33 600	38 400	43 200	48 000
102	10 200	15 300	20 400	25 500	30 600	35 700	40 800	45 900	51 000
108	10 800	16 200	21 600	27 000	32 400	37 800	43 200	48 600	54 000
120	12 000	18 000	24 000	30 000	36 000	42 000	48 000	54 000	60 000
132	13 200	19 800	26 400	33 000	39 600	46 200	52 800	59 400	66 000
144	14 400	21 600	28 800	36 000	43 200	50 400	57 600	64 800	72 000

Note—The values in this table are equal to 2*PD*, where *P* is the pressure class in psi and *D* is the nominal diameter in inches.