



Designation: D710 – 19

Standard Specification for Vulcanized Fibre Sheets, Rolls, Rods, and Tubes Used for Electrical Insulation¹

This standard is issued under the fixed designation D710; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers vulcanized fibre (Note 1) sheets, rolls, round rods, and round tubes of such grades suitable for use as electrical insulation.

NOTE 1—The variant spelling “fibre” has been approved by Committee D09 for use in this standard.

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 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:²

- D495 Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation
- D619 Test Methods for Vulcanized Fibre Used for Electrical Insulation
- D696 Test Method for Coefficient of Linear Thermal Expansion of Plastics Between -30°C and 30°C with a Vitreous Silica Dilatometer
- D952 Test Method for Bond or Cohesive Strength of Sheet Plastics and Electrical Insulating Materials
- D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials

¹ This specification is under the jurisdiction of ASTM Committee D09 on Electrical and Electronic Insulating Materials and is the direct responsibility of Subcommittee D09.07 on Electrical Insulating Materials.

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² 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.

2.2 Other Documents:³

IEEE Publication No. 1, “General Principles for Temperature Limits in the Rating of Electrical Equipment.”

3. Terminology

3.1 Definitions:

3.1.1 *vulcanized fibre, n*—a material made from chemically gelatinized cellulosic paper or board using zinc chloride as the gelatinizing agent.

3.1.1.1 *Discussion*—The zinc chloride is subsequently removed by leaching. The resulting product, after being dried and finished by calendering, is a material of partially regenerated cellulose in which the fibrous structure is retained in varying degrees depending on the grade of paper used and on the processing conditions. Vulcanized fibre does not contain vulcanized rubber or sulfur as the name might imply. It is almost completely pure cellulose, with a trace amount of zinc chloride.

4. Grades

4.1 Three grades of vulcanized fibre are covered, as follows:

4.1.1 *Bone Grade*—This grade is characterized by the greater hardness and stiffness associated with higher density. It machines more smoothly and with less tendency to separate the plies in difficult machining operations than the other grades. It is made in thickness of $\frac{1}{64}$ to $\frac{1}{16}$ in. (0.38 to 1.59 mm).

4.1.2 *Commercial Grade*—This grade is considered as the general-purpose grade and is sometimes referred to as mechanical and electrical grade. It possesses good physical and electrical properties and can be fabricated satisfactorily by punching, turning, and forming operations. It is made in thicknesses from 0.005 to 0.100 in. (0.12 to 2.54 mm).

4.1.3 *Electrical Insulation Grade*—This grade is intended primarily for electrical applications and others involving difficult bending or forming operations. It is made in thicknesses from 0.005 to $\frac{3}{32}$ in. (0.12 to 2.35 mm). Thin material of this grade is sometimes referred to as “fish paper.”

³ Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., P.O. Box 1331, Piscataway, NJ 08854-1331, <http://www.ieee.org>.

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

4.2 Commercial Fibre which is thicker than 0.100 in. (2.54 mm) is primarily laminated from thinner sheets of vulcanized fibre, although some homogeneous fibre is commercially available. Laminated (or built-up) fibre is composed of a number of plies of vulcanized fibre bonded together with a suitable adhesive. It retains all the basic properties of solid fibre, including high arc resistance on edges and faces, and in addition has better dimensional stability and less warpage. Thicknesses up to 4 in. (102 mm) are commercially available. Laminated Fibre is generally, but not always, dense enough to also qualify as Bone Grade.

5. Forms and Colors

5.1 Vulcanized fibre is available in the forms and colors listed in Table 1.

6. Chemical Composition

6.1 The material shall conform to the requirements for chemical composition prescribed in Table 2.

7. Detail Requirements

7.1 Sheets and Rolls—Sheet and Roll material, unless otherwise specified, shall conform to the requirements as to physical and electrical properties prescribed in Tables 3-9.

7.1.1 Bond Strength (Laminated Sheets Only)—Tested in accordance with Test Method D952 shall conform to the following requirements:

Thicknesses	Psi, (MPa) min
All	800 (5.5)

7.2 Round Rods—Round rods shall conform to the requirements as to physical properties prescribed in Tables 10 and 11, and Table 12.

7.3 Round Tubes—Round tubes shall conform to the requirements as to physical and electrical properties prescribed in Tables 13 and 14. Density of tubing shall conform to the requirements prescribed in Table 6 for the respective grade and thickness.

8. Sheet Sizes and Permissible Variations

8.1 Sheets shall be furnished in the manufacturer’s standard sheet sizes.

NOTE 2—The range of manufacturer’s standard sizes for the various grades and thicknesses are shown in Table 15.

8.2 When sheets and rolls are trimmed to a specified width, the maximum permissible variation in width is ± 1/2 in. (± 12.7 mm).

TABLE 1 Forms and Colors Available

Grades	Forms ^A	Colors ^B
Bone	sheets, rolls and rods, tubes	gray, black, red
Commercial	sheets, rolls and rods	gray, black, red, white
Electrical	sheets and rolls	gray, blue
Insulation		

^A Sheets and rods are available in both single-layer and laminated form.
^B In any of these standard colors, it is possible that there will be considerable variation of shade.

TABLE 2 Chemical Requirements

Grade	Color	Zinc Chloride, max. %	Ash max. %	Silica Content, max. %
All	gray, black, white, blue	0.1	1.5	0.3
	red	0.1	7	0.3

TABLE 3 Flexural Strength Requirement for Sheets and Rolls, min, psi (MPa)

Nominal Thickness in. (mm)	Bone Grade		Commercial Grade	
	Length-wise	Cross-wise	Length-wise	Cross-wise
1/16 (1.59) up to 1/8 (3.18), incl	16 000 (110)	14 000 (97)	15 000 ^A (103)	13 000 ^A (90)
Over 1/8 (3.18) to 1/2 (12.7), incl	15 000 (103)	13 000 (90)	14 000 (97)	12 000 (83)
Over 1/2 (12.7) to 1 (25.4), incl	...	...	13 000 (90)	11 000 (76)

^A These two values also apply to Electrical Insulation Grade.

TABLE 4 Water Absorption and Dielectric Strength Requirements for Sheets and Rolls

Grade	Nominal Thickness, in. (mm)	Water Absorption, ^A max. %		Dielectric Strength, ^B min, V/mil (kV/mm)	
		2 h	24 h		
Bone	1/32 (0.79)	55	63	175 (6.9)	
	1/16 (1.59)	30	55	175 (6.9)	
	1/8 (3.18)	20	48	150 (5.9)	
	3/16 (4.76)	17	42	100 (3.9)	
	1/4 (6.35)	14	37	100 (3.9)	
	Commercial	1/32 (0.79)	60	68	175 (6.9)
		1/16 (1.59)	52	66	175 (6.9)
		1/8 (3.18)	35	61	150 (5.9)
		3/16 (4.76)	24	56	100 (3.9)
		1/4 (6.35)	20	52	100 (3.9)
5/16 (7.94)		17	47	100 (3.9)	
3/8 (9.52)		15	43	100 (3.9)	
7/16 (11.11)		14	39	50 (2.0)	
1/2 (12.7)		13	36	50 (2.0)	
5/8 (15.88)		11	31	^A	
3/4 (19.05)	10	27	^A		
7/8 (22.22)	8	23	^A		
1 (25.4)	8	21	^A		
1 1/4 (31.8)	8	18	^A		
1 1/2 (38.1)	8	17	^A		
2 (50.8) and over	8	17	^A		
Electrical insulation	0.005 to 0.007 (0.12 to 0.18), incl	...	...	200 (7.9)
	over 0.007 to 0.040 (0.18 to 1.02), incl	...	...	250 (9.8)
	over 0.040 to 1/8 (1.02 to 3.18), incl	...	...	175 (6.9)
	1/32 (0.80)	60	68	...	
	1/16 (1.59)	52	66	...	
	1/8 (3.17)	35	61	...	

^A For intermediate thicknesses, the value for the next smaller thickness shall apply.
^B For intermediate thicknesses, the value for the next larger thickness shall apply.

8.3 When sheets are trimmed to a specified length, the maximum permissible variation in length is ± 1/2 in.

8.4 The maximum permissible variations in widths of strips cut from sheets by the indicated operations are as prescribed in Table 16.

TABLE 5 Bursting Strength Requirements for Sheets and Rolls, min, psi (MPa)

Nominal Thickness, in. (mm)	Bone Grade	Commercial Grade	Electrical Insulation Grade
0.005 (0.13)	...	...	65 (0.4)
0.007 (0.18)	...	...	95 (8.7)
0.010 (0.25)	...	125 (0.9)	125 (0.9)
0.012 (0.30)	...	150 (1.0)	150 (1.0)
0.015 (0.38)	...	185 (1.3)	185 (1.3)
0.020 (0.51)	...	250 (1.7)	250 (1.7)
0.030 (0.76)	325 (2.2)	375 (2.6)	375 (2.6)
0.045 (1.14)	470 (3.2)	560 (3.9)	560 (3.9)
0.060 (1.52)	550 (3.8)	750 (5.2)	750 (5.2)

TABLE 6 Density Requirements for Sheets and Rolls, min, g/cm^{3A}

Nominal Thickness or Diameter, in. (mm)	Commercial Grade	Electric Insulation Grade
Under 0.010 (0.25)	0.95	0.95
0.010 to 0.015 incl, (0.25 to 0.38)	1.00	1.00
Over 0.015 to 3/32 incl, (0.38 to 2.38)	1.15	1.15
Over 3/32 to 1/8 incl, (2.38 to 3.18)	1.20	1.20
Over 1/8 to 5/16 incl, (3.18 to 15.88)	1.20	...
Over 5/16 to 1 incl, (15.88 to 25.4)	1.10	...
Over 1 to 1 1/4 incl, (25.4 to 31.8)	1.05	...
Over 1 1/4 (31.8)	1.01	...

^A The minimum density of all forms and thicknesses of bone grade shall be 1.30 g/cm³.

TABLE 7 Tearing Strength Requirements for Sheets and Rolls, Electric Insulation Grade

Nominal Thickness, in. (mm)	Machine Direction, min, g	Cross Direction, min, g
0.005 (0.13)	75	100
0.007 (0.18)	150	175
0.010 (0.25)	225	275
0.012 (0.30)	275	335
0.015 (0.38)	350	425

TABLE 8 Impact Strength Requirements for Sheets

Grade	Nominal Thickness, in. (mm)	Impact Strength, Izod, Edgewise Notched, min, ft-lb/in. J/m of notch	
		Lengthwise	Crosswise
Bone	1/16 to 1/4 (1.59 to 6.35)	1.4 (75)	1.0 (53)
Commercial	1/16 to 1/4 (1.59 to 6.35)	1.6 (85)	1.2 (64)
Electrical insulation	1/16 to 1/8 (1.59 to 3.2)	1.6 (85)	1.2 (64)

TABLE 9 Hardness Requirements for Sheets 1/16 in. (1.6 mm) or More in Thickness

Grade	Rockwell Hardness, min
Bone	R 80
Commercial	R 50

8.5 The maximum permissible variation in thickness of sheets and rolls is as prescribed in **Table 17**.

9. Rod Sizes and Permissible Variations

9.1 Furnish rods in the same nominal sizes as sheets. Cut rods from sheet, the length being limited by the length of the sheet.

TABLE 10 Tensile Strength Requirements for Round Rods, min, psi (MPa)

Nominal Diameter, in. (mm)	Bone Grade	Commercial Grade
1/8 to 1/2 (3.18 to 12.7), incl	8500 (59)	8000 (55)
Over 1/2 (12.7)	...	7000 (48)

TABLE 11 Water Absorption Requirements for Round Rods

Grade	Nominal Diameter, in. (mm)	Water Absorption, max, %	
		2 h	24 h
Bone	1/16 to 3/16 (1.59 to 4.76), incl	35	75
	over 3/16 to 1/4 (4.76 to 6.35), incl	15	50
Commercial	1/16 to 3/16 (1.59 to 4.76), incl	40	80
	over 3/16 to 1/2 (4.76 to 12.7), incl	20	60
	over 1/2 to 1 (12.7 to 25.4), incl	10	30
	over 1	8	25

TABLE 12 Density Requirements for Round Rods

Grade	Nominal Diameter, in. (mm)	Density g/cm ³ , min
Bone	1/16 to 3/32 (1.59 to 2.38), incl	1.15
	over 3/32 (2.38)	1.30
Commercial	over 3/32 to 5/8 (2.38 to 15.88), incl	1.20
	over 5/8 to 1 (15.88 to 25.4), incl	1.10
	over 1 to 1 1/4 (25.4 to 31.8), incl	1.05
	over 1 1/4 (31.8)	1.01

TABLE 13 Compressive Strength Requirement for Round Tubes

Grade	Nominal Wall Thickness, in. ^A (mm)	Axial Compressive Strength, min, psi (MPa)
Bone and commercial	up to 1/8 (3.18), incl	11 000 (76)
	over 1/8 to 5/16 (3.18 to 7.94), incl	12 000 (83)

^A Wall thickness 1/32 in. min; outside diameter 2.0 in. max.

9.2 The maximum permissible variations in diameters of rods are as shown in **Table 18**.

9.3 The maximum permissible variations in lengths of circular sawed pieces of rods are as shown in **Table 19**.

10. Tube Sizes and Permissible Variations

10.1 The sizes of tubing are as shown in **Table 20** and **Table 21**.

10.2 The maximum permissible variations in inside and outside diameters of tubes are as shown in **Table 22**.

10.3 The maximum permissible variations in length of circular sawed pieces of tubes are as shown in **Table 23**.

11. Workmanship

11.1 The material shall be uniform in quality and consistent with the properties prescribed in this specification. It shall be free of blisters, and reasonably free of wrinkles, cracks, scratches, and dents.

TABLE 14 Water Absorption and Dielectric Strength Requirements for Round Tubes

Grade	Nominal Wall Thickness, in. (mm)	Water Absorption, max, %		Dielectric Strength, min, V/mil (kV/mm)
		2 h	24 h	
Bone and commercial	up to 1/16 (1.59)	...	...	175 (6.9)
	over 1/16 to 1/8 (1.59 to 3.18), incl	...	...	150 (5.9)
	1/32 to 1/8 (0.79 to 3.18), incl	50	75	...
	over 1/8 to 1/4 (3.18 to 6.35), incl	20	50	100 (3.9)
	over 1/4 to 5/16 (6.35 to 7.94), incl	10	25	100 (3.9)

TABLE 15 Range of Manufacturers' Sheet Sizes

NOTE 1—Due to variations in the size of manufacturing equipment, there is some variation in the length and width of manufacturers' standard sheet sizes. Consult manufacturers' catalogs for sizes available. The ranges of manufacturers' standard sheet sizes are as follows:

Grade	Width, in. (mm)	Length, in. (mm)
Bone	48 to 54 (1219 to 1322)	66 to 86 (1676 to 2184)
	48 to 58 (1219 to 1473)	72 to 90 (1829 to 2286)
Commercial	48 to 58 (1219 to 1473)	78 to 90 (2032 to 2286)
Electrical insulation	48 to 58 (1219 to 1473)	39 to 90 (991 to 2286)
Laminated form	48 to 52 (1219 to 1320)	39 to 90 (991 to 2286)

TABLE 16 Permissible Variations in Widths of Strip Cut from Sheets of All Grades, Plus or Minus, in.^A

Width, in. (mm)	Permissible Variations, in. (mm)			
	Slit (Ribbon Rolls)	Sheared	Band Sawed	Smooth Sawed
3/16 (4.76) and under	0.010	0.015	0.020	0.006
1/4 to 1/2 (6.35 to 12.7), incl	0.015	0.020	0.030	0.008
5/16 to 1 (14.29 to 25.4), incl	0.020	0.030	0.045	0.010
1 1/8 to 2 (28.58 to 50.8), incl	0.030	0.040	0.060	0.012
Over 2 to 4 (50.8 to 101.6)	0.040	0.050	0.075	0.014

^A On strip of widths not listed in this table, the permissible variations shall be the same as for the next greater width.

TABLE 17 Permissible Variations in Thickness of Full Sheets and Rolls of all Grades^A

Nominal Thickness, in. (mm)	Tolerance, plus or minus, in. (mm)
0.004 to 0.040 (0.10 to 1.02)	10 %
0.041 to 0.049 (1.04 to 1.24)	0.004 (0.10)
0.050 to 0.062 (1.27 to 1.57)	0.005 (0.13)
0.063 to 0.094 (1.60 to 2.39)	0.007 (0.18)
0.095 to 0.125 (2.41 to 3.18)	0.010 (0.25)
0.126 to 0.188 (3.20 to 4.78)	0.025 (0.64)
0.189 to 0.250 (4.80 to 6.35)	0.030 (0.76)
over 1/4 to 3/8 (6.35 to 9.5), incl	0.035 (0.89)
over 3/8 to 1/2 (9.5 to 12.7), incl	0.040 (1.02)
over 1/2 to 5/8 (12.7 to 15.9), incl	0.045 (1.14)
over 5/8 to 3/4 (15.9 to 19.0), incl	0.055 (1.40)
over 3/4 to 1 (19.0 to 25.4), incl	0.070 (1.78)
over 1 to 1 1/4 (25.4 to 31.8), incl	0.090 (2.29)
over 1 1/4 to 1 1/2 (31.8 to 38.1), incl	0.110 (2.79)
over 1 1/2 to 1 3/4 (38.1 to 44.4), incl	0.130 (3.30)
over 1 3/4 to 2 (44.4 to 50.8), incl	0.140 (3.56)
over 2 to 2 1/4 (50.8 to 57.2), incl	0.160 (4.06)
over 2 1/4 to 2 1/2 (57.2 to 63.5), incl	0.175 (4.44)
over 2 1/2 to 2 3/4 (63.5 to 69.9), incl	0.190 (4.83)
over 2 3/4 to 3 (69.9 to 76.2), incl	0.210 (5.33)
over 3 to 3 1/4 (76.2 to 82.6), incl	0.225 (5.72)
over 3 1/4 to 3 1/2 (82.6 to 88.9), incl	0.240 (6.10)
over 3 1/2 to 3 3/4 (88.9 to 95.3), incl	0.260 (6.60)
over 3 3/4 to 4 (95.3 to 101.6), incl	0.280 (7.11)

^A On sheets of nominal thickness not listed in this table, the permissible variations shall be the same as for the next greater thickness.

12. Sampling

12.1 To determine conformance with the requirements of this specification, sample lots in accordance with Inspection Level S-2 of Practice D3636.

13. Test Methods

13.1 Condition vulcanized fibre and test in accordance with Test Method D619.

14. Inspection

14.1 The purchaser and supplier shall agree upon the inspection as part of the purchase contract.

15. Rejection and Rehearing

15.1 Material that fails to meet the requirements of this specification is subject to rejection. When the number of defectives for any test are in excess of the acceptance number for that test as determined by the AQL value agreed upon between the supplier and the user, this shall constitute a basis for rejection.

15.2 Report rejection to the producer or supplier promptly and in writing. In the case of dissatisfaction with the actions

TABLE 18 Permissible Variations in Diameter of Round Rods of All Grades, Plus or Minus, in.

Nominal Diameter, in. (mm)	Bone Grade	Commercial Grade
1/16 to 1/4 (1.59 to 6.35), incl	0.005	0.005
Over 1/4 to 1/2 (6.35 to 12.7), incl	0.006	0.006
Over 1/2 to 1 (12.7 to 25.4), incl	...	0.006
Over 1 to 2 (25.4 to 50.8), incl	...	0.010

TABLE 19 Permissible Variations in Length of Rods of All Grades

Nominal Length, in. (mm)	Permissible Variations in Length as Cut, plus or minus, in. (mm)
0 to 3 (76.2), incl	0.015 (0.38)
Over 3 to 6 (76.2 to 152.4), incl	0.020 (0.51)
Over 6 to 12 (152.4 to 304.8), incl	0.030 (0.76)
Over 12 to 24 (304.8 to 609.6), incl	0.035 (0.89)
Over 24 to 48 (609.6 to 1219.2), incl	0.040 (1.02)
Over 48 to 84 (1219.2 to 2133.6), incl	0.062 (1.57)

taken as a result of these tests, the producer or supplier is entitled to make a claim for a rehearing.

16. Certification

16.1 When specified in the purchase order or contract, furnish a producer's or supplier's certification to the purchaser that the material was manufactured, sampled, tested, and