Designation: D 3664 – 00

An American National Standard

Standard Specification for Biaxially Oriented Polymeric Resin Film for Capacitors in Electrical Equipment[1]

This standard is issued under the fixed designation D 3664; 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 thin biaxially oriented polymeric resin film for use in capacitors for electrical equipment. The material is biaxially oriented to improve the tensile properties in the machine (MD) and transverse (TD) directions.

1.2 The following safety hazards caveat pertains only to the test methods section 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.* For specific warning statements see 9.3 and Table 1 footnote B.

1.3 The values stated in SI units are the standard. The values in parentheses are for information only.

NOTE 1—This standard resembles IEC 60674–3–2, Specification for plastic films for electrical use, in title only. The content is significantly different.

2. Referenced Documents

2.1 *ASTM Standards:*

D 149 Test Methods for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies[2]

D 150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials[2]

D 202 Test Methods for Sampling and Testing Untreated Paper Used for Electrical Insulation[2]

D 257 Test Methods for D–C Resistance or Conductance of Insulating Materials[2]

D 374 Test Methods for Thickness of Solid Electrical Insulation[2]

D 543 Test Method for Resistance of Plastics to Chemical Reagents[3]

D 570 Test Method for Water Absorption of Plastics[3]

D 756 Practice for Determination of Weight and Shape Changes of Plastics Under Accelerated Service Conditions[3]

D 774 Test Method for Bursting Strength of Paper[4]

D 882 Test Methods for Tensile Properties of Thin Plastic Sheeting[3]

D 1004 Test Method for Initial Tear Resistance of Plastic Film and Sheeting[3]

D 1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature[3]

D 1434 Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting[4]

D 1435 Practice for Outdoor Weathering of Plastics[3]

D 1505 Test Method for Density of Plastics by the Density-Gradient Technique[3]

D 2176 Test Method for Folding Endurance of Paper by the M.I.T. Tester[4]

D 2305 Test Methods for Polymeric Films Used for Electrical Insulation[2]

D 2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)[5]

D 3417 Test Method for Heats of Fusion and Crystallization of Polymers by Thermal Analysis[5]

D 3420 Test Method for Dynamic Ball Burst (Pendulum) Impact Resistance of Plastic Film[5]

D 3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials[6]

D 3755 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials Under Direct-Voltage Stress[6]

[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 Flexible and Rigid Insulating Materials.

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[2] *Annual Book of ASTM Standards*, Vol 10.01.

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

[4] *Annual Book of ASTM Standards*, Vol 15.09.

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

[6] *Annual Book of ASTM Standards*, Vol 10.02.

D 3985 Test Method for Oxygen Gas Transmission Rate Through Plastic Film and Sheeting Using a Coulometric Sensor[4]

D 6054 Practice for Conditioning Electrical Insulating Materials for Testing[6]

E 96 Test Methods for Water Vapor Transmission of Materials[7]

E 252 Test Method for Thickness of Thin Foil and Film by Weighing[8]

2.2 *IEC Standards:*

IEC 60674–3–2 Specification for plastic films for electrical purposes—Part 3: Specifications for individual materials—Sheet 2: Requirements for balanced biaxially oriented polyethylene phthalate (PET) films used for electrical insulation[9]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *shiner*, *n—as related to dielectric films*, a protrusion of material beyond the plane of either edge of the roll.

3.1.2 *space factor*, *n— as related to dielectric films*, a measure of surface roughness of film expressed by the following equation:

$$\text{Space factor} = 100\,[T_b - T_g]\,[T_g]^{-1} \quad (1)$$

where:

T_b = bulking thickness determined using Test Methods D 374, and

T_g = gravimetric thickness determined using Test Method E 252.

Space factor is expressed as %.

TABLE 1 Physical, Mechanical, and Electrical Requirements for Biaxially Oriented Polyethylene Terephthalate Capacitor Film (25.4 µm or less in thickness)[A]

Tensile Properties

Tensile strength modulus, and elongation, MD and TD:

Nominal Thickness, µm	Tensile Strength, min, MPA MD and TD	Break Elongation, % min MD	Break Elongation, % min TD	Tensile Modulus min, MPa MD and TD
1.5	110	40	20	2410
1.8	110	40	20	2410
2.0	110	...	30	2410
2.5	117	...	35	2410
3.0	131	...	35	2410
3.5	131	...	35	2716
4.0	131	45		2716
5.0	138	...	40	3103
6.0	138	...	40	3103
8.0	145	...	45	3103
10.0	145	...	50	3103
12.0	145	...	60	3103
19.0	145	...	60	2759
23.0	145	...	65	2759

Insulation resistance and conducting paths:

TABLE 1 *Continued*

Nominal Thickness, µm	Insulation Resistance, min MΩ at 125°C	Conducting Paths, max No. per m²
1.5	1000	...
1.8	1000	...
2.0	1000	...
2.5	850	...
3.0	850	...
3.5	850	128
4.0	825	107
5.0	825	86
6.0	800	64
8.0	600	53
10.0	600	43
12.0	600	22
19.0	500	11
23.0	400	11

Permittivity, 23°C, 50 % RH:

60 Hz	3.2 ± 0.1
1 kHz	3.2 ± 0.1

Dissipation factor, max 23°C:

	60 Hz	1 kHz
2.0 to 4.0 µm thick	0.006	0.008
5.0 to 25.0 µm thick	0.004	0.006

Thickness, µm:

Nominal Thickness, µm	Average Thickness per Single-Slit Roll: Based on Roll Weight min	max	Ten-Sheet Stack min	max
1.5	1.48	1.62	...	...
1.8	1.61	1.89	...	...
2.0	1.79	2.11	1.50	3.00
2.5	2.30	2.70	2.03	3.56
3.0	2.71	3.19	2.54	4.06
3.5	3.10	3.69	3.05	4.57
4.0	3.72	4.28	3.81	5.33
5.0	4.65	5.25	4.57	6.10
6.0	5.64	6.36	5.59	7.11
8.0	7.52	8.48	7.62	9.14

Nominal Thickness, µm	Average Thickness per Single-Slit Roll, µm: Based on Roll Weight min	max	Ten-Sheet Stack min	max
10.0	9.40	10.60	9.40	11.43
12.0	11.28	12.72	11.43	13.46
19.0	18.05	19.95	17.78	20.32
23.0	21.85	24.15	21.84	24.89

Width tolerance, variation from nominal, mm:	
less than 76 mm	±0.2
76 to 152 mm	±0.4
over 152 to 456 mm	±0.8
over 456 mm	±1.6
Density, 23/23°C, g/cm³ [B]	1.385 to 1.410
Melting point, min,° C	252
Shrinkage, max, MD and TD at 150 ± 1°C, %	3.0 MD, 2.0 TD

Dielectric breakdown voltage, dc:

Number of capacitors that must survive the critical test voltage per 20 capacitors[C]

Critical test voltage, V	Thickness, µm: 1.5	1.8	2.0	2.5	3.0	3.5	4.0	5.0	6.0	8.0	10.0	12.0	19.0	23.0
100			18											
200				17		18	18							
300					17			18						
400						17								
500							17		19					
600								17		19	19			
800												19		
1000									18				19	
1200										18				
1600											18			
1800												18		

[7] *Annual Book of ASTM Standards*, Vol 04.06.

[8] *Annual Book of ASTM Standards*, Vol 02.02.

[9] Available from American National Standards Institute, 11 W. 42nd Street, New York, NY 10036.

TABLE 1 *Continued*

2200												18	19
Min avg dc voltage of 20 capacitors	100	175	200	300	500	600	700	900	1500	2000	2400	2800	3700	4000

[A] See Section 9 for Test Methods.

[B] Use 1,3-dibromopropane and n-heptane for preparing density gradient tube. **Warning**—n-heptane is flammable and volatile.

[C] This number has been statistically determined. Normally it will be met by any group of 20 capacitors. However, to definitely prove statistically that the specified number has been met for any mill roll lot of materials, it will be necessary to wind 60 capacitors from 3 slit rolls (20 from rolls A and B, 20 from rolls B and C, and 20 from A and C). If the average of the 3 groups is lower than the allowable number, the material is rejectable.

Aqueous extract conductivity, max, µS/cm	2
Acidity, max, milliequivalents/g	0.002

4. Classification

4.1 This specification covers the following:

4.1.1 *Type I*—having smooth surfaces (space factor <5 %, see 3.1.2);

4.1.1.1 *Grade 1*—not pre-treated,

4.1.1.2 *Grade 2*—one side pre-treated to facilitate the vacuum deposition of metal, and

4.1.1.3 *Grade 3*—both sides pre-treated.

4.1.2 *Type II*—having at least one rough surface (space factor ≥5 %, see 3.1.2);

4.1.2.1 *Grade 1*—not pre-treated,

4.1.2.2 *Grade 2*—one side pre-treated to facilitate the vacuum deposition of metal, and

4.1.2.3 *Grade 3*—both sides pre-treated.

4.2 *Materials*:

4.2.1 *Class A*—polyethylene terephthalate (PET).

4.2.2 *Class B*—polypropylene (PP).

5. General Requirements

5.1 The material shall be of uniform composition, and as free from metal particles, contamination, blisters, holes, and other imperfections as commercially feasible.

5.2 Information of general engineering interest is given in the Appendix.

6. Detail Requirements

6.1 The material shall conform to requirements prescribed in Table 1 or Table 2.

7. Sampling

7.1 Define an inspection lot as all material of the same thickness from the same mill roll.

7.2 Unless otherwise agreed upon between the purchaser and seller, sample material for test according to Practice D 3636. Set inspection levels and acceptable quality levels (AQL) as agreed upon between the purchaser and seller.

8. Conditioning

8.1 If required, condition the test specimens in accordance with Procedure A of Practice D 6054 and Test Methods D 2305.

8.2 Use test conditions in accordance with Practice D 6054, unless otherwise specified.

TABLE 2 Physical, Mechanical, and Electrical Requirements for Biaxially Oriented Polypropylene Capacitor Film (25.4 µm or less in thickness)[A]

Property		Value
Tensile strength, min, MPA (MD or TD)	Type I	120
	Type II	90
Elongation, min, % (MD or TD)	Type I	40
	Type II	30

Conducting Paths Nominal Thickness, µm	Conducting Paths, max per m^2
4.0	2.6
5.0	2.3
6.0	1.8
7.0	1.7
7.4	1.7
8.0	1.5
9.0	1.3
10.0	1.2
10.1	1.2
11.0	1.1
12.0 or greater	1.0

Permittivity, 23°C, 50% RH	
60 Hz	2.2 ± 0.1
1 kHz	2.2 ± 0.1
Dissipation Factor, 23°C, 50 % RH	
60 Hz	0.003
1 kHz	0.0002
Thickness Tolerance, µm	±10 %
Width Tolerance, mm	
up to 50 mm	±0.5 mm
over 50 mm to 300 mm	±1.0 mm
over 300 mm to 450 mm	±2.0 mm
over 450 mm to 750 mm	±4.0 mm
Density, 23°C, g/cm^3[B]	0.91 ± 0.01
Melting Point, min,° C	165
Shrinkage, max	To be agreed upon by purchaser and manufacturer

Dielectric Breakdown Voltage, dc:

Nominal Film Thickness	Average Breakdown Voltage, V	Not more than 1 of 21 results shall be below, V
4.0	480	160
5.0	750	300
6.0	1140	480
7.0	1610	700
7.4	1700	740
8.0	2000	960
9.0	2430	1305
10.0	2900	1650
10.1	2930	1665
11.0	3300	1925
12.0	3720	2220
12.7	4000	2475
25.0	8000	5000

[A] See Section 9 for Test Methods.

[B] Use methanol and ethylene-glycol for preparing density gradient tube.

9. Test Methods

9.1 *Tensile Strength, Modulus, and Elongation*—Test Methods D 882, Method A. Test at 50 mm/min (2 in./min) with an initial jaw separation of 50-mm (2-in.). Test a 25-mm (1-in.) width or the width as received, if less.

9.2 *Density*—Test Method D 1505.

9.3 *Permittivity and Dissipation Factor*—Test Methods D 150. Use a maximum applied voltage of 30 V ac. Use the fluid displacement method. Recommended fluids are air, *n*-heptane, or 1 or 5×10^{-6} m^2/s (cSt) silicone fluid having a dissipation factor less than 0.00001. Conducting paint, sprayed