Designation: D3664 – 04 (Reapproved 2009)

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

This standard is issued under the fixed designation D3664; 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 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.

1.3 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.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D149 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation

D202 Test Methods for Sampling and Testing Untreated Paper Used for Electrical Insulation

D257 Test Methods for DC Resistance or Conductance of Insulating Materials

D374 Test Methods for Thickness of Solid Electrical Insulation (Withdrawn 2013)[3]

D543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D570 Test Method for Water Absorption of Plastics

D756 Practice for Determination of Weight and Shape Changes of Plastics Under Accelerated Service Conditions (Withdrawn 1998)[3]

D774/D774M Test Method for Bursting Strength of Paper (Withdrawn 2010)[3]

D882 Test Method for Tensile Properties of Thin Plastic Sheeting

D1004 Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting

D1204 Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature

D1434 Test Method for Determining Gas Permeability Characteristics of Plastic Film and Sheeting

D1435 Practice for Outdoor Weathering of Plastics

D1505 Test Method for Density of Plastics by the Density-Gradient Technique

D2176 Test Method for Folding Endurance of Paper by the M.I.T. Tester (Withdrawn 2010)[3]

D2305 Test Methods for Polymeric Films Used for Electrical Insulation

D2863 Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)

D3417 Test Method for Enthalpies of Fusion and Crystallization of Polymers by Differential Scanning Calorimetry (DSC) (Withdrawn 2004)[3]

D3420 Test Method for Pendulum Impact Resistance of Plastic Film

D3636 Practice for Sampling and Judging Quality of Solid Electrical Insulating Materials

D3755 Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials Under Direct-Voltage Stress

D3985 Test Method for Oxygen Gas Transmission Rate

[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] 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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

Through Plastic Film and Sheeting Using a Coulometric Sensor

D6054 Practice for Conditioning Electrical Insulating Materials for Testing (Withdrawn 2012)[3]

E96/E96M Test Methods for Water Vapor Transmission of Materials

E252 Test Method for Thickness of Foil, Thin Sheet, and Film by Mass Measurement

2.2 *IEC Standards:*[4]

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

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

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:

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

where:

T_b = bulking thickness determined using Test Methods D374, and

T_g = gravimetric thickness determined using Test Method E252.

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		Tensile Modulus min, MPa MD and TD
		MD	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:		
Nominal Thickness, µm	Insulation Resistance, min MΩ at 125°C	Conducting Paths, max No. per m^2
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,	Average Thickness per Single-Slit Roll			
	Based on Roll Weight		Ten-Sheet Stack	
µm	min	max	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		Ten-Sheet Stack	
	min	max	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/cm^3[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:

Critical test voltage, V	Number of capacitors that must survive the critical test voltage per 20 capacitors[C]													
	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		
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 For purposes of sampling, and inspection lot for examination shall consist of all film of the same type, grade, class, and nominal thickness submitted for inspection at one time. If a single shipment contains film having different lot numbers assigned by the film manufacturer, sample each lot number separately.

7.2 Unless otherwise agreed upon between the purchaser and seller, sample material for test according to Practice