Designation: D 3664 – 0~~0~~4

An American National Standard

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

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## 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.

[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. Referenced Documents

2.1 *ASTM Standards:* [2]

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

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

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

D 257 Test Methods for D-C DC Resistance or Conductance of Insulating Materials

D 374 Test Methods for Thickness of Solid Electrical Insulation

D 543 Test Method 543 Practices for Evaluating the Resistance of Plastics to Chemical Reagents

D 570 Test Method for Water Absorption of Plastics

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

D 774/D 774M Test Method for Bursting Strength of Paper

D 882 Test Methods for Tensile Properties of Thin Plastic Sheeting

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

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

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

D 1435 Practice for Outdoor Weathering of Plastics

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

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

D 2305 Test Methods for Polymeric Films Used for Electrical Insulation

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

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

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

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

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

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

D 6054 Practice for Conditioning Electrical Insulating Materials for Testing

E 96 Test Methods for Water Vapor Transmission of Materials

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

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

## 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 |
|---|---|

[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*, Vol 10.01. volume information, refer to the standard's Document Summary page on the ASTM website.

*Annual Book of ASTM Standards*, Vol 08.01.

[3] Withdrawn.

*Annual Book of ASTM*

[4] Available from American National Standards, Vol 15.09. Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

**TABLE 1** *Continued*

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, µm | Average Thickness per Single-Slit Roll | | | |
|---|---|---|---|---|
| | Based on Roll Weight | | Ten-Sheet Stack | |
| | 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 |

**TABLE 1** *Continued*

| | |
|---|---|
| Density, 23/23°C, g/cm$^{3B}$ | 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 ~~D~~For purposes of sampling, and inspection lot for examination shall consist of all ~~material~~ 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 ~~same mill roll.~~ 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 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.

**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.

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

## 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 $5 \times 10^{-6}$ $m^2/s$ (cSt) silicone fluid having a dissipation factor less than 0.00001. Conducting paint, sprayed or evaporated metal electrodes, are acceptable if care is taken to avoid errors as outlined in Test Methods D 150. In case of disagreement, use the fluid-displacement method as the referee method. (**Warning**—Heptane is readily flammable. Use proper precautions.

9.4 *Surface Resistivity and Volume Resistivity*—Test Methods D 257 with electrification for 60 s at 100 V dc.

9.5 *Melting Point*—Test Method D 3417.

9.6 *Shrinkage*—Test Method D 1204.

9.7 *Thickness*—Test Methods D 374, Procedures 6.2. See the Thickness Section of Test Methods D 202 for directions for handling ten-sheet stack specimens.

9.8 *Bursting Strength*—Test Method D 774/D 774M.

9.9 *Tear Strength*—Test Method D 1004.

9.10 *Impact Strength*—Test Method D 3420.

9.11 *Fold Endurance*—Test Method D 2176.

9.12 *Color or Clarity*—Visual observation.

9.13 *Moisture Absorption*—Test Method D 570, 24–~~24~~ h at 23°C.

9.14 *Moisture Permeability*—Test Methods E 96.

9.15 *Oxygen Index*—Test Method D 2863.

9.16 *Oxygen Permeability*—Test Method D 1434 or Test Method D 3985.

9.17 *Resistance to Corrosive Agents*—~~Test Method~~ Practices D 543 for acids, alkalies, and organic solvents; Test Methods E 96 for water; Practice D 1435 for sunlight.

9.18 Special requirements such as heat or solvent resistance and hygroscopic coefficient of expansion are subjects for individual negotiation.

9.19 *Aqueous Extract Conductivity*—Test Methods D 202, except use a 5-g specimen and 200 mL of boiling distilled water. Omit stirring. After filtering, wash specimen with 50 mL of hot distilled water and add to filtrate. Adjust final volume to 250 mL with hot distilled water. Divide the calculated result by two. Save the solution to perform acidity test as in 8.21.

9.20 *Acidity*—Test Methods D 202, except titrate extract as in 9.19.

9.21 *Conducting Paths*—Method A of Test Methods D 202 using 100 V dc.

9.22 *Insulation Resistance*—Test Methods D 257. Measure on 0.5-µF unimpregnated single-layer capacitors with 3-mm margins, 3-min total electrification at 100 V dc. Preheat capacitors in oven at 125 ± 1°C for ½ h prior to test. Maintain temperature at 125 ± 1°C during measurement.

9.23 *Dielectric Breakdown Voltage* (*dc*)—See 9.3 for Warning. Test Method D 3755. Measure on 0.5-µF unimpregnated single-layer capacitors subjected to dc voltage at 100-V/s rate of rise at room temperature and 50 % relative humidity. Conduct tests on "as-wound" units, using a 20-mm minimum or preferably 50-mm wide film with a 16-mm margin and a 3-mm arbor. Discard units failing a 6-V shorting test.

9.24 *Thickness of Capacitor Film* :

9.24.1 *Roll Weight Method*—Calculate the average thickness from the average density, and from the width, length, and net weight of the role.

9.24.2 *Ten–Sheet Stack Method*—Use Method A or C of Test Methods D 374. Make measurements on a ten-sheet stack of film from a single-slit roll. Keep the micrometer foot more than 20 mm from any folded edge of a stack, as specified in Test Methods D 202, or 6 mm from the edge of the sheet.

9.24.3 *Gravimetric Method*—Use Test Method E 252.

## 10. Roll Requirements

10.1 The following requirements apply:

10.1.1 *Core*—Cores must not distort or collapse from the winding tension, nor flake or degrade the sheet.

NOTE 2—Current industry practice is to wrap the material on either 76 or 152-mm (3 or 6-in.) diameter cores. Film for film/foil capacitor use is also supplied on 29-mm diameter cores. Details of whether the core may extend to the edge of the material or protrude beyond are subject to agreement between purchaser and manufacturer.

10.1.2 *Patching*—None is allowed.

10.1.3 *Shiners*—More than three per roll or those extending more than 1.6 mm (0.062 in.) are unacceptable.

10.1.4 *Splices*—The maximum number of splices permitted in a slit roll is given in Table 3. The minimum distance between splices, or from beginning or end of a slit roll is 162 m (500 ft), unless otherwise agreed upon between the purchaser and the supplier. Details of the splice, such as color, trailing tails at the top or bottom, sandwiched or overlapped, shall be agreed upon by the purchaser and supplier.

10.1.5 *Telescoping*—There shall be no more than 1.6-mm (0.062-in.) displacement from the plane of the edge of the roll.

10.1.6 *Wrinkles*—Permit no wrinkles that cause permanent deformation of the film.

10.1.7 *Marking*—Mark the following information on the core or on an accompanying label: mill roll number, footage, actual sheet thickness or gage, width, and the manufacturer's designation.

## 11. Packaging

11.1 Package the material in standard commercial containers designed to protect the roll from damage, and constructed to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery, unless otherwise specified in the contract or order.

**TABLE 3 Slit Roll Splice Frequency (Maximum Number Permitted)**

| Roll Inside Diameter 76 mm | | | |
|---|---|---|---|
| Film Thickness | Roll Outside Diameter | | |
| | 240 mm | 330 mm | 410 mm |
| 1.5 – 23.0 | 2 | 3 | 4 |

| Roll Inside Diameter 152 mm | | | | |
|---|---|---|---|---|
| Film Thickness | Roll Outside Diameter | | | |
| | 230 mm | 280 mm | 360 mm | 455 mm |
| 1.5 – 23.0 | 2 | 3 | 4 | 5 |

## 12. Marking

12.1 Identify shipping containers with the name and the specification number of the material, the thickness, the width, the footage, the roll and core diameters, the manufacturer's name, and the number of the contract or order.

## 13. Keywords

13.1 capacitor; polyethylene terephthalate; polymeric resin film; polypropylene

## APPENDIX

**(Nonmandatory Information)**

### X1. INFORMATION OF GENERAL ENGINEERING INTEREST 25 μm (0.001 in.), NOMINAL THICKNESS

**TABLE X1.1 Information of General Engineering Interest (Biaxially Oriented Polyethylene Terephthalate Film)**

| Property[A,B] | Value |
|---|---|
| Bursting strength: | |
| kPa | >475 |
| psi | >69 |
| Tear strength: | |
| MPa | >12.4 |
| psi | >1800 |
| Impact strength: | |
| J/mm | 96.4 |
| J/mil | 2.5 |
| Fold endurance, cycles | >14 000 |
| Color or clarity | clear to translucent |
| Moisture absorption, % | <0.6 |
| Moisture permeability: | |
| $g/m^2 \cdot 24$ h | <23.2 |
| $g/100\ in^2 \cdot 24$ h | <1.5 |
| Hygroscopic coefficient of expansion,% | |
| $(\Delta l/l)/\Delta$ % RH: | |
| mm/mm·% RH = in/in·% RH | $0.6 \times 10^{-5}$ |
| Oxygen index | 20–25 |
| Oxygen permeability: | |
| $cm^3/m^2 \cdot 24$ h·atm·m | <3.66 |
| $cm^3/100\ in.^2 \cdot 24$ h·atm·mil | <6. |
| Corona | [C] |
| Resistance to corrosive agents: | |
| Weak acids | excellent |
| Strong acids | fair |
| Weak alkali | poor |
| Strong alkali | poor |
| Organic solvents | excellent |
| Water | excellent |
| Sunlight | poor unless specifically treated |
| Moisture and heat (hydrolytic stability) | poor |
| Surface resistivity, typical, Ω (per square): | |
| 23°C, 30 % RH | $1 \times 10^{16}$ |
| 23°C, 80 % RH | $1 \times 10^{12}$ |
| Volume resistivity, typical, Ω-cm: | |
| 25°C, 50 % RH | $1 \times 10^{18}$ |
| 150°C, 50 % RH | $1 \times 10^{13}$ |

[A] If these are to be specified, they are subject to agreement between the purchaser and the manufacturer.
[B] See Section 9 for test methods.
[C] Not recommended for use where continuous corona or electrical discharges are likely to occur.

**TABLE X1.2 Information of General Engineering Interest (Biaxially Oriented Polypropylene Film)**

| Property[A,B] | Value |
|---|---|
| Surface resistivity, typical, Ω (per square): | ≥10E14 |
| 23°C, 50 % RH | |
| Volume resistivity, typical, Ω-cm: | >10E15 |
| 23°C, 50 %RH | |

[A] If these are to be specified, they are subject to agreement between the purchaser and the manufacturer.
[B] See Section 9 for test methods.