



Designation: **D5213—12 D5213 – 19**

# Standard Specification for Polymeric Resin Film for Electrical Insulation and Dielectric Applications<sup>1</sup>

This standard is issued under the fixed designation D5213; 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 ( $\epsilon$ ) 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 requirements for the material, dimensions and tolerances, and property values of film, in sheet or strip form, with or without heat-sealable coatings.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

NOTE 1—This document is similar to IEC 60674, Part 3, Sheets 2, 4, 5, 6, and 7.

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:*<sup>2</sup>

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

**D883** Terminology Relating to Plastics

**D1711** Terminology Relating to Electrical Insulation

**D2305** Test Methods for Polymeric Films Used for Electrical Insulation

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

**D4088** Practice for Preparation for Shipment of Solid Electrical Insulating Materials (Withdrawn 2003)<sup>3</sup>

2.2 *IEC Standards:*

**Publication 60674-3** Specification for Electrical Films for Electrical Purposes<sup>4</sup>

## 3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminologies **D1711** and **D883** unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *sheet, n*—material greater than 75 mm in width.

3.2.2 *strip, n*—material 75 mm or less in width.

## 4. Classification

4.1 This specification covers the following:

4.1.1 *Type I*—General purpose,

4.1.2 *Type II*—Heat sealable,

4.1.2.1 *Grade 1*—One side coated, and

<sup>1</sup> 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 Electrical Insulating Materials.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

<sup>4</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

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

4.1.2.2 *Grade 2*—Two sides coated.

4.2 *Materials:*

- 4.2.1 *Item A*—Poly(N,N'-p,p'-oxydiphenylene pyromellitimide),
- 4.2.2 *Item B*—Poly(N,N'-p,p'-oxydiphenylene biphenyltetracarboxylimide),
- 4.2.3 *Item C*—Poly(N,N'-p-phenylene biphenyltetracarboxylimide),
- 4.2.4 *Item D*—FEP-fluorocarbon, and
- 4.2.5 *Item E*—Polyethylene terephthalate.
- 4.2.6 *Item F*—Polyethylene naphthalate.
- 4.2.7 *Item G*—Polyetherimide.

4.3 For the purposes of this specification, a sheet refers to material greater than 75 mm in width and a strip refers to material 75mm or less in width.

**5. Ordering Information**

5.1 Order the film covered by this specification stating the type, grade, class, thickness, width, and roll dimensions.

**6. Materials**

- 6.1 Type I material is flexible, unsupported film.
- 6.2 Type II material is film meeting all of the requirements of Type I, and having a heat-sealable coating on one or both sides.

**7. Requirements**

7.1 The film covered by this specification shall meet the property requirements given in **Tables 1-7** and **Table 8** when tested by the methods given in Test Methods **D2305**.

7.1.1 Type II films, prior to coating, shall meet all of the requirements given in **Table 1** for films of the thicknesses given in **Table 9**.

7.1.2 Type II films, after coating, shall meet all of the requirements given in **Table 1** for elongation, before and after heating, and for shrinkage as given in **Table 1** for films of the thicknesses given in **Table 9**.

7.2 *Roll Diameters:*

7.2.1 The outside diameters of rolls of film shall not vary from the value specified on the purchase order by more than  $\pm 6$  mm (0.25 in.).

7.2.2 The inside diameters of cores of standard rolls of film shall not vary from the value specified on the purchase order by more than  $\pm 1.5$  mm (0.060 in.).

7.3 The widths of film in rolls shall be within the following tolerances:

7.3.1 Twenty-five mm (1 in.) wide or less,  $\pm 0.4$  mm (~~0.015 in.~~)(0.015 in.).

7.3.2 Over 25 to 100 mm (over 1 to 4 in.),  $\pm 0.8$  mm (~~0.030 in.~~)(0.030 in.).

7.3.3 Over 100 mm (4 in.),  $\pm 1.6$  mm (0.062 in.).

7.4 The number of splices in standard rolls shall not exceed the values given in **Table 10** for Type I film or **Table 11** and **Table 12** for Type II films.

**TABLE 1 Property Values for Type I, Class A Film poly(N,N'-p-p'-oxydiphenylene pyromellitimide)**

	Average Property Value							
	Nominal Thickness, $\mu\text{m}$ (mils)							
	7.5 (0.3)	13 (0.5)	20 (0.8)	25 (1.0)	50 (2.0)	75 (3.0)	100 (4.0)	130 (5.0)
Tensile strength, min MPa (psi), machine direction and transverse direction	69 (10 000)	97 (14 000)	138 (20 000)	138 (20 000)	138 (20 000)	138 (20 000)	138 (20 000)	138 (20 000)
Elongation, min percent, machine and transverse direction	10	20	35	35	40	45	45	45
Shrinkage, max percent, after exposure to 200 °C (392 F), machine and transverse direction	...	...	0.30	0.30	0.35	0.35	0.35	0.35
Moisture absorption, max percent, 100 % RH	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Dielectric strength, min kV/mm (V/mil), 60 Hz <sup>A,B</sup>	120 (3000)	120 (3000)	180 (4500)	180 (4500)	150 (3800)	140 (3600)	100 (2500)	100 (2500)
Volume resistivity, min $\Omega\text{-cm}$ , <sup>B,C</sup>	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$
Permittivity, max at 1 kHz <sup>B</sup>	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Dissipation factor, max at 1 kHz <sup>B</sup>	0.007	0.005	0.005	0.004	0.004	0.004	0.004	0.004

<sup>A</sup> Use Type 3 electrodes in air of Table 1 of Test Method **D149** (opposing 6.4-mm diameter rods).

<sup>B</sup> At 23 °C (73.4 °F), 50 % RH.

<sup>C</sup> The median value of 5 measurements shall be used for compliance.

**TABLE 2 Property Values for Type I, Class B Film poly(N,N'-p-p'-oxydiphenylene biphenyltetracarboxylimide)**

	Average Property Value								
	Nominal Thickness, $\mu\text{m}$ (mils)								
	7.5 (0.3)	13 (0.5)	20 (0.8)	25 (1.0)	40 (1.6)	50 (2.0)	75 (3.0)	100 (4.0)	130 (5.0)
Tensile strength, min MPa (psi), machine direction and transverse direction	110 (15 000)	138 (20 000)	196 (28 000)	196 (28 000)	196 (28 000)	196 (28 000)	196 (28 000)	196 (28 000)	196 (28 000)
Elongation, min percent, machine and transverse direction	24	40	80	80	80	80	80	80	80
Shrinkage, max percent, after exposure to 200 °C (392 °F), machine and transverse direction	...	...	0.30	0.30	0.35	0.35	0.35	0.35	0.35
Moisture absorption, max percent, 100 % RH	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Dielectric strength, min kV/mm (V/mil), 60 Hz <sup>A,B</sup>	120 (3000)	120 (3000)	180 (4500)	180 (4500)	150 (3800)	140 (3500)	130 (3300)	100 (2500)	95 (2400)
Volume resistivity, min $\Omega\text{-cm}$ , <sup>B,C</sup>	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$
Permittivity, max at 1 kHz <sup>B</sup>	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Dissipation factor, max at 1 kHz <sup>B</sup>	0.007	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

<sup>A</sup> Use Type 3 electrodes in air of Table 1 of Test Method D149 (opposing 6.4-mm diameter rods).

<sup>B</sup> At 23 °C (73.4 °F), 50 % RH.

<sup>C</sup> The median value of 5 measurements shall be used for compliance.

**TABLE 3 Property Values for Type I, Class C Film poly(N,N'-p-phenylene biphenyltetracarboxylimide)**

	Average Property Value								
	Nominal Thickness, $\mu\text{m}$ (mils)								
	7.5 (0.3)	13 (0.5)	20 (0.8)	25 (1.0)	40 (1.6)	50 (2.0)	75 (3.0)	100 (4.0)	130 (5.0)
Tensile strength, min MPa (psi), machine direction and transverse direction	133 (19 000)	176 (25 000)	241 (34 000)	241 (34 000)	241 (34 000)	241 (34 000)	241 (34 000)	241 (34 000)	241 (34 000)
Elongation, min percent, machine and transverse direction	25	25	25	25	25	25	25	25	25
Shrinkage, max percent, after exposure to 200 °C (392 °F), machine and transverse direction	...	...	0.15	0.15	0.15	0.20	0.20	0.20	0.20
Moisture absorption, max percent, 100 % RH	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Dielectric strength, min kV/mm (V/mil), 60 Hz <sup>A,B</sup>	120 (3000)	120 (3000)	180 (4500)	180 (4500)	150 (3800)	140 (3500)	120 (3000)	100 (2500)	95 (2400)
Volume resistivity, min $\Omega\text{-cm}$ , <sup>B,C</sup>	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$
Permittivity, max at 1 kHz <sup>B</sup>	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Dissipation factor, max at 1 kHz <sup>B</sup>	0.007	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005

<sup>A</sup> Use Type 3 electrodes in air of Table 1 of Test Method D149 (opposing 6.4-mm diameter rods).

<sup>B</sup> At 23 °C (73.4 °F), 50 % RH.

<sup>C</sup> The median value of 5 measurements shall be used for compliance.

7.5 The thicknesses shall be within the tolerances specified in Table 13 for Type I film or Table 3 for Type II film.

7.6 The color of the sheet or strip shall be uniform within a given lot, as determined by visual examination.

7.7 The film shall be uniform in appearance, as determined by visual examination. The film shall be clean and free from contamination, wrinkles, holes, scratches, and other defects that might affect either appearance or serviceability. The heat-sealable coating for Type II material shall be uniform in appearance.

## 8. Sampling

8.1 Sample in accordance with Practice D3636, unless otherwise agreed upon between the supplier and the purchaser.

8.2 For purposes of sampling, an 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.

8.3 The total quantity of material to be taken from each lot shall be approximately twice that estimated to be required for the tests that are to be made, in order to permit repeat tests without resampling.

8.4 These materials are normally made in master rolls of approximately 360 kg (800 lb) in weight. Take samples for examination and testing from the end of the master rolls.

## 9. Number of Tests

9.1 Unless otherwise agreed upon by the purchaser and the seller, routine lot inspection tests shall consist of evaluation of all of the properties specified in 7.4 – 7.7. For these properties, each master roll shall be considered a lot for sampling. All samples must pass inspection.

**TABLE 4 Property Values for Type I, Class D Film (FEP—Fluorocarbon)**

	Average Property Value												
	Nominal Thickness, $\mu\text{m}$ (mils)												
	13 (0.50)	25 (1.0)	51 (2.0)	76 (3.0)	102 (4.0)	127 (5.0)	254 (10.0)	356 (14.0)	508 (20.0)	762 (30.0)	1016 (40.0)	1524 (60.0)	2413 (95.0)
Tensile strength, min MPa (psi), machine direction and transverse direction	13.8 (2000)	17.25 (2500)	17.25 (2500)	17.25 (2500)	17.25 (2500)	17.25 (2500)	17.25 (2500)	17.25 (2500)	17.25 (2500)	17.25 (2500)	17.25 (2500)	17.25 (2500)	17.25 (2500)
Elongation, min, %, machine direction and transverse direction	175	250	250	250	250	250	250	250	250	250	250	250	250
Shrinkage, max percent, after exposure to 200 °C (392 °F)	5.0	5.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	4.0	4.0	4.0	5.0
Moisture absorption, max percent, 100 % RH	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Dielectric strength, min at 60 Hz kV/mm (V/mil) <sup>A,B</sup>	160 (4000)	160 (4000)	140 (3500)	120 (3000)	110 (2750)	100 (2500)	72 (1800)	64 (1600)	56 (1400)	...	...	...	...
Volume resistivity, min, $\Omega\text{-cm}^{B,C}$	$10^{17}$	$10^{17}$	$10^{17}$	$10^{17}$	$10^{17}$	$10^{17}$	$10^{17}$	$10^{17}$	$10^{17}$	$10^{17}$	$10^{17}$	$10^{17}$	$10^{17}$
Permittivity, max at 1 kHz <sup>B</sup>	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
Dissipation factor, max at 1 kHz <sup>B</sup>	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003

<sup>A</sup> Use Type 3 electrodes in air of Table 1 of Test Method D149 (opposing 6.4-mm diameter rods).

<sup>B</sup> At 23 °C (73.4 °F), 50 % RH.

<sup>C</sup> The median value of 5 measurements shall be used for compliance.

**TABLE 5 Property Values for Type I, Class E Film (Polyethylene Terephthalate)**

	Average Property Value							
	Nominal Thickness, $\mu\text{m}$ (mils)							
	12 (0.48)	15 (0.60)	23 (0.92)	36 (1.42)	75 (3.00)	100 (4.00)	190 (7.50)	250 (10.00)
Tensile strength, min MPa (psi), machine direction and transverse direction	145 (21 000)	145 (21 000)	138 (20 000)	138 (20 000)	138 (20 000)	138 (20 000)	138 (20 000)	110 (16 000)
Elongation, min % machine direction and transverse direction	60	60	65	70	70	70	70	70
Shrinkage, max percent after exposure to 150 °C (302 °F), 30 min	3.5	3.0	3.0	3.0	3.0	3.0	3.0	2.0
Moisture absorption, max %, 100 % RH	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Dielectric strength, min at 60 Hz, kV/mm (V/mil) <sup>A,B</sup>	208 (5300)	190 (4800)	174 (4400)	130 (3300)	105 (2700)	80 (2000)	60 (1500)	50 (1300)
Volume resistivity, min, $\Omega\text{-cm}^{B,C}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$	$10^{15}$
Permittivity, max at 1 kHz <sup>B</sup>	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Dissipation factor, max at 1 kHz <sup>B</sup>	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006

<sup>A</sup> Use Type 3 electrodes in air of Table 1 of Test Method D149 (opposing 6.4-mm diameter rods).

<sup>B</sup> At 23 °C (73.4 °F), 50 % RH.

<sup>C</sup> The median value of 5 measurements shall be used for compliance.

9.2 Routine lot inspection tests for properties specified in 7.1, including definition of the number of master rolls per lot, shall be agreed upon between the purchaser and the seller. All samples must pass inspection.

9.3 The number of specimens tested from each sample for properties specified in 7.1 and 7.5 shall be in accordance with the requirements of the individual test method. The test result on a sample shall be the average of the results on individual specimens prepared from that sample, unless otherwise stated in the test method.

9.4 For slit rolls and full-width rolls other than master rolls, the number of samples taken for properties specified in 7.2 – 7.4 shall be subject to agreement between the purchaser and the seller.

## 10. Certification

10.1 The purchase order or contract shall state any requirements for certification by the producer. If required, a certification shall state that the film was sampled in accordance with Section 8, tested in accordance with Test Methods D2305, and found to be in conformance with the requirements shown in Section 7. If required by the purchase order, or contract, the producer shall furnish a report of the testing used as the basis for the certification.

## 11. Identification and Marking

11.1 *Identification*—Marking of the material shall show the name of the material, type and grade, dimensions, and quantity.

11.2 *Shipping Containers*—Boxes or crates shall be marked with the name of the material, type and grade, and dimensions and lot number; and the name and address of the supplier.