DUPONT™ KAPTON®

POLYIMIDE FILM

INTRODUCTION

DuPont manufactures and sells a variety of high-quality polyimide film products in conformance with ISO 9002 certification.

These specifications describe the values and tolerances for DuPont™ Kapton® film polyimide properties. Where necessary for thorough understanding, test methods and procedures have been included.

Any aspects of the specifications that require further interpretation or clarification should be discussed with your DuPont™ Kapton® representative.

TYPES OF KAPTON® POLYIMIDE FILM

DuPont makes several types of Kapton® polyimide film. Types HN, FN, and HPP-ST are used most commonly.

In addition to these three types of Kapton®, films are available with the following attributes:

- antistat
- thermally conductive
- polyimides for fine line circuitry
- cryogenic insulation
- corona resistant
- pigmented for color
- conformable
- other films tailored to meet customers' needs

Data for these films are covered in separate product bulletins, which can be obtained from your DuPont™ Kapton® representative.

DuPont™ Kapton® HN polyimide film

Kapton® HN polyimide film is a tough, aromatic polyimide film, exhibiting an excellent balance of physical, chemical, and electrical properties over a wide temperature range, particularly at unusually high temperatures. Kapton® HN is available in the following gauges: 30 (7.5 µm), 50 (12.7 µm), 100 (25.4 µm), 200 (50.8 µm), 300 (76.2 µm), and 500 (127 µm). Other gauges, may become available by special request.

DuPont™ Kapton® FN polyimide film

Kapton® FN polyimide film is a heat sealable grade that retains the unique balance of properties of Kapton® HN over a wide temperature range. This is achieved by combining Kapton® HN with FEP fluorocarbon resin in a composite structure.

Table 1 lists the common types of FN film available. Other combinations are available. Consult your DuPont™ Kapton® representative for further information.

Table 1 – DuPont™ Kapton® FN polyimide film Types

	Construction, mil (µm)		
Designation	FEP	HN	FEP
120FN616	0.10 (2.5)	1.00 (25.4)	0.10 (2.5)
150FN019	1.00 (25.4)	0.50 (12.7)	
200FN919	0.50 (12.7)	1.00 (25.4)	0.50 (12.7)
200FN011		1.00 (25.4)	1.00 (25.4)
250FN029		2.00 (50.8)	0.50 (12.7)
300FN021		2.00 (50.8)	1.00 (25.4)
300FN929	0.50 (12.7)	2.00 (50.8)	0.50 (12.7)
400FN022		2.00 (50.8)	2.00 (50.8)
500FN131	1.00 (25.4)	3.00 (76.2)	1.00 (25.4)

DuPont™ Kapton® HPP-ST polyimide film

Kapton® HPP-ST polyimide film is the same tough polyimide film as Kapton® HN film, exhibiting an excellent balance of physical, chemical, and electrical properties over a wide temperature range, with superior dimensional stability and adhesion characteristics. This product is available in 50 (12.7 µm), 75 (19.1 µm), 100 (25.4 µm), 200 (50.8 µm), 300 (76.2 µm), and 500 (127 µm) gauges.

Certification

Kapton® is certified to meet the requirements of ASTMD-5213-07 in addition to the items covered by this specifications bulletin. Written confirmation is available with each delivery upon request.

THERMAL DURABILITY

The thermal durability of Kapton® film depends on the environmental conditions under which it is aged and tested. Its lifetime depends on the criterion of failure. Kapton® is routinely tested at the manufacturing site in the following manner:

Sheets of film 8.5" x 11" (216 mm x 279 mm) are freely suspended in an oven at a temperature of 400°C ±2°C (752°F ±3.6°F) for 2 hrs (1 hr for 30 [7.6 µm] and 50 [12.7 µm] gauge film). The aged material is tested on an Instron Tensile Tester as described in **Table 2**. The elongation of the film at 23.5°C (74.3°F) should not be less than 10% after this aging at 400°C (752°F).

In addition, Kapton® conforms to ASTMD-5213-07, Standard Specification for Polymeric Resin Film for Electrical Insulation and Dielectric Applications.

Underwriters Laboratories, Inc. lists a thermal index of 200 to 220°C (392 to 428°F) (depending on gauge and type) for mechanical properties and 220 to 240°C (428 to 464°F) (depending on gauge and type) for electrical properties, under their file number E39505 for Kapton® polyimide film.

PROPERTIES OF DUPONT™ KAPTON® FN POLYIMIDE FILM

Heat Seal Strength

Film-to-Film Seals

The peel strength of heat seals between the coated and uncoated sides of one-side coated Kapton® or between the coated sides of both one- and two-side coated Kapton® is determined as follows. Seals are made in a jaw sealer at 350°C (662°F), 20 psig (1.4 bar), with a 20-sec dwell time. After cooling, the seals are cut into 1" (25.4 mm) wide strips using a Thwing-Albert JDC sample cutter or its equivalent. The seal strength is measured with an Instron-type tensile tester. Seal strength is defined as the peak instantaneous strength occurring in each seal. Five specimen values are averaged.

The minimum peel strength between the coated sides of one- or two-side coated Kapton® will be 700 g/in (2.7 N/cm), except for 120FN616, which will be 450 g/in (1.7 N/cm). The minimum peel strength between the coated and uncoated side of one-side coated Kapton® will be 450 g/in (1.7 N/cm).

Film-to-Copper Seals

The ability of FEP film to adhere to copper is measured using the same heat seal peel strength technique as described in "Film-to-Film Seals."

The peel strength is measured with the FEP side sealed to the untreated side of 1 mil (25.4 µm), 3/4 oz GT copper foil; it will be a minimum of 300 g/in (1.2 N/cm).

As-Received Strength (Cold Peel) of Bonds Between Kapton® Type HN and Fluoropolymer Layers

The bond between the Kapton® HN and fluorocarbon resin layers on all Kapton® FN products, except 120FN616, will have a minimum peel strength of 225 g/in (0.87 N/cm), measured using an Instron-type tensile tester and a 180° peel.

Table 2 – Mechanical Properties of DuPont™ Kapton® HN polyimide film

Property	0.50 (12.7)*	1.00 (25.4)*	2.00 (50.8)*	3.00 (76.2)*	5.00 (127)*	Method
Tensile Strength, psi (MPa) at 23°C (73°F). Machine Direction (MD) and Transverse Direction (TD), min.	24,000 (138)	24,000 (165)	24,000 (165)	24,000 (165)	24,000 (165)	ASTM D-882-91, Method A, using an Instron Tensite Tester (specimen size: 1/2" x 6" [12.7 mm x 152 mm]; jaw separation: 4" [102 mm]; jaw speed: 2"/min [51 mm/min]). Calculate the average of five specimens based on original measured thickness.
Elongation, %, MD and TD, min.	35	40	45	50	50	Same as above.
Shrinkage, %, MD and TD at 200°C (392°F), max.	–	0.3	0.35	0.35	0.35	The percent shrinkage is obtained for either the MD or TD using the average of three measurements in either direction before and after conditioning. Prior to measurement, the 12" x 12" (305 mm x 305 mm) specimen is conditioned by freely suspending it for 2 hr** in an oven controlled to 200°C (392°F).
Moisture Absorption, %, max.	4.0	4.0	4.0	4.0	4.0	ASTM D-570-92, using 24-hr immersion at 23°C (73°F). Average of three specimens.

*Also applies to Type HPP-ST, except shrinkage, which is show in Table 5.

**1 hr for 30 and 50 gauge film

Table 2 – Electrical Properties of DuPont™ Kapton® HN polyimide film

Property	0.50 (12.7)*	1.00 (25.4)*	2.00 (50.8)*	3.00 (76.2)*	5.00 (127)*	Method
Dielectric Strength, AC V/mil (kV/mm), min.	3,000 (118)	6,000 (236)	5,000 (197)	4,500 (177)	3,000 (118)	ASTM D-149-97 (Average of ten specimens.) Flat sheets in air placed between 1/4" (6 mm) diameter brass electrodes with 1/32" (0.8 mm) edge radius subjected to 60 cycles AC voltage at 500 V/sec rate of rise to the breakdown voltage.
Volume Resistivity, ohm-cm at 200°C (392°F), min.	10^{12}	10^{12}	10^{12}	10^{12}	10^{12}	ASTM D-257-93
Dielectric Constant at 1 kHz, max.	4.0	3.9	3.9	3.9	3.9	ASTM D-150-94. Use conducting silver paint electrodes, two-terminal system of measurement at standard conditions. Results are based on an average of five tests using measured thickness of specimens.
Dissipation Factor at 1 kHz, max.	0.0050	0.0036	0.0036	0.0036	0.0036	Same as above.

*Also applies to Type HPP-ST.

Table 4 – Dielectric Strength of DuPont™ Kapton® FN polyimide film

Gauge Construction	Minimum Breakdown V/mil (kV/mm)
120FN616	4,200 (165)
150FN019	3,700 (146)
200FN919	3,200 (126)
200FN011	3,200 (126)
250FN029	2,750 (108)
300FN021	2,700 (106)
300FN929	2,700 (106)
400FN022	2,200 (87)
500FN131	2,200 (87)

Test Method

Average of ten specimens tested per ASTM D-149-97. Flat sheets in air placed between 1/4" (6 mm) diameter brass electrodes with 1/32" (0.8 mm) edge radius subjected to 60 cycles AC voltage. Rise is 500 V/sec to the breakdown voltage.

GENERAL

Materials Kapton® HN and Kapton® HPP-ST polyimide films are polyimide polymers in the form of a film.

Kapton® FN polyimide film is a combination of Kapton® HN polyimide film with FEP fluorocarbon resin on one or both sides.

Uniformity

Material shall be uniform in composition and free from defects that impair serviceability and/or appearance in proven applications.

Cores

Cores shall be of sufficient strength to prevent collapsing from handling. Standard core internal diameters (I.D.) are nominally 3" and 6" (76 mm and 152 mm) with the following specifications:

Paper

3" (76 mm) I.D. 3.032" ± 0.008" (77.01 mm ± 0.2 mm)

6" (152 mm) I.D. 6.028" ± 0.010" (153.11 mm ± 0.25 mm)

Plastic

3" (76 mm) I.D. 3.024" ± 0.005" (77.01 mm ± 0.2 mm)

6" (152 mm) I.D. 6.041" ± 0.010" (153.44 mm ± 0.25 mm)

Core material will be plastic for 3" (76 mm) I.D. cores less than 5/8" (16 mm) wide.

Core material will be fiber for 3" (76 mm) I.D. cores wider than 5/8" (16 mm) and for 6" (152 mm) I.D. cores. A split 3" (76 mm) I.D. fiber core is standard for all universal and Step-Pac® rolls.

If these cores are not suitable, further information on other options may be obtained from your DuPont™ Kapton® representative.

Width Tolerance

The maximum variation in film width from that specified on the order shall be as follows:

Slit Width Range	*Tolerance*
1-1/2" (38mm) or less	±0.005" (0.13 mm)
1-1/2" to 4" (38 mm to 102 mm)	±0.030" (0.76 mm)
>4" (>102 mm)	±0.060" (1.5 mm)

Table 5 – Shrinkage of DuPont™ Kapton® HPP-ST polyimide film

	Property Value—From Thickness, mil (µm)				
Property	**0.50 (12.7)**	**1.00 (25.4)**	**2.00 (50.8)**	**3.00 (76.2)**	**5.00 (127)**
Shrinkage, %, MD and TD at 200°C (392°F), max.	0.10	0.10	0.10	0.10	0.10

Test Method

The percent shrinkage obtained for either the MD or TD by using the average of three measurements in either direction before and after conditioning. Temperature exposure 200°C ±2°C (392°F ±3.6°F) for 1 hr. Measurements must be made at the same temperature and humidity conditions before and after conditioning. To ensure sample/ambient equilibrium before and after conditioning, specimens should be exposed for 3 hr.

Table 6 – DuPont™ Kapton® polyimide film Specifications and Tolerances

Film Type	Thickness Nominal mil (µm)*	Thickness Tolerance		Width Range		Unit Weight		Area Factor	
		Min. mil (µm)	Max.mil (µm)	Min. in (mm)	Max. in (mm)	Min. g/m²	Max. g/m²	ft²/lb	(m²/kg)
50HN	0.50 (12.7)	0.42 (10.6)	0.58 (14.7)	3/16 (4.8)	52 (1320)	14.0	26.0	272	55.7
100HN	1.00 (25.4)	0.90 (22.8)	1.05 (26.7)	3/16 (4.8)	52 (1320)	32.7	39.7	136	27.9
200HN	2.00 (50.8)	1.85 (47.0)	2.15 (54.6)	3/16 (4.8)	52 (1320)	66.9	77.9	68	13.9
300HN	3.00 (76.2)	2.85 (72.4)	3.15 (80.0)	3/16 (4.8)	52 (1320)	101.9	115.4	45	9.2
500HN	5.00 (127)	4.80 (122)	5.10 (130)	3/16 (4.8)	52 (1320)	169.5	192.5	27	5.5
50HPP-ST	0.50 (12.7)	0.42 (10.6)	0.58 (14.7)	3/16 (4.8)	52 (1320)	14.0	26.0	272	55.7
100HPP-ST	1.00 (25.4)	0.90 (22.8)	1.05 (26.7)	3/16 (4.8)	52 (1320)	32.7	39.7	136	27.9
200HPP-ST	2.00 (50.8)	1.85 (47.0)	2.15 (54.6)	3/16 (4.8)	52 (1320)	66.9	77.9	68	13.9
300HPP-ST	3.00 (76.2)	2.85 (72.4)	3.15 (80.0)	3/16 (4.8)	50 (1270)	101.9	115.4	45	9.2
500HPP-ST	5.00 (127)	4.80 (122)	5.10 (130)	3/16 (4.8)	50 (1270)	169.5	192.5	27	5.5
120FN616	1.20 (30.5)	1.10 (27.9)	1.40 (35.6)	3/16 (4.8)	44 (1118)	41.0	58.0	104	21.3
150FN019	1.50 (38.1)	1.25 (31.8)	1.75 (44.5)	3/16 (4.8)	44 (1118)	53.0	74.0	77	15.8
200FN011	2.00 (50.8)	1.70 (43.2)	2.30 (58.4)	3/16 (4.8)	44 (1118)	77.0	104.0	54	11.1
200FN919	2.00 (50.8)	1.70 (43.2)	2.30 (58.4)	3/16 (4.8)	44 (1118)	77.0	104.0	54	11.1
250FN029	2.50 (63.5)	2.25 (57.2)	2.75 (69.9)	3/16 (4.8)	44 (1118)	87.0	113.0	49	10.0
300FN021	3.00 (76.2)	2.60 (66.0)	3.40 (86.4)	3/16 (4.8)	44 (1118)	111.0	142.0	39	8.0
300FN929	3.00 (76.2)	2.60 (66.0)	3.40 (86.4)	3/16 (4.8)	44 (1118)	111.0	142.0	39	8.0
400FN022	4.00 (102)	3.50 (88.9)	4.50 (114)	3/16 (4.8)	44 (1118)	163.0	200.0	27	5.5
500FN131	5.00 (127)	4.50 (114)	5.50 (140)	3/16 (4.8)	44 (1118)	195.0	239.0	23	4.7

The usual dimensions of pad rolls are 3” (76 mm) I.D. x 6” (152 mm) or 9” (230 mm) outside diameter (O.D.) for widths up to 4” (102 mm). For wider rolls, the usual dimensions are 6” (152 mm) I.D. x 9-1/2” (240 mm) or 11” (280 mm) O.D. for Universal and Step-Pac® rolls, the dimensions are 3” (76 mm) I.D. x 6” (152 mm), 8” (203 mm), or 12” (305 mm) O.D. If these dimensions are not suitable, information on other options is available from your DuPont™ Kapton® technical or customer service representative.

Roll Types

DuPont™ Kapton® polyimide film is supplied in three types of rolls: pad, universal, and Step-Pac® wind.

Pad Roll Specifications

- Core width will be the film width +1/8” (+3.2 mm), -0
- Core edges shall not project more than 1/16” (1.6 mm) beyond the roll face on either side.
- Core shall not be recessed on either side.
- The outside and starting ends of the film shall be fastened in a manner to prevent unwinding.
- “Dishing” or “cupping” may not exceed 1/16” (1.6 mm), measured with a straightedge across the diameter of the roll.

Universal and Step-Pac® Roll Specifications

- The difference between the lengths of the projecting core on each side shall not exceed 3/16” (4.8 mm).
- Film shall not project from the main body of the roll more than 1/8” (3.2 mm).

- The outside and starting ends of the film shall be fastened in a manner to prevent unwinding.
- Roll face depression, the difference between the highest and lowest points of the roll, unstressed, shall not exceed 3/16" (4.8 mm).

Table 7 – Reference Guide: Standard Length versus Roll O.D. (U.S. Supply)

Type	Standard Length Roll	Roll O.D.	
		3" Core I.D.	6" Core I.D.
100 HN	5,000 ft] (1,525 m) 10,000 ft (3,050 m)	9-1/2" (241 mm) 11" (279 mm)	11" (279 mm) 14" (356 mm)
200HN	2,500 ft (763 m)	9-1/2" (241 mm)	11" (279 mm)
300HN	1,670 ft (509 m)	9-1/2" (241 mm)	11" (279 mm)
500HN	1,000 ft (305 m)	9-1/2" (241 mm)	11" (279 mm)

Splices

Description

Three types of splice are available.

- Polyester film-based yellow tape (standard).
- DuPont™ Kapton® polyimide film-based tape (special requirements only).
- Heat seal splice, for films 12" (305 mm) or less (Kapton® FN).

Splices will be centered on the joint to ±1/4" (±6 mm). They will be smooth and wrinkle-free to avoid distortion of the adjacent film layers in the roll.

Tape Splices

Tape splices are standard on all gauges of Kapton® HN and HPP-ST polyimide film and on all gauges of Kapton® FN polyimide film more than 12" (305mm) wide.

Tape splices are made with the butt edges of the film covered on both sides with pressure-sensitive adhesive tape. Two-inch (50 mm) wide splicing tape is used.

Heat Seal Splices

Overlap heat seal splices are made on all DuPont™ Kapton® FN polyimide films, except 250FN029, with an overlap that is a minimum of 3/8" (9.5 mm) wide.

On 250FN029, a butt splice is made using 120FN616 as the joining tape applied on the FEP surface. The butt splice is oriented with the 120FN616 tape on the top of the film as it unwinds from a universal put-up and on the bottom as it unwinds from a pad.

Overlap heat seal splices for one-side and two-side FEP composites are oriented with the leading edge of the new film on the bottom for universal and Step-Pac® put-ups. Pad put-ups of one- or two-side FEP composites have the leading edge of the new film on the top.

PACKAGING AND MARKING

Packaging Kapton® polyimide film shall be adequately packed to prevent loss of contents or damage during shipment.

All film will be wrapped with a non-fibrous material.

Marking

Kapton® is identified, as shown in **Table 8**, to allow complete traceability back to the raw materials and processing conditions.

Arrangements for special markings can be made (such as part or specification number). Consult with your DuPont™ Kapton® technical or customer service representative for details.

All package marking information is available with bar code labels.

Table 8 – Package Marking

	Shipping Container	Package	Core Label*
Scheduled Date	X	X	X
Customer Order Number	X	X	
DuPont Order Number	X	X	X
Gauge	X	X	X
Type	X	X	X
Width	X	X	X
Number of Rolls per Container	X	X	
Net Weight	X	X	
Actual Footage	X		
Mill Roll Number	X	X	X

DUPONT™ KAPTON®

FOR MORE INFORMATION ON DUPONT™ KAPTON® POLYIMIDE FILMS, PLEASE CONTACT YOUR LOCAL REPRESENTATIVE, OR VISIT OUR SALES & SUPPORT WEBPAGE FOR ADDITIONAL REGIONAL CONTACT INFORMATION.

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