



# Kapton®

polyimide film

## General Specifications

### Introduction

DuPont High Performance Materials manufactures and sells a variety of high-quality plastic film products in conformance with ISO 9002 certification.

These specifications describe the values and tolerances for Kapton® film 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 representatives of DuPont High Performance Materials.

### Types of Kapton® Polyimide Film

DuPont makes several types of Kapton® film. Types HN, FN, and VN are used most commonly.

Types H, F, and V are alternative, special versions of these standard types. The specifications in this bulletin apply to them as well. 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.

#### *Type HN Film*

Kapton® Type HN 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. Chemically, its polyimide polymer makeup is the result of a polycondensation reaction between pyromellitic dianhydride and 4,4'-diaminodiphenyl ether. Kapton® HN is available in the following gauges: 30 (7.5  $\mu\text{m}$ ), 50 (12.7  $\mu\text{m}$ ), 100 (25.4  $\mu\text{m}$ ), 200 (50.8  $\mu\text{m}$ ), 300 (76.2  $\mu\text{m}$ ), and 500 (127  $\mu\text{m}$ ). Other gauges, such as 75 (19.1  $\mu\text{m}$ ) and 400 (102  $\mu\text{m}$ ), are available by special request.

#### *Type FN Film*

Kapton® Type FN film is a heat sealable grade that retains the unique balance of properties of Kapton® Type HN over a wide temperature range. This is achieved by combining Type HN with DuPont Teflon® 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® marketing representative for further information.

**Table 1**  
**Kapton® FN Polyimide Film Types**

Designation	Construction, mil (µm)		
	FEP	HN	FEP
120FN616	0.10 (2.5)	1.00 (25.4)	0.10 (2.5)
120FN616B	0.15 (3.8)	1.00 (25.4)	0.15 (3.8)
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)

### Type VN Film

Kapton® Type VN is the same tough polyimide film as Type HN Film, exhibiting an excellent balance of physical, chemical, and electrical properties over a wide temperature range, with superior dimensional stability at elevated temperatures. 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 the military specification MIL-P-46112 B and ASTM D-5213-95 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" × 11" (216 mm × 279 mm) are freely suspended in an oven at a temperature of 400°C ±2°C (752°F ±3.6°F), monitored with a thermocouple to ensure accuracy. Sheets are removed after 2 hr (1 hr for 30 [7.6 µm] and 50 [12.7 µm] gauge film) and 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). This conforms to MIL-P-46112B "Elongation After Aging at 400°C" test (paragraph 4.4.5) and "Elongation, Percent, After Two Hour 400°C" requirement (**Table 2**).

In addition, Kapton® conforms to ASTM D-5213-95, 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 Type FN 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 psi (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® film will be 700 g/in (2.7 N/cm), except for 120FN616 and 120FN616B, 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), ¾ 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 Teflon® Layers

The bond between the Kapton® Type HN and Teflon® fluorocarbon resin layers on all Type FN products except 120FN616 and 120FN616B 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 Kapton® Type HN Polyimide Film**

Property	Property Value—Film Thickness, mil (μm)						Method
	0.30 (7.6)	0.50 (12.7)*	1.00 (25.4)*	2.00 (50.8)*	3.00 (76.2)*	5.00 (127)*	
Tensile Strength, psi (MPa) at 23°C (73°F). Machine Direction (MD) and Transverse Direction (TD), min.	16,000 (110)	20,000 (138)	24,000 (165)	24,000 (165)	24,000 (165)	24,000 (165)	ASTM D-882-91, Method A, using an Instron Tensile Tester (specimen size: ½" × 6" [12.7 mm × 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.	25	35	40	45	50	50	Same as above.
Shrinkage, %, MD and TD at 400°C (752°F), max.	4.0	4.0	2.5	2.5	2.5	2.5	MIL-P-46112B. 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 8½" × 11" (216 mm × 279 mm) specimen is conditioned by freely suspending it for 2 hr** in an oven controlled to 400°C (752°F).
Moisture Absorption, %, max.	4.0	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 VN, except shrinkage, which is shown in Table 5.

\*\*1 hr for 30 and 50 gauge film

**Table 3**  
**Electrical Properties of HN Film**

Property	Property Value—Film Thickness, mil (μm)						Method
	0.30 (7.6)	0.50 (12.7)*	1.00 (25.4)*	2.00 (50.8)*	3.00 (76.2)*	5.00 (127)*	
Dielectric Strength, AC V/mil (kV/mm), min.	3,000 (118)	3,000 (118)	6,000 (236)	5,000 (197)	4,500 (177)	3,000 (118)	ASTM D-149-94. (Average of ten specimens.) Flat sheets in air placed between ¼" (6 mm) diameter brass electrodes with ⅓₂" (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 <sup>12</sup>	10 <sup>12</sup>	10 <sup>12</sup>	10 <sup>12</sup>	10 <sup>12</sup>	10 <sup>12</sup>	ASTM D-257-93
Dielectric Constant at 1 kHz, max.	4.0	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.	0.0070	0.0050	0.0036	0.0036	0.0036	0.0036	Same as above.

\*Also applies to Type VN

**Table 4**  
**Dielectric Strength of Kapton® Type FN**  
**Polyimide Films**

Gauge Construction	Minimum Breakdown V/mil (kV/mm)
120FN616	4,200 (165)
120FN616B	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-149-92. Flat sheets in air placed between ¼" (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® Type HN and Type VN films are polyimide polymers in the form of a film.

Kapton® Type FN film is a combination of Type HN film with Teflon® 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.

*U.S. 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" (76.81 mm ± 0.1 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.

**Table 5**  
**Shrinkage of Kapton® Type VN Polyimide Film**

Property	Property Value Film Thickness, mil (µm)				
	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.

**Width Tolerance**

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

<b>Slit Width Range</b>	<b>Tolerance</b>
1½" (38 mm) or less	±0.005" (0.13 mm)
1½" to 4" (38 mm to 102 mm)	±0.030" (0.76 mm)
>4" (>102 mm)	±0.060" (1.5 mm)

**Luxembourg Supply**

Cores shall be of sufficient strength to prevent collapsing from handling. Luxembourg supplies pad rolls in widths below 9½" (240 mm) and universal wound rolls.

Standard core internal diameter for Luxembourg is 3" (76 mm) (nominal 3" ±0.008" [76 mm ±0.2 mm]).

Standard cores for pad rolls are paper cores, except for widths below ½" (13 mm), where it will be plastic.

Standard universal: core length

2.8" ±0.08" (70 mm ±2 mm) (split core)

Wide universal: core length

4.3" ±0.08" (110 mm ±2 mm) (non-split core)

A different put-up called Step-Pac™ is available from the U.S. Contact your DuPont Kapton® representative for more information.

**Width Tolerance**

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

<b>Slit Width Range</b>	<b>Tolerance</b>
0.9" (22 mm) or less Universal	0.008" (0.20 mm)
6" (152 mm) or less Pad rolls	0.016" (0.40 mm)
6" to 9½" (153 mm to 240 mm) Pad rolls	0.04" (1.00 mm)
Outside diameter tolerance: ±0.4" (10 mm)	

**Table 6**  
**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/m <sup>2</sup>	Max. g/m <sup>2</sup>	ft <sup>2</sup> /lb	(m <sup>2</sup> /kg)
30HN	0.30 (7.6)	0.24 (6.1)	0.36 (9.1)	¾/16 (4.8)	52 (1320)	7.6	14.0	453	92.8
50HN	0.50 (12.7)	0.35 (8.9)	0.65 (16.5)	¾/16 (4.8)	52 (1320)	14.0	26.0	272	55.7
100HN	1.00 (25.4)	0.85 (21.6)	1.15 (29.2)	¾/16 (4.8)	52 (1320)	32.7	39.7	136	27.9
200HN	2.00 (50.8)	1.75 (44.5)	2.25 (57.2)	¾/16 (4.8)	52 (1320)	66.9	77.9	68	13.9
300HN	3.00 (76.2)	2.72 (69.1)	3.28 (83.3)	¾/16 (4.8)	52 (1320)	101.9	115.4	45	9.2
500HN	5.00 (127)	4.65 (118)	5.35 (136)	¾/16 (4.8)	52 (1320)	169.5	192.5	27	5.5
50VN	0.50 (12.7)	0.35 (8.9)	0.65 (16.5)	¾/16 (4.8)	52 (1320)	14.0	26.0	272	55.7
100VN	1.00 (25.4)	0.85 (21.6)	1.15 (29.2)	¾/16 (4.8)	52 (1320)	32.7	39.7	136	27.9
200VN	2.00 (50.8)	1.75 (44.5)	2.25 (57.2)	¾/16 (4.8)	52 (1320)	66.9	77.9	68	13.9
300VN	3.00 (76.2)	2.72 (69.1)	3.28 (83.3)	¾/16 (4.8)	50 (1270)	101.9	115.4	45	9.2
500VN	5.00 (127)	4.65 (118)	5.35 (136)	¾/16 (4.8)	50 (1270)	169.5	192.5	27	5.5
120FN616	1.20 (30.5)	1.10 (27.9)	1.40 (35.6)	¾/16 (4.8)	44 (1118)	41.0	58.0	104	21.3
120FN616B	1.30 (33.0)	1.20 (30.5)	1.50 (38.1)	¾/16 (4.8)	44 (1118)	47.0	54.0	92	18.8
150FN019	1.50 (38.1)	1.25 (31.8)	1.75 (44.5)	¾/16 (4.8)	44 (1118)	53.0	74.0	77	15.8
200FN011	2.00 (50.8)	1.70 (43.2)	2.30 (58.4)	¾/16 (4.8)	44 (1118)	77.0	104.0	54	11.1
200FN919	2.00 (50.8)	1.70 (43.2)	2.30 (58.4)	¾/16 (4.8)	44 (1118)	77.0	104.0	54	11.1
250FN029	2.50 (63.5)	2.25 (57.2)	2.75 (69.9)	¾/16 (4.8)	44 (1118)	87.0	113.0	49	10.0
300FN021	3.00 (76.2)	2.60 (66.0)	3.40 (86.4)	¾/16 (4.8)	44 (1118)	111.0	142.0	39	8.0
300FN929	3.00 (76.2)	2.60 (66.0)	3.40 (86.4)	¾/16 (4.8)	44 (1118)	111.0	142.0	39	8.0
400FN022	4.00 (102)	3.50 (88.9)	4.50 (114)	¾/16 (4.8)	44 (1118)	163.0	200.0	27	5.5
500FN131	5.00 (127)	4.50 (114)	5.50 (140)	¾/16 (4.8)	44 (1118)	195.0	239.0	23	4.7

\*Reference: ASTM D-374-94, Method A, C, or D.

The usual dimensions of pad rolls are 3" (76 mm) I.D. × 6" (152 mm) or 9" (230 mm) outside diameter (O.D.) for widths up to 4" (102 mm). In Luxembourg, 152 mm, 180 mm, 203 mm, and 240 mm O.D. rolls are available. For wider rolls, the usual dimensions are 6" (152 mm) I.D. × 9½" (240 mm) or 11" (280 mm) O.D. For Universal and Step-Pac™ rolls, the dimensions are 3" (76 mm) I.D. × 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 High Performance Films technical or customer service representative.

## Roll Types

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.
100HN	5,000 ft (1,525 m)	9½" (241 mm)	11" (279 mm)
	10,000 ft (3,050 m)	11" (279 mm)	14" (356 mm)
200HN	2,500 ft (763 m)	9½" (241 mm)	11" (279 mm)
300HN	1,670 ft (509 m)	9½" (241 mm)	11" (279 mm)
500HN	1,000 ft (305 m)	9½" (241 mm)	11" (279 mm)

## Splices

### Description

Three types of splice are available.

- Mylar® polyester film-based yellow tape (standard).
- Kapton® polyimide film-based tape (special requirements only).
- Heat seal splice, 12" (305 mm) or less in width (Type FN).

Splices will be centered on the joint to  $\pm 1/4''$  ( $\pm 6$  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 HN and VN film and on all gauges of FN film more than 12" (305 mm) 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 FN 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
I.D. and O.D.**	X	X	

\* Affixed to the core on all cores. 2.25" (57 mm) wide and over.

Included with the package on all cores less than 2.25" (57 mm) wide

\*\* Inside diameter of core and nominal outside diameter of roll

## North America

### *United States*

DuPont High Performance Materials  
P.O. Box 89  
Route 23 South and DuPont Road  
Circleville, OH 43113  
Ordering Information:  
Tel: (800) 967-5607  
Product Information:  
Tel: (800) 237-4357  
Fax: (800) 879-4481

### *Canada*

DuPont Canada, Inc.  
P.O. Box 2200, Streetsville  
Mississauga, Ontario, Canada  
L5M 2H3  
Inquiries: (905) 821-5603  
Customer Service: (800) 784-5231  
Fax: (905) 821-5230

## Latin America

### *Argentina*

DuPont Argentina  
Av. Mitre y Calle 5  
CP 1884, Berazategui, Argentina  
Pcia de Buenos Aires  
Tel: 54-1-256-2435  
Fax: 54-1-319-4451

### *Brazil*

DuPont do Brasil  
Al. Itapecuru, 506  
06454-080, Alphaville  
Barueri, Sao Paulo  
Tel: 55-11-421-8689  
Fax: 55-11-421-8686

### *Mexico*

DuPont S.A. de C.V.  
Homero 206  
Col. Chapultepec Morales  
Mexico, D.F. 11570  
Tel: 525-722-1184  
Fax: 525-722-1370

### *Venezuela*

DuPont Venezuela  
Edificio "Los Frailes"  
Calle la Guarita  
Urbanization Chuao  
CP 1060, Caracas, Venezuela  
Tel: 58-2-92-8547  
Fax: 58-2-91-5638

## Europe

### *Luxembourg*

DuPont de Nemours  
(Luxembourg) S.A.  
Contern  
L-2984 Luxembourg  
Grand Duchy of Luxembourg  
Tel: 352-3666-5575  
Fax: 352-3666-5000

### *Community of Independent States*

DuPont de Nemours Intl. S.A.  
Representative Office—Corporate  
B. Palashevsky per. 13/2  
103104 Moscow  
Russia  
Tel: 7-095-956-3850  
Fax: 7-095-956-3853

### *Deutschland*

DuPont de Nemours (Deutschland)  
GmbH  
DuPont Straße 1  
D-61343 Bad Homburg v.d.H.  
Tel: 49-6172-87-2790  
Fax: 49-6172-87-2930

### *France*

DuPont de Nemours (France) S.A.  
Z.A. de Courtaboeuf  
3 Av. du Canada—B.P. 85  
F-91943 Les Ulis Cedex A  
Tel: 33-1-69 82 52 96  
Fax: 33-1-69-82 53 92

### *Italy*

DuPont de Nemours (Italiana) S.p.A.  
16, Via A. Volta  
I-20093 Cologno Monzese  
Tel: 39-2-25-302 326  
Fax: 39-2-25-43310

### *United Kingdom*

DuPont (U.K.) Ltd.  
Maylands Avenue  
GB-Hemel Hempstead  
Herts HP2 7DP  
Tel: 44-1442-21-8637  
Fax: 44-1442-21-8639

## Asia Pacific

### *Japan*

DuPont Kabushiki Katsha  
Arco Tower  
8-1, Shimomeguro 1-chome  
Meguro-ku, Tokyo 153  
Japan  
Tel: 81-3-5434-6139  
Fax: 81-3-5434-6193

### *Hong Kong/China*

DuPont China Ltd.  
1122 New World Office Bldg.  
East Wing  
Salisbury Road, Kowloon  
Hong Kong  
Tel: 852-2734-5401  
Fax: 852-2721-4117

### *India*

DuPont South Asia Ltd.  
503-505, Madhava  
Bandra Kurla Commercial Complex  
Bandra (E)  
Bombay 400 051  
India  
Tel: 91-22-6438255  
Fax: 91-22-6438297

### *Korea*

DuPont Korea Ltd.  
4/5th Floor, Asia Tower  
#726, Yeoksam-dong, Kangnam-ku  
Seoul 135-082, Korea  
Tel: 82-2-222-5398  
Fax: 82-2-222-5476

### *Singapore*

DuPont Singapore Pte Ltd.  
1 Maritime Square  
#07-01 World Trade Centre  
Singapore 099253  
Tel: 65-279-3434  
Fax: 65-279-3456

### *Taiwan*

DuPont Taiwan Ltd.  
7, Tsu-Chiang 1st Road  
Chungli, Taoyuan  
Taiwan, ROC  
Tel: 866-3-4549204  
Fax: 866-3-4620676

Contact DuPont on the Internet at [www.dupont.com](http://www.dupont.com)

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