EA02025

TEXAS INSTRUMENTS, INC.'S

09/10/03 LETTER TO ODI

REQUEST 10

BOX 13

PART A – G

PART E

Kapton
POLYIMIDE FILM

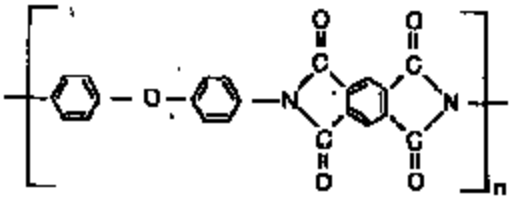
safe handling

Industrial Films Division

SAFETY IN HANDLING AND USE

Introduction

KAPTON polyimide film is a strong, tough, transparent amber-colored plastic film exhibiting excellent physical, chemical and electrical properties over an extremely wide temperature range. It has the structure:



KAPTON is produced in three forms, Type H, Type V, and Type F. Type H is the basic uncoated polyimide film. Type V is similar to Type H but has superior dimensional stability. Type F is coated on one or both sides with Teflon® FEP fluorocarbon resin which imparts heat sealability, provides a moisture barrier, and enhances chemical resistance.

KAPTON is used as insulation for wire and cable, formed coils, magnet wire and transformers, and motor slot liners, among other uses. It also is used as a substrate for flexible printed circuits.

This booklet provides guidelines for the safe handling of KAPTON during processing, use, and disposal.

Users of Type F KAPTON should also refer to DuPont bulletin "Teflon® Fluorocarbon Resins — Safety in Handling and Use."

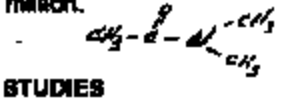
I. GENERAL PROPERTIES

KAPTON Type H and Type V, exhibits no melting point or softening point. A one-mil thick film has a zero-strength temperature of 815°C (1500°F). Zero-strength is measured as the maximum temperature at which the film will sustain a load of 138 KPa (20 psi) for 5 seconds.

KAPTON is insoluble in most common organic solvents after immersion for up to a year (Ref. 1). The hydrolytic stability of KAPTON Type H has been measured after 166 days exposure to boiling water. The film retained 65% of its tensile properties and 20% of its elongation. KAPTON is dissolved by strong acids (Ref. 2, 3) such as fuming nitric and concentrated sulfuric acid, particularly on heating, and is hydrolyzed by alkali and super-heated steam.

KAPTON Type F exhibits better chemical, hydrolytic, and oxidative resistance than Types H and V.

KAPTON may contain up to 1% by weight of dimethyl acetamide residual solvent. At elevated temperatures, some of the solvent may be released and must be removed by exhaust ventilation or diluted to safe levels. OSHA (29 CRF 1910.1000) has established the safe level for dimethyl acetamide as ten parts per million.



II. PYROLYSIS STUDIES

Studies (Ref. 4, 5) have shown the outstanding thermal stability of polyimide film. Its rate of degradation is dependent upon the availability of oxygen. In air at about 500°C (932°F) KAPTON decomposes and completely disappears after twelve hours. At 450°C in air, carbon monoxide may be formed in significant amounts. In a vacuum or inert atmosphere, 60 to 65% of the film remains after prolonged aging at 1000°C (1832°F). The residue retains its original shape but has lost its mechanical strength. The major off-gases are carbon dioxide and carbon monoxide. (See chart)

*Reg. U.S. Pat. & T.M. Off.

Kapton

POLYIMIDE FILM

ADHESION TO KAPTON®

KAPTON® polyimide film, made only by Du Pont, is available in three basic film types. Type H KAPTON is 100% polyimide film. Type F is coated on one or both sides with a TEFLON® FEP fluorocarbon adhesive and Type V is a plain polyimide film having superior dimensional stability properties. Typical property information for KAPTON is found in Bulletin E-72087, "Summary of Properties." Specifications are found in Bulletin E-67824, "Industry Specifications Bulletin FC-85-2." For flexible printed circuit applications the trade specification IPC-FC-231/Sheet 1, applies to KAPTON.

ADHESIVE SELECTION

For some applications KAPTON must be bonded to other materials, such as copper foil, which requires the use of an adhesive. Optimum adhesion results are usually obtained from commercially coated KAPTON which is available from a variety of suppliers such as those listed in Bulletin E-72091, "Suppliers of Adhesive Coatings on KAPTON." This listing represents most of those companies offering coated KAPTON but should not be regarded as a complete listing. Detailed information on the use of these adhesive coated products can be obtained from the supplier's bulletins. Specific requirements for copper laminates produced as substrates for flexible printed circuits are outlined in trade specifications:

- USA: IPC-FC-241
- British: BS-4584
- German: DIN-40802

When commercially coated film is not suitable for an application, most vendors offer a dry film form of their adhesives for use as a bonding film in laminations. However, better adhesion is normally obtained from commercial solution coatings than from the dry bonding film. The dry film adhesive does have the advantage that it can be cut to shapes which cover only that portion of the polyimide film where adhesion is desired.

If neither commercially coated polyimide film nor adhesive bonding film is suitable for the application, the remaining option is for the user to apply a solution adhesive. Some generic classes of adhesives which bond KAPTON include acrylics, epoxies, butyral-phenolics, polyesters, silicones, urethanes, fluorocarbons and blends of these materials.

Selection of an adhesive is usually dependent on the properties required of the adhesive and the demands of the application. Property considerations are the thermal rating, chemical resistance, fill and flow characteristics, flexibility, peel strength, flammability, moisture resistance and insulation resistance. Also to be considered is the ease of processing, lamination temperature and whether the lamination is to be made in continuous roll equipment or in a platen press.

ADHESIVE PROPERTIES

Adhesives used with KAPTON Type H are usually a modified version of the generic adhesive family (e.g., modified-epoxy). These formulations are proprietary to the suppliers of coated KAPTON and require specific processing conditions to achieve the maximum bond strength. Always use the supplier's recommended lamination conditions for the specific adhesive you select.

Listed in Table I are several adhesive types along with information on typical lamination temperatures and maximum operating temperatures (short term exposure). When using an epoxy adhesive, anhydride curing agents are preferred. If an amine curing agent must be used, avoid an excess of curing agent as the free alkaline materials can degrade the polyimide.

TABLE 1

Adhesive Types	Lamination Temperatures °F (°C)	Maximum Operating Temperature °F (°C)
Fluorocarbons	550-600 (290-315)	to 500 (260)
Polyimides	600-700 (290-370)	to 650 (345)
Epoxies	73-450 (23-230)	to 600 (315)
Pressure Sensitive Silicones	73-300 (23-150)	to 500 (260)
Rubber-Phenolics	300-400 (150-205)	to 500 (260)
Acrylics	350-375 (175-190)	to 550 (290)
Polyesters	275-300 (135-150)	to 220 (105)

Solution forms of most of the adhesives above are available from suppliers of adhesives to the electronics industry. Listings of suppliers can be found in buyer's guides for electronic products. Bulletin E-74149, "Suppliers of Adhesives to the Electronics Industry," provides a representative listing of adhesive suppliers who can be consulted with for specific adhesive needs.

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III. FLAMMABILITY

Lewis and Stabler (Ref. 6) report the flammability characteristics of polyimide film as "self-extinguishing." KAPTON has a 94 VTM-0 rating, the highest given in the U.L. 94 vertical burning test for thin films. The oxygen index is 37% for 100 H film (ASTM 2863).

IV. HANDLING PRACTICES

Safe handling of Type H and V KAPTON polyimide films at high temperatures requires adequate ventilation. If small quantities of KAPTON are involved, as is often the case, normal air circulation will be all that is needed in case of overheating. Whether or not existing ventilation is adequate at higher temperatures will depend on the combined factors of film quantity, temperature, and exposure time. For additional information on the Teflon® FEP coatings used on Type F KAPTON, refer to the booklet — "Teflon® Fluorocarbon Resins — Safety in Handling and Use."

A. Soldering and Hot Wire Stripping

Major uses for all types of KAPTON include electrical insulation for wire and cable and other electronic equipment. In virtually all of these applications, soldering is a routine fabricating procedure as is the use of a heated element to remove insulation. Soldering operations rarely produce sufficient off-gases to be of toxicological significance.

Ventilation practices should follow the same common sense rules applicable to any soldering procedure. Normal ventilation provided for worker comfort usually provides adequate safety. During hot-wire stripping, it is recommended that exhaust ducts be used at the workbench.

There have been no reports of ill effects during soldering or hot-wire stripping of wire and cable insulated with KAPTON.

B. Welding and Flame Cutting

Direct application of welding arcs and torches can quickly destroy most plastics, including all types of KAPTON film. For practical reasons, therefore, it is best to remove all such parts from equipment to be welded. Where removal is not possible, such as in welding or cutting coated parts, mechanical ventilation should be provided.

Because KAPTON is rated for use at very high temperatures, parts made from it may survive at locations close to the point of direct flame contact. Thus some in-place welding operations can be done. Since the quantity of film heated is usually relatively small (less than one pound), ventilation requirements seldom exceed those for normal welding work. Because of the possibility of inadvertent overheating, however, the use of a small fan or elephant-trunk exhaust is advisable.

C. Scrap Disposal

Disposal of scrap KAPTON polyimide films presents no special problem to the user. Small amounts of scrap may be incinerated along with general plant refuse. The incinerator should have sufficient draft to exhaust all combustion products to the stack. Care should be taken to avoid breathing smoke and fumes from any fire. Because KAPTON is so difficult to burn, it is often best to dispose of scrap film in a landfill. KAPTON can be expected to be stable in landfills.

D. Fire Hazards

Whether in storage or use, KAPTON is unlikely to add appreciably to the hazards of fire. Bulk quantities of KAPTON (over 100 pounds) should be stored away from flammable materials.

In the event of fire, personnel entering the area should use a fresh air supply or a respirator. This type of equipment is standard in fighting many types of fire. All types of chemical extinguishers may be used to fight fires involving KAPTON. Large quantities of water also may be used to cool and extinguish a fire.

E. Static Electricity

The processing of KAPTON polyimide film can cause the generation of a strong static charge. Unless this charge is bled off as it forms through the use of ionizing radiation or metal tinsel, it can build to many thousands of volts and discharge to people or to metal equipment. In dust or solvent laden air, a flash fire or explosion could result. Precautions for static charges should also be taken when removing plastic films used as protective packaging for KAPTON.

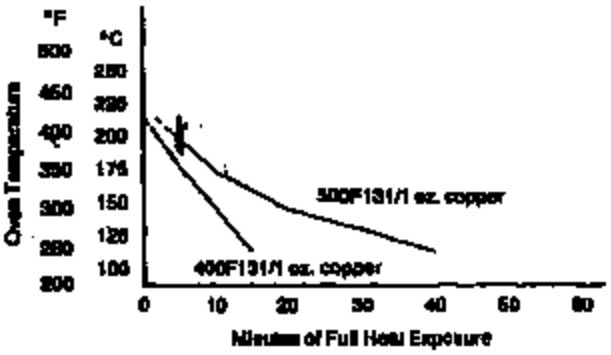
REFERENCES

1. J. T. Milek, "Polyimide Plastics: A State-of-the-Art-Report," Electronic Properties Information Center, S-8, October 1, 1965, Air Force Systems Command, Contract AF33 (615)-2460, Proj. 7381; Task 738103.

2. C. E. Sroog, A. L. Endrey, S. V. Abrams, C. E. Berr, W. M. Edwards, and K. L. Oliver, J. Poly. Sci. A, 3(4), 1373-90 (1965).

Given in Figure 3 are minimum times to dry laminates of Type F to copper prior to dip soldering. The times are different than in Figure 2 due to the presence of the copper foil.

FIGURE 3
DRYING CONDITIONS FOR KAPTON TYPE F LAMINATES PRIOR TO DIP SOLDERING



SOLDERING AND PRESS CONDITIONS FOR TYPE H LAMINATES

The recommended predrying conditions prior to dip soldering and platen pressing laminates based on type H film will vary according to type of thermoset adhesive used in addition to factors mentioned for Type F laminates. The moisture retention and permeability of the film and adhesive must be considered along with the impermeability of the copper foil layers. Consult your laminate supplier for recommended predrying conditions specific to the combination of materials supplied.

EFFECTS OF HUMIDITY ON PEEL STRENGTH

Humidity can have a large effect on peel strength with certain adhesive systems, and RH ought to be controlled in peel strength measurements. A summary of our investigation into this phenomenon is given in Table III. Results show that those adhesives having functional groups capable of absorbing water vapor will promote high peel strengths at high RH and low peel strengths at low RH. Between an RH of 10% and an RH of 70%, the effect can be as large as 6 lbs. per lineal inch (10.5 N/cm). Those adhesives which do not have hygroscopic functional groups are not affected by RH changes in terms of peel values.

TABLE III
EFFECTS OF RELATIVE HUMIDITY ON PEEL STRENGTH

Adhesive Type	Peel Strength, lb./in. (N/cm) 10% RH	70% RH
Acrylic	5.8 (10.2)	11.5 (20.1)
Epoxy-Amide	5.4 (9.5)	10.0 (17.5)
Epoxy-Novolac	2.0 (3.5)	2.1 (3.7)
Phenolic-Butyral	3.8 (6.7)	5.2 (9.1)
Phenolic-Nitrile	4.7 (8.2)	4.3 (7.5)

EFFECT OF SURFACE ON PEEL STRENGTH

The top surface of KAPTON is referred to as the "bright" or "shiny" side. The bottom side is "dull" and purposely roughened in the manufacture of the film to improve film handling characteristics. Most adhesives bond better to the dull side of the film. The effect is generally 1-2 lbs. per lineal inch (1.8-3.5 N/cm) but can be as high as 4 lbs. per inch (7.0 N/cm) or negligible depending on the adhesive system used.

Experience has also shown that peel strength normally increases with the thickness of the film. Within a laminate based on a given film thickness, a range of peel strengths can also be expected, which is inherent in the film surface, the adhesive system and the test method applied. For example, a typical peel strength range for an acrylic adhesive is 6 lbs./in. (10.5 N/cm). For 100H this range can result in values as low as 2 lbs./in. (3.5 N/cm).

Unless specifically recommended by the adhesive supplier, the surface of KAPTON should be used as received. If the film has been contaminated with grease or oils, it should be cleaned with solvent (such as methylethyl ketone or toluene). Metal surfaces should be thoroughly cleaned. For best adhesion, they should be roughened mechanically or by chemical treatment.

When higher adhesion levels are required for a given adhesive system, the range of the peel strength values for the laminate may usually be reduced if the surface of the film is mechanically or chemically abraded, light pumice scrubbing or caustic etching. Caution must be exercised with any such treatment to avoid damaging the film.

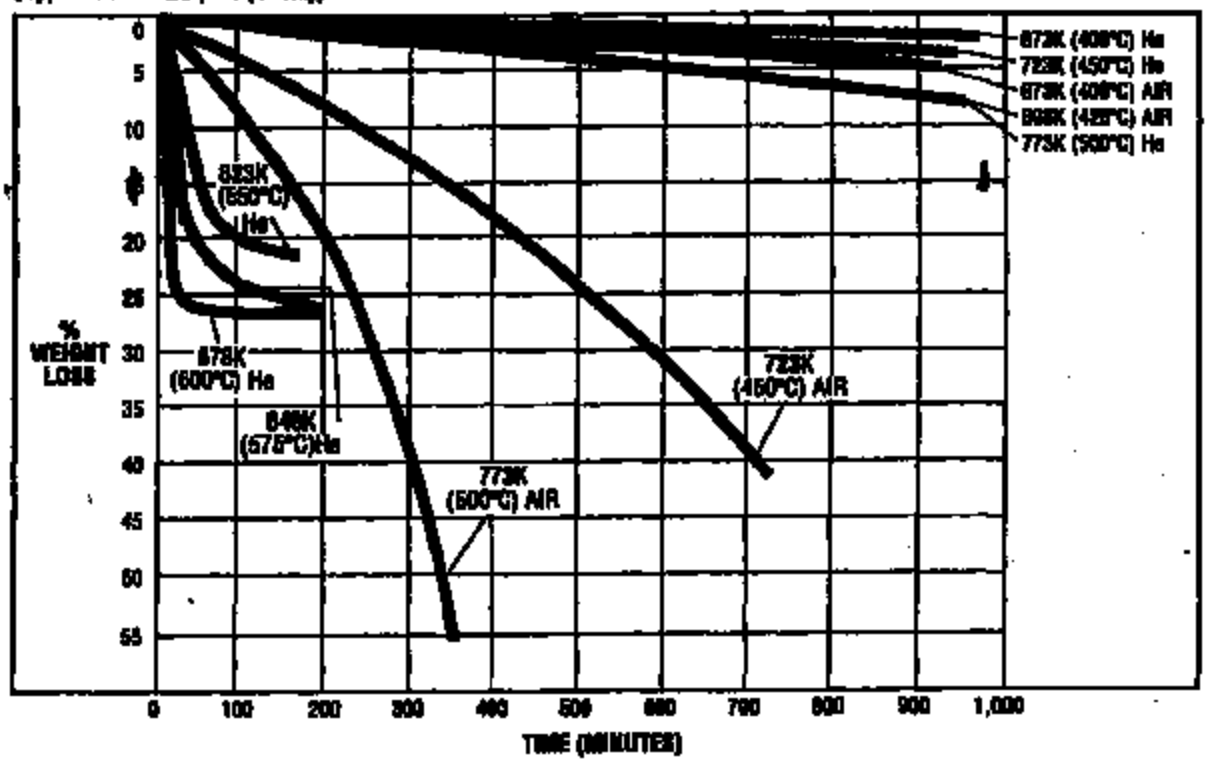
EFFECT OF THERMAL TREATMENT ON PEEL STRENGTH

High thermal treatment of KAPTON will often improve bondability. Temperatures of about 400°C for as long as 6-10 minutes are required, and structural changes probably occur.

Studies of adherability of typical printed circuit adhesives to heat treated KAPTON and standard KAPTON have shown that heat treatment provides an advantage with most adhesives. The greatest advantage was gained with acrylic, epoxy, phenolic butyrals and phenolic nitriles. Improvement over standard film averaged from 40% to 97% for these adhesive types.

ISOTHERMAL WEIGHT LOSS

(Type H Film 25 μm (1 mil))



3. N. A. Androva, M. I. Bessonov, L. A. Laius, and A. P. Rudakov, "Polyimides — A New Class of Thermally Stable Polymers," Progress in Mats. Sci. Series, Vol. VII, Technomic Publ. Co., Stamford, Conn., 1970, p. 79-85.

4. 1968 Listing of Plastic Materials, etc., P. 10, March 1968, National Sanitation Foundation.

5. General Electric Co. Res. Lab., Research of Dielectric Materials, Rept. #ML-TDR-64-57, May 1964, DDC AD-602 436, NASA N64-26308.

6. R. F. Stabler and L. L. Lewis, "KAPTON Polyimide Film — A New Insulation for Aerospace Wire and Cable," Paper presented at Soc. of Aerospace Materials and Process Engineers Meeting, San Francisco, May 25, 1965.

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KAPTON® Polyimide Film
Technical Bulletin

Suppliers of Adhesives to the Electronics Industry

DuPont Electronics

High Performance Substrates and Materials

September 1988

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○ Fenwal Inc., Ashland, MA	(508) 881-2000
○ Formulated Resins Inc., Greenville, RI	(401) 949-2060
○ GE/ Silicon Products Div., Waterford, NY	(518) 237-3330
● B.F. Goodrich Adhesives Div., Akron, OH	(216) 374-3000
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○ Whittaker (Dayton Chemicals Div.) West Alexandria, OH	(513) 839-4612

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KAPTON® Polyimide Film
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CH-1218 Le Grand-Saconnex
Geneva, Switzerland
41 (22) 717-5111
Fax: 41 (22) 717-5109

Asia Pacific
Japan
Du Pont Japan Ltd.
Du Pont Tower, Shin-Nikko Building
10-1, Toranomon 2-chome
Minato-ku, Tokyo
105 Japan
81-3-3585-5511
Fax: 81-3-3224-5863

ASEAN
Du Pont Singapore PTE Ltd.
1 Maritime Square
07-01, World Trade Centre
Singapore 0409
65-273-2244
Fax: 65-272-5055

Australia
Du Pont (Australia) Ltd.
Northside Gardens
168 Walker Street
North Sydney, NSW 2060
Australia
61-2-923-6111
Fax: 61-2-929-7217

Hong Kong/China
Du Pont Asia Pacific Ltd.
1122 New World Office Bldg
East Wing
Salisbury Road, Kowloon
Hong Kong
852-734-5345
Fax: 852-724-4495

Korea
Du Pont Korea Ltd.
9th Floor, Kyobo Bldg.
1, Chongro 1-Ka, Chongro-Ku
Seoul 110-714, Korea
82-2-721-5114
Fax: 82-2-732-5930

Taiwan
Du Pont Taiwan Ltd.
13th Floor, Hung Kuo Building
167 Tun Hwa North Road
Taipei, Taiwan 10590, R.O.C.
886-2-719-1999
Fax: 886-2-712-0444

Du Pont Electronics

DD/NHTSA No. 3
99281

TI-NHTSA 018164

DU PONT

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

NAME
HFC-134a

FORMULA
CH_2FCF_3

MANUFACTURER/DISTRIBUTOR
E. I. du Pont de Nemours & Co. (Inc.)

ADDRESS
Wilmington, DE 19898

CHEMICAL FAMILY
Halogenated Hydrocarbon

TSCA INVENTORY STATUS
Reported/Included

PRODUCT INFORMATION PHONE
(800) 441-9450

MEDICAL EMERGENCY PHONE
(800) 441-3637

TRANSPORTATION PHONE
CHEMTREC (800) 424-9300

PHYSICAL DATA

BOILING POINT
-26.5°C (-14.5°F) @ 736 mmHg

LIQUID DENSITY
1.21 g/cc @ 25°C (77°F)

VAPOR DENSITY (AIR = 1)
3.18

FORM
Liquefied Gas

COLOR
Colorless

PERCENT VOLATILE BY VOLUME
100

VAPOR PRESSURE
96 psig @ 25°C (77°F)

SOLUBILITY IN WATER
0.15% by wt at 25°C (77°F) & 14.7 psia

APPEARANCE
Clear

ODOR
Slight Ethereal

HAZARDOUS COMPONENTS

MATERIAL(S)	CAS NO.	APPROXIMATE %
Ethane,1,1,1,2-Tetrafluoro	811-97-2	100

HAZARDOUS REACTIVITY

STABILITY
Material is stable. However, avoid open flames and high temperatures.

INCOMPATIBILITY
Alkali or Alkaline earth metals--powdered Al, Zn, Be, etc.

DECOMPOSITION
HFC-134a can be decomposed by high temperatures (open flames, glowing metal surfaces, etc.) forming hydrofluoric acid--possibly carbonyl fluoride.

POLYMERIZATION
Will not occur.

FIRE AND EXPLOSION DATA

FLASH POINT
Will not burn. METHOD TOC

FLAMMABLE LIMITS IN AIR, % BY VOL.
LOWER Not applicable.
UPPER Not applicable.

AUTOIGNITION TEMPERATURE
Not determined.

FIRE AND EXPLOSION HAZARDS
Cylinders may rupture under fire conditions. Decomposition may occur.

EXTINGUISHING MEDIA
As appropriate for combustibles in area.

SPECIAL FIRE FIGHTING INSTRUCTIONS
Cool cylinders with water spray. Self-contained breathing apparatus (SCBA) may be required if cylinders rupture or release under fire conditions.

HEALTH HAZARD INFORMATION

PRINCIPAL HEALTH HAZARDS

Inhalation of high concentrations of vapor is harmful and may cause heart irregularities, unconsciousness or death. Intentional misuse can be fatal. Vapor reduces oxygen available for breathing and is heavier than air. Liquid contact can cause frostbite

Inhalation 4 Hour ALC: 567,000 ppm in rats

The compound is untested for skin and eye irritancy and is untested for animal sensitization.

Acute Toxicity in Animals

The effects in animals from short exposure by inhalation include no toxic effects observed at vapor concentrations up to 81,000 ppm. Lethargy and rapid respiration were observed at a vapor concentration of 205,000 ppm.

Pulmonary congestion, edema, and central nervous system effects occurred at a vapor concentration of 750,000 ppm. Cardiac sensitization occurred in dogs at 75,000 ppm from the action of exogenous epinephrine.

Subchronic Toxicity in Animals

Inhalation: The effects in animals from exposure by inhalation for two weeks include no observable adverse effects. Ingestion: No adverse effects were observed in male and female rats administered 300 mg/kg/day of HFC-134a for 52 weeks.

No acceptable information is available to confidently predict the effects of excessive human exposure to this compound.

CARCINOGENICITY

HFC-134a is not listed as a carcinogen by IARC, NTP, OSHA, ACGIH, or Du Pont.

EXPOSURE LIMITS

PEL (OSHA): Not established.
TLV* (ACGIH): Not established.

SAFETY PRECAUTIONS

Avoid breathing vapor and liquid contact with skin or eyes. Provide adequate ventilation for storage, handling, and use, especially for enclosed and low spaces.

*TLV is a registered trademark of the American Conference of Governmental Industrial Hygienists.

HEALTH HAZARD INFORMATION (con't)

FIRST AID

IF HIGH CONCENTRATIONS ARE INHALED: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

IN CASE OF EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

IN CASE OF SKIN CONTACT: Flush skin with water after excessive contact. Wash contaminated clothing before reuse. Treat for frostbite if necessary.

IF SWALLOWED: Ingestion is not considered a potential route of exposure.

NOTE TO PHYSICIANS

Because of possible disturbances of cardiac rhythm, catecholamine drugs, such as epinephrine, should be considered only as a last resort in life-threatening emergencies.

PROTECTION INFORMATION

GENERALLY APPLICABLE CONTROL MEASURES

Normal ventilation for standard manufacturing procedures is generally adequate. Local exhaust should be used when large amounts are released. Mechanical ventilation should be used in low places.

PERSONAL PROTECTIVE EQUIPMENT

Lined butyl gloves and chemical splash goggles should be used when handling liquid. Under normal manufacturing conditions, no respiratory protection is required when using this product. Self-contained breathing apparatus (SCBA) is required if a large release occurs.

DISPOSAL INFORMATION

SPILL, LEAK OR RELEASE

Ventilate area—especially low places where heavy vapors might collect. Remove open flames. Use self-contained breathing apparatus (SCBA) if large spill or leak occurs.

WASTE DISPOSAL

Contaminated HFC-134a can be recovered by distillation or removed to a permitted waste disposal facility. Comply with Federal, State, and local regulations.

TI-NHTSA 018169

DU PONT

DD/NHTSA No. 3
04284

SHIPPING INFORMATION

DOT (172.101)

PROPER SHIPPING NAME
Refrigerant Gas, N.O.S.
(Tetrafluoroethane)

HAZARD CLASS
Nonflammable gas

UN NO.
1078

DOT/IMO (172.102)

PROPER SHIPPING NAME
Refrigerant Gas, N.O.S.
(Tetrafluoroethane)

HAZARD CLASS
Nonflammable gas, 2.2

UN NO.
1078

IMO LABEL
Nonflammable gas

OTHER INFORMATION

SHIPPING CONTAINERS
Cylinders, ton tanks, tank cars and tank trucks

STORAGE CONDITIONS
Clean, dry area. Do not heat above 125°F.

ADDITIONAL INFORMATION AND REFERENCES

NFCA - HMIS RATINGS

Health	1
Flammability	0
Reactivity	1
Personal Protection	-

Personal Protection rating to be supplied by user depending on use conditions.

DATE OF LATEST REVISION/REVIEW: 4/88

PERSON RESPONSIBLE FOR MSDS:
K. P. BROWN
Du Pont Co.
C&P Dept., Chestnut Run-709
Wilmington, DE 19898
(302) 999-3018

138337A

TI-NHTSA 018170

DD/NHTSA No. 3
06287

DuPont Electronics

DuPont Company
Barley Mill Plaza
P.O. Box [illegible]
Wilmington, Delaware [illegible]

Dear Customer:

Thank you for calling Du Pont. Enclosed please find the literature you requested on Kapton®. Your interest in our product is greatly appreciated.

Also enclosed is my business card if additional information or technical assistance is needed.

Sincerely,

Donald J. Farrelly, Jr.

DJF/ tlp
Enclosures

®Du Pont Registered Trademark

TI-NHTSA 018171

KAP002

MATERIAL SAFETY DATA SHEET

E. I. DUPONT DE NEMOURS & CO
POLYMER PRODUCTS DEPARTMENT
ELECTRONICS DEPARTMENT
1007 MARKET STREET
WILMINGTON, DE 19898

TELEPHONE NUMBERS
MEDICAL EMERGENCY 800-441-3637
PRODUCT INFORMATION 800-441-7515
TRANSPORTATION EMERGENCY 800-424-9300

MATERIAL IDENTIFICATION

PRODUCT NAME	Kapton® Polyimide Film, coated types F, FN, XP, ZN
CHEMICAL NAME	Aromatic Polyimide plus up to 1 % dimethyl acetamide and a polyfluorocarbon coating.
CAS REGISTRY NUMBER	NA
TSCA INVENTORY STATUS	All reportable ingredients are listed in the TSCA Chemical Substance Inventory.
DOT HAZARD CLASS	Not regulated
SHIPPING NAME	NA
PREPARER	C. B. Stouffer DATE September 27, 1989

HAZARDOUS COMPONENTS

MATERIAL	Dimethyl acetamide
CAS NO.	127-19-5
CONCENTRATION %	Up to 1%
OSHA PEL	10 ppm (skin)*
ACGIH TLV	10 ppm (skin)*
DUPONT AEL	10 ppm (skin)*

*The "skin" notation serves as a reminder that exposure can result through skin absorption as well as through inhalation, and that appropriate precautions should be taken to prevent both types of exposure.

SUBSTANCES PRESENT AT A CONCENTRATION OF 0.1% OR MORE CLASSIFIED AS A CARCINOGEN BY IARC, NTP OR OSHA: None

PHYSICAL/CHEMICAL DATA

APPEARANCE	Transparent film, light amber color
ODOR	None
MELTING POINT	None
SOLUBILITY IN WATER	Insoluble
VOLATILE CONTENT	1% max
SPECIFIC GRAVITY	>1.4

TI-NHTSA 018172

FIRE AND EXPLOSION HAZARD DATA

FLASH IGNITION TEMPERATURE NA

UNUSUAL FIRE, EXPLOSION HAZARDS Chars but does not burn. Static charge may build up during handling of Kapton® film.

HAZARDOUS COMBUSTION PRODUCTS Hydrogen fluoride, carbon monoxide, carbonyl fluoride.

SPECIAL FIRE FIGHTING INSTRUCTIONS Wear self-contained breathing apparatus and clothing to protect from hydrogen fluoride, which react with water to form hydrofluoric acid. Wear Neoprene gloves when handling refuse from a fire involving fluorocarbon resins.

EXTINGUISHING MEDIA Water, carbon dioxide, foam, dry chemical.

HAZARDOUS REACTIVITY

CONDITIONS TO AVOID Temperatures above 260°C without adequate ventilation. Coated types of Kapton® will burn in an atmosphere of 95% oxygen.

MATERIALS TO AVOID Alkali metal and interhalogen compounds.

HAZARDOUS DECOMPOSITION PRODUCTS Above 260°C coated types of Kapton® can evolve toxic gaseous materials such as hydrogen fluoride and perfluoroolefins. Major off-gases are carbon monoxide and carbon dioxide.

HEALTH HAZARD DATA

Read "Safety in Handling and Use" Bulletin E-72084 before using Kapton®. Avoid contamination of tobacco products.

ACUTE OR IMMEDIATE EFFECTS: ROUTES OF ENTRY AND SYMPTOMS

INGESTION Not a probable route of exposure.

SKIN No irritation expected. Less than 1 ppm dimethyl acetamide was extracted from film by distilled water at 40°C for 4 hours.

EYE Not a probable route of exposure. Mechanical irritation.

INHALATION Vapors and fumes liberated above 260°C or from smoking tobacco or cigarettes contaminated with coated types of Kapton® film may cause influenza type symptoms (polymer fume fever) with chills fever and sore throat, which may not occur until several hours after after exposure, and pass within 36-48 hours, even without treatment.

Inhalation is not a probable route of exposure for film. For the polymer from which this film is made, du Pont recommends treating polymer dust as

a nuisance particulate, and has established an AEL of 10 mg/m^3 total dust, the same as the TLV for nuisance particulates.

EMERGENCY FIRST AID

- If exposed to fumes from overheating or combustion, move to fresh air. Consult a physician if symptoms persist.
- For prolonged skin contact, wash with soap and water. In case of skin irritation, consult a physician.
- Flush eyes with plenty of water. Consult a physician if symptoms persist.

CHRONIC EFFECTS None known.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE None known.

PROTECTION INFORMATION

EYE Safety glasses recommended.

SKIN Gloves recommended.

VENTILATION Local exhaust for operation above 200°C.

RESPIRATOR Not required for normal processing.

DISPOSAL

SPILL, LEAK OR RELEASE Sweep up to avoid slipping hazard.

WASTE DISPOSAL Landfill or incinerate in compliance with federal, state, and local regulations. Incinerator should be equipped with scrubber to remove acidic hydrogen fluoride from off-gases.

AQUATIC TOXICITY Insoluble

STORAGE CONDITIONS Store away from flammable materials.

The information in this Material Safety Data Sheet relates only to the specific material (s) designated herein and does not relate to use in combination with any other material or in any process.

NA = Not applicable
NE = Not established
AEL = Du Pont Company's Acceptable Exposure Limit
> = New or revised information in this section when ">" is in left margin

SECTION 313 SUPPLIER NOTIFICATION

This product contains no known toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 and of 40 CFR 372.

STATE RIGHT TO KNOW LAWS

No substances on the state hazardous substances list, for the states indicated below, are used in the manufacture of products on this Material Safety Data Sheet, with the exceptions indicated. While we do not specifically analyze these products, or the raw materials used in their manufacture, for substances on various state hazardous substances lists, to the best of our knowledge the products on this Material Safety Data Sheet contain no such substances except for those specifically listed below:

SUBSTANCES ON THE PENNSYLVANIA HAZARDOUS SUBSTANCES LIST PRESENT AT A CONCENTRATION OF 1% OR MORE:

Dimethyl acetamide (1% maximum)

SUBSTANCES ON THE PENNSYLVANIA SPECIAL HAZARDOUS SUBSTANCES LIST PRESENT AT A CONCENTRATION OF 0.01% OR MORE: None known.

NON--HAZARDOUS INGREDIENTS PRESENT AT A CONCENTRATION OF 3% OR MORE REQUIRED TO BE LISTED BY PENSYLVANIA:

	CAS No.
Polyimide film	25038-81-7
Polyfluorocarbon coating	25067-11-2 or 26655-00-5 or 25038-71-5

WARNING: SUBSTANCES KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER: None known.

WARNING: SUBSTANCES KNOWN TO THE STATE OF CALIFORNIA TO CAUSE BIRTH DEFECTS OR OTHER REPRODUCTIVE HARM: None known.

SUBSTANCES ON THE NEW JERSEY WORKPLACE HAZARDOUS SUBSTANCE LIST PRESENT AT A CONCENTRATION OF 1% OR MORE (0.1% FOR SUBSTANCES IDENTIFIED AS CARCINOGENS, MUTAGENS OR TERATOGENS):

Dimethyl acetamide (1% maximum).

Kapton
POLYIMIDE FILM

GENERAL SPECIFICATIONS BULLETIN G5-87-4

GENERAL

INTRODUCTION

The Electronics Department of the Du Pont Company manufactures and sells a variety of high quality plastic film products.

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

Any aspects of the specifications requiring further interpretation or clarification should be discussed with representatives of the Du Pont Electronics Department.

Types of Kapton® Polyimide Film

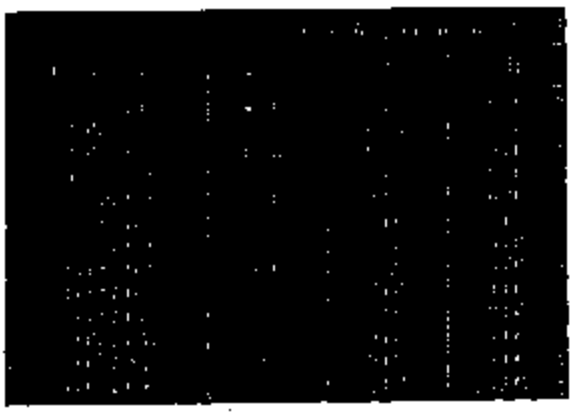
Du Pont makes three types of "Kapton" polyimide film, Type HN, Type FN and Type VN.

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 make up is the result of a polycondensation reaction between pyromellitic dianhydride and 4,4'-diaminodiphenyl-ether. "Kapton" HN is available in 30, 50, 100, 200, 300 and 500 gauges.

Type FN Film

"Kapton" Type FN film is a heat sealable grade which retains the unique balance of properties that "Kapton" Type HN possesses over a wide temperature range. This is achieved by combining Type HN "Kapton" and Teflon® FEP fluorocarbon resin together in a composite structure. Listed below are those combinations commercially available at this time. Other combinations are available. Consult your Electronics Department marketing representative for further information.



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 100, 200, 300 and 500 gauges.

Certification

"Kapton" is certified to meet the requirements of the military specification MIL-P-46112 B (MR) in addition to the items covered by this specifications bulletin. Written confirmation is available with each delivery upon request.

DU PONT

TI-NHTSA 018176

Kapton®
POLYIMIDE FILM

GENERAL SPECIFICATIONS
BULLETIN GS-87-4

GENERAL

INTRODUCTION

The Electronics Department of the Du Pont Company manufactures and sells a variety of high quality plastic film products.

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

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Types of Kapton® Polyimide Film

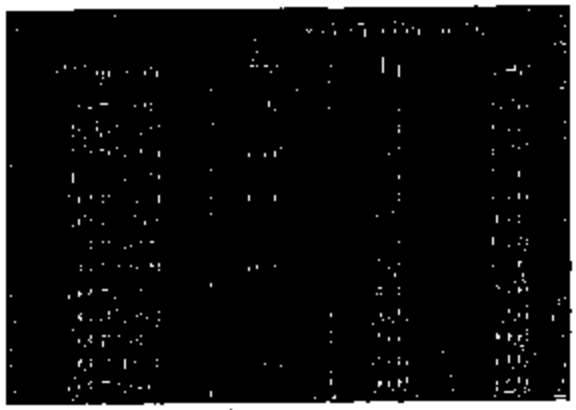
Du Pont makes three types of "Kapton" polyimide film, Type HN, Type FN and Type VN.

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 make up is the result of a polycondensation reaction between pyromellitic dianhydride and 4,4'-diaminodiphenylether. "Kapton" HN is available in 30, 50, 100, 200, 300 and 500 gauges.

Type FN Film

"Kapton" Type FN film is a heat sealable grade which retains the unique balance of properties that "Kapton" Type HN possesses over a wide temperature range. This is achieved by combining Type HN "Kapton" and Teflon® FEP fluorocarbon resin together in a composite structure. Listed below are those combinations commercially available at this time. Other combinations are available. Consult your Electronics Department marketing representative for further information.



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 100, 200, 300 and 500 gauges.

Certification

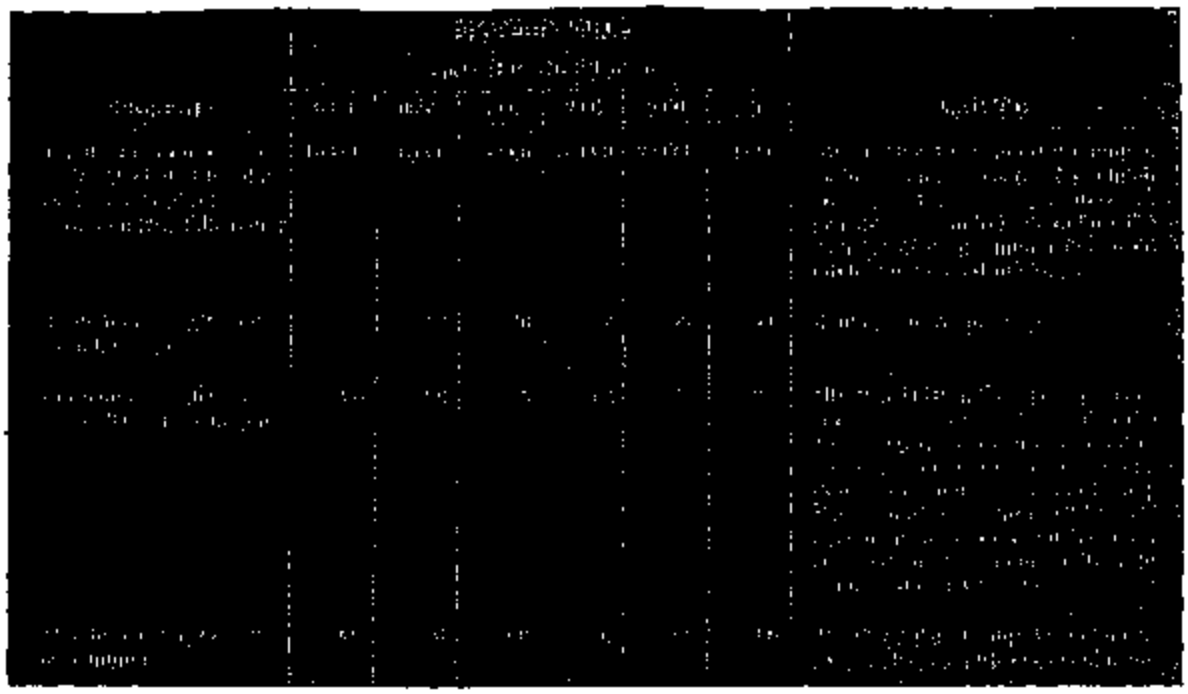
"Kapton" is certified to meet the requirements of the military specification MIL-P-46112 B (MR) in addition to the items covered by this specifications bulletin. Written confirmation is available with each delivery upon request.

DU PONT

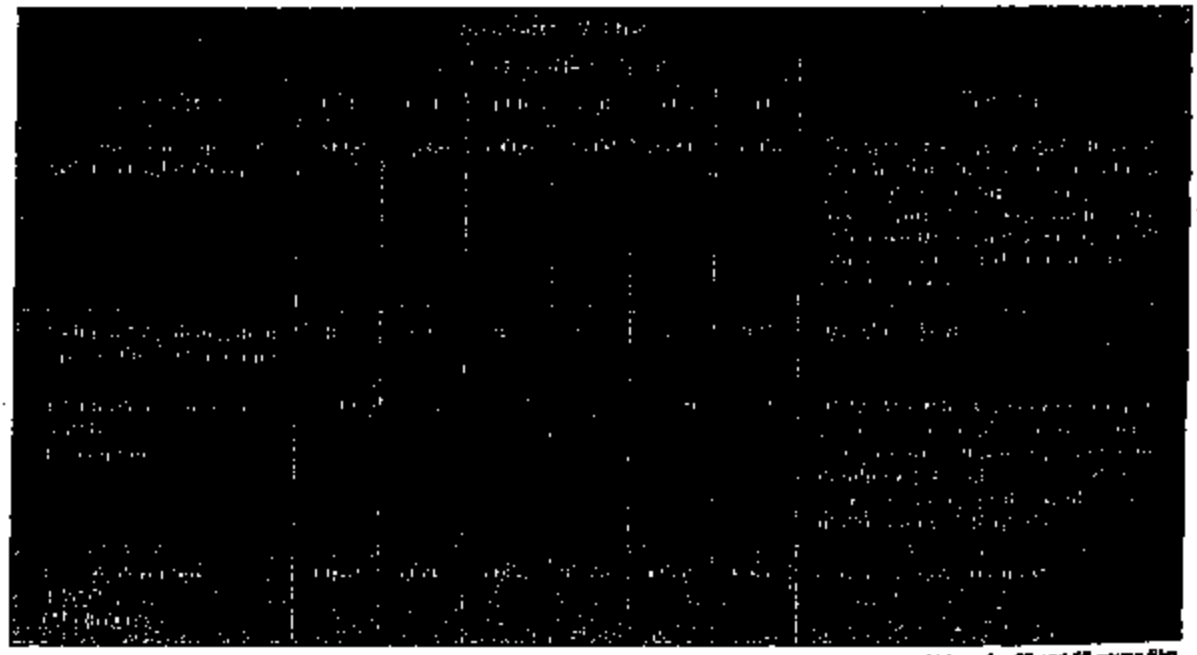
TI-NHTSA 018177

PROPERTIES OF TYPE HN FILM

MECHANICAL



ELECTRICAL



*1 hour for 30 and 50 gauge film.

Thermal Durability

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

Sheets of film 8½" x 11" are freely suspended in an oven at 400°C. The temperature of the oven is monitored with a thermocouple to insure a temperature accuracy of ±2°C. Sheets are removed after 2 hours* and tested on an Instron Tensile Tester as described above under "Elongation." The elongation (at 23.5°C.) of the film should not be less than 10% after this aging at 400°C. This conforms to the "Elongation after Aging at 400°C." test (paragraph

4,4,5) and "Elongation, percent, after 2 hour 400°C." requirement (Table 1) of MIL-P-46112 B (MR).

Underwriters Laboratories Inc. lists a thermal index of 200°C.–220°C. (depending on gauge and type) for mechanical properties and 220°C.–240°C. (depending on gauge and type) for electrical properties under their file no. E39505 for "Kapton" polyimide film.

*1 hour for 30 & 50 gauge film.

PROPERTIES OF TYPE FN FILM

A. Heat Seal Strength

1. Film to Film Seals

The heat seal peel strength between the coated and uncoated side of one side coated Kapton® polyimide film or the coated to coated side of one or two side coated "Kapton" is measured in the following manner: Seals are made in a jaw sealer at 350°C., 20 psi, 20 sec. dwell time. After cooling, the seals are cut to 1" wide strips using a Thwing-Albert JDC sample cutter or equivalent. The strength of the seal 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" polyimide film will be 600 gms./inch except for 120FN616 which will be 450 gms./in. The minimum peel strength between the coated and uncoated side of one side coated "Kapton" will be 450 gms./inch.

2. Film to Copper Seals for 120FN616 Film

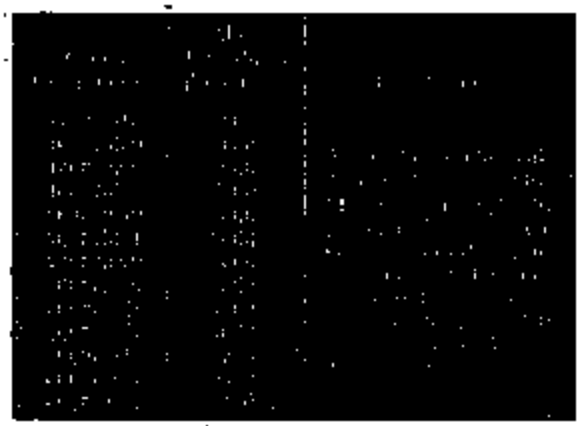
The ability of 120FN616 film to adhere to copper is measured by using the same heat seal peel strength technique as described above.

The peel strength obtained when 120FN616 is sealed to the untreated side of ¾ oz. GT copper foil (1 mil) will be a minimum of 250 gms./in.

3. As-Received Strength (Cold peel) of Bonds Between the Type HN "Kapton" and "Teflon" Layers

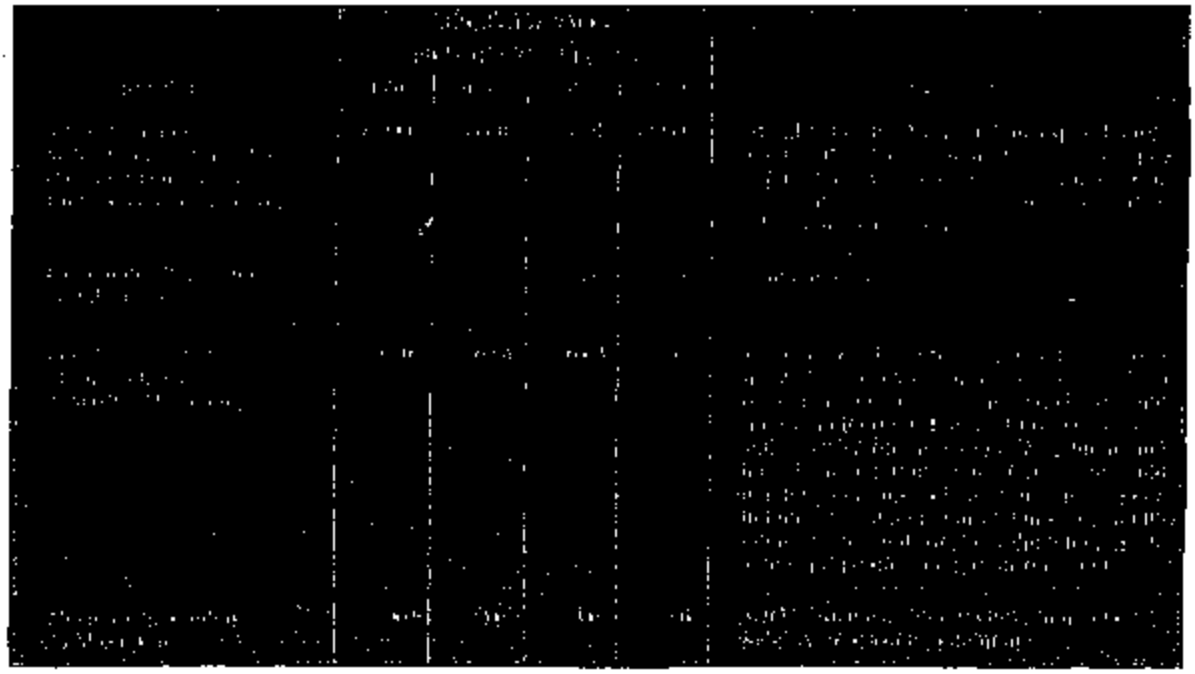
The bond between the Type HN "Kapton" and Teflon® fluorocarbon resin layers on all type FN products except 120FN616 will have a minimum peel strength of 225 gms./in. as measured using an Instron type tensile tester and a 180° peel.

B. Dielectric Strength

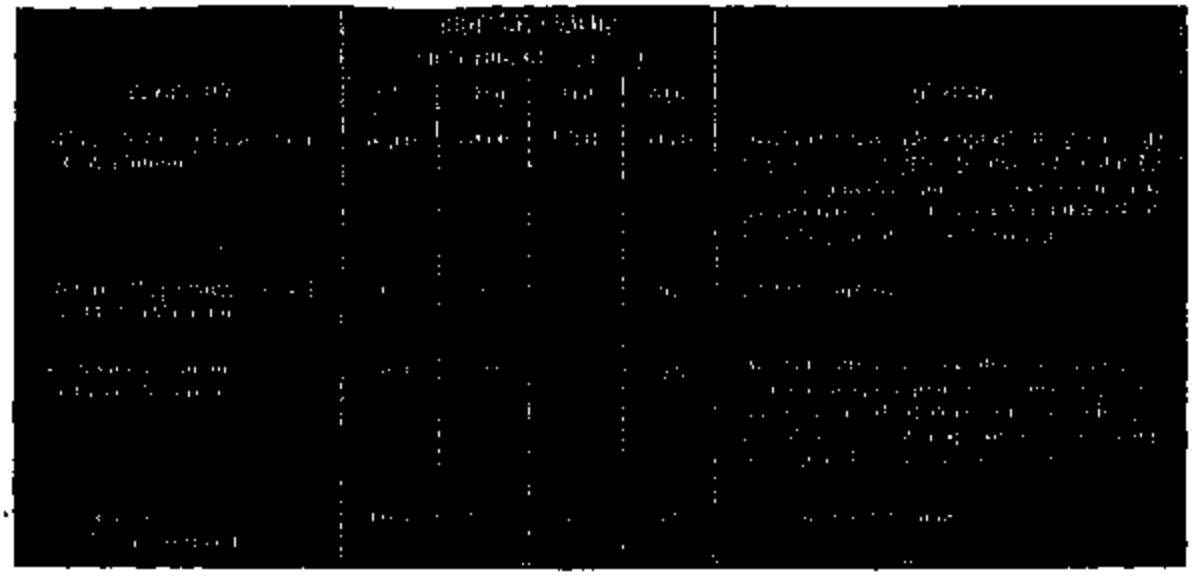


PROPERTIES OF TYPE VN FILM

MECHANICAL



ELECTRICAL



Thermal Durability

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

Sheets of film 8½" x 11" are freely suspended in an oven at 400°C. The temperature of the oven is monitored with a thermocouple to insure a temperature accuracy of ±2°C. Sheets are removed after 2 hours and tested on an Instron Tensile Tester as described above under "Elongation." The elongation (at 23.5°C.) of the film should not be less than 10% after this aging at 400°C. This conforms to the "Elongation after Aging at 400°C." test (paragraph 4.4.8) and "Elongation, percent, after 2 hour 400°C." requirement (Table 1) of MIL-P-46112 B(MR).

Underwriters Laboratories Inc. lists a thermal index of 200°C.–220°C. (depending on gauge and type) for mechanical properties and 220°C.–240°C. (depending on gauge and type) for electrical properties under their file no. E39505 for "Kapton" polyimide film.

GENERAL

A. MATERIAL

Type HN and Type VN Film—A polyimide polymer in the form of a film.

Type FN Film—A combination of Kapton® polyimide film Type HN with Teflon® FEP fluorocarbon resin on one or both sides.

B. UNIFORMITY

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

C. CORES

Cores shall be of sufficient strength to prevent collapsing on handling. Standard core I.D.'s are 3" and 6" with the following specifications: 3" I.D. is 3.032" ± 0.008", 6" I.D. is 6.028" ± 0.010". Core material will be plastic for 3" I.D. cores less than ½" wide. Core material will be fibre for 3" I.D. cores wider than ½" and 6" I.D. cores. A split 3" I.D. fibre core is standard for all universal rolls. Core width for universal wind is 2¾".

If these cores are not suitable, further information on other options may be obtained from your Electronics Department marketing representative.

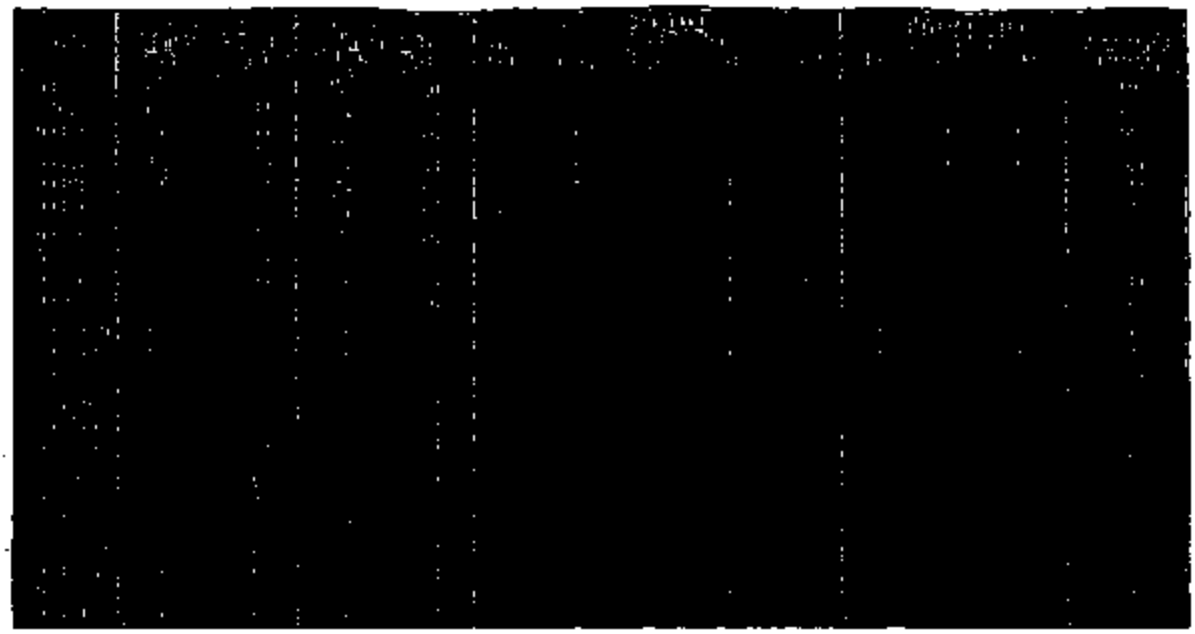
D. WIDTH TOLERANCE

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

Slit Width Range	Tolerance
½" or less Universal only	± 7 mils
1" or less	± 15 mils
1 1/16"–4"	± 30 mils
4 1/16" or wider	± 60 mils

E. ROLL TYPES

"Kapton" film is supplied in two types of rolls, pad and universal wind. Available film widths and roll O.D.'s are specified on the next page.



(9.5"x 6" pad roll is available in widths up to ½" only in 200HN, 200HN, 200HN, 200HN, 100FN016, 200FN021, 200FN029, 200FN021, 200FN029.
* O.D. Tolerance is ± ½" for pads and ± ¼" for universal.
* Type HN, FN and VN films in pads are supplied in width increments of ½". Most films are supplied in width increments of ¼" in widths ½" to 2".

* All universal rolls are available in ½" width increments with ½" maximum widths. The minimum width is ½" for 2" x 6" O.D. x O.D.; the minimum width is ½" for 3" x 8", and 3" x 12" O.D. x O.D.

Specifications for pad rolls are:

1. Core width will be film width +1/4", −0".
2. Core edges shall not project more than 1/16" beyond roll face on either side.
3. Core shall not be recessed on either side.
4. The outside and starting ends of the film shall be fastened in such a manner as to prevent unwinding.
5. "Dishing" or "cupping" may not exceed 1/16" measured with a straight edge across the diameter of the roll.

Specifications for the universal rolls are:

1. The difference between the length of projecting core on each side shall not exceed 3/16".
2. Film shall not project from the main body of the roll more than 1/8".
3. The outside and starting ends of the film shall be fastened in such a manner as to prevent unwinding.
4. Roll face depression, the difference between the highest and lowest points unstressed, shall not exceed 3/16".
5. Width of traverse is 1 1/4", − 1/4", + 1/8".

F. SPLICES

1. Description

Three types of splice are available.

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

Splices will be sufficiently smooth and wrinkle-free so as not to distort adjacent layers of film and approximately centered to ± 1/4".

Tape splices are standard on all gauges of "HN" and "VN" film and also on all gauges of "FN" film more than 12" wide.

Tape splices are made as follows. A butt splice with film ends covered on both sides of the film with splice tape. For films less than 0.002" thick a 1" wide pressure sensitive tape is used. For films 0.002" thick and greater a 2" wide pressure sensitive tape will be used.

Heat seal splices are made as follows. On all films but 250FN029 the splice is an overlap splice a minimum of 1/2" long. On 250FN029 a butt splice is made using 120FN616 as the joining tape applied on the FEP surface.

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

The 250FN029 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.

2. Maximum Splices per Slit Roll

The minimum average footage between splices for most rolls is shown in Table I. To calculate the maximum number of splices in a roll divide the nominal feet per roll by the minimum average length between splices and subtract one.

3. Splice Placement

Table I shows the minimum length between splices and from the beginning and end of a roll, for most "Kapton" rolls. No splice is allowed, however, once a roll has reached the minimum O.D.

TABLE I

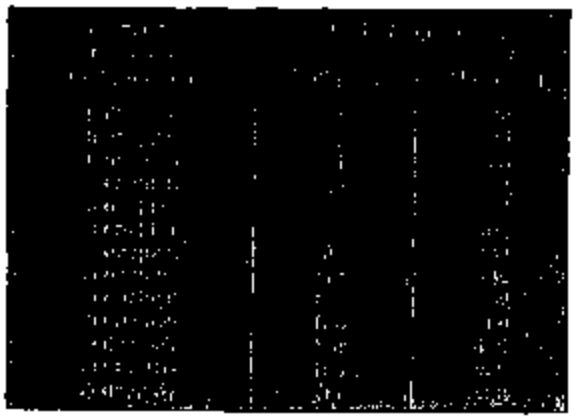
MINIMUM AVERAGE SPLICE FREE LENGTH (FEET)

NOTES: [redacted]

MINIMUM LENGTH BETWEEN SPLICES OR BEGINNING AND END OF A ROLL (FEET)

6. AVERAGE THICKNESS TOLERANCES (UNIT WEIGHT)

*Applies to Type VN films also.



Test Method and Sampling Procedure

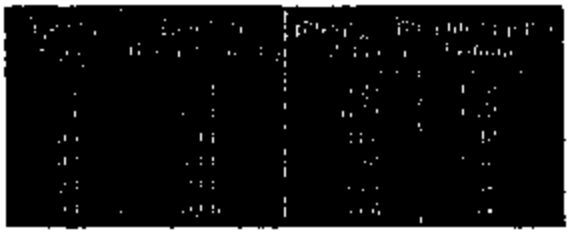
Weigh test specimens equal to the width of slit roll and not less than 1/3 meter long to the nearest 0.10 gram on a torsion balance.

To confirm average thickness tolerances, obtain a sample consisting of a minimum of one specimen from each of several randomly selected slit rolls as follows:

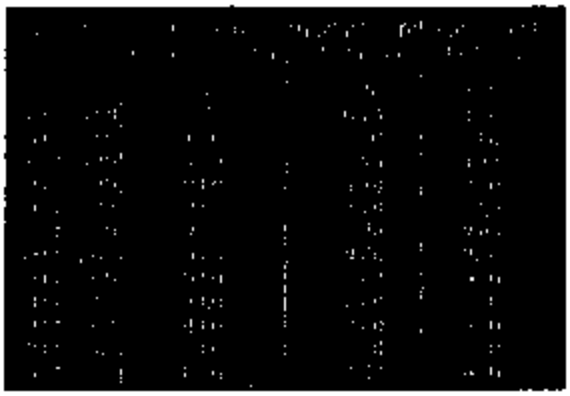
Slit Roll Width		Minimum Number of Slit Rolls to be Sampled
Under 6"	=	25 ÷ slit roll width (in.)
6" and Over		4

H. MICROMETER THICKNESS

Thickness tolerances are based on a statistical analysis of routine process control data.



*Applies to Type VN films also.



Test Method

Make the following measurements to confirm that film from a single slit roll meets the micrometer tolerances:

1. Measure in accordance with ASTM-D-374-79, Method A or C.
2. Obtain the average of 10 randomly selected readings from a minimum area of 12 square inches. Recheck before rejecting any slit roll. Abnormal readings may occasionally result from dust particles or spot surface imperfections. Discard such readings as they will adversely affect the accuracy of measurements designated to indicate general sheet thickness.

Gauge Depression

To reduce web handling difficulties which would occur if film representing thickness extremes were shipped in the same roll, a gauge depression standard is applied.

Roll depression is the difference in diameter between the hardest and softest part of the roll or the difference between the undepressed and depressed (finger pressure) diameter at the softest part, whichever is greater.

Table II lists the maximum allowable depression for most pad rolls. There is no gauge depression standard for universal wind since that roll is limited to a maximum of 7/8" wide.

TABLE II

KAPTON® POLYIMIDE FILM GAUGE DEPRESSION STANDARDS—PAD ROLLS
(Maximum allowable depression in 1/4" increments)

Kapton
POLYIMIDE FILM

GENERAL SPECIFICATIONS BULLETIN GS-87-4

GENERAL

INTRODUCTION

The Electronics Department of the Du Pont Company manufactures and sells a variety of high quality plastic film products.

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

Any aspects of the specifications requiring further interpretation or clarification should be discussed with representatives of the Du Pont Electronics Department.

Types of Kapton® Polyimide Film

Du Pont makes three types of "Kapton" polyimide film, Type HN, Type FN and Type VN.

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 make up is the result of a polycondensation reaction between pyromellitic dianhydride and 4,4'-diaminodiphenylether. "Kapton" HN is available in 30, 50, 100, 200, 300 and 500 gauges.

Type FN Film

"Kapton" Type FN film is a heat sealable grade which retains the unique balance of properties that "Kapton" Type HN possesses over a wide temperature range. This is achieved by combining Type HN "Kapton" and Teflon® FEP fluorocarbon resin together in a composite structure. Listed below are those combinations commercially available at this time. Other combinations are available. Consult your Electronics Department marketing representative for further information.

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 100, 200, 300 and 500 gauges.

Certification

"Kapton" is certified to meet the requirements of the military specification MIL-P-46112 B (MR) in addition to the items covered by this specifications bulletin. Written confirmation is available with each delivery upon request.

DUPONT

TI-NHTSA 018184

Kapton
POLYIMIDE FILM

GENERAL SPECIFICATIONS BULLETIN GS-87-4

GENERAL

INTRODUCTION

The Electronics Department of the Du Pont Company manufactures and sells a variety of high quality plastic film products.

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

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Types of Kapton® Polyimide Film

Du Pont makes three types of "Kapton" polyimide film, Type HN, Type FN and Type VN.

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 make up is the result of a polycondensation reaction between pyromellitic dianhydride and 4,4'-diaminodiphenyl-ether. "Kapton" HN is available in 30, 50, 100, 200, 300 and 500 gauges.

Type FN Film

"Kapton" Type FN film is a heat sealable grade which retains the unique balance of properties that "Kapton" Type HN possesses over a wide temperature range. This is achieved by combining Type HN "Kapton" and Teflon® FEP fluorocarbon resin together in a composite structure. Listed below are those combinations commercially available at this time. Other combinations are available. Consult your Electronics Department marketing representative for further information.

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 100, 200, 300 and 500 gauges.

Certification

"Kapton" is certified to meet the requirements of the military specification MIL-P-46112 B (MR) in addition to the items covered by this specifications bulletin. Written confirmation is available with each delivery upon request.

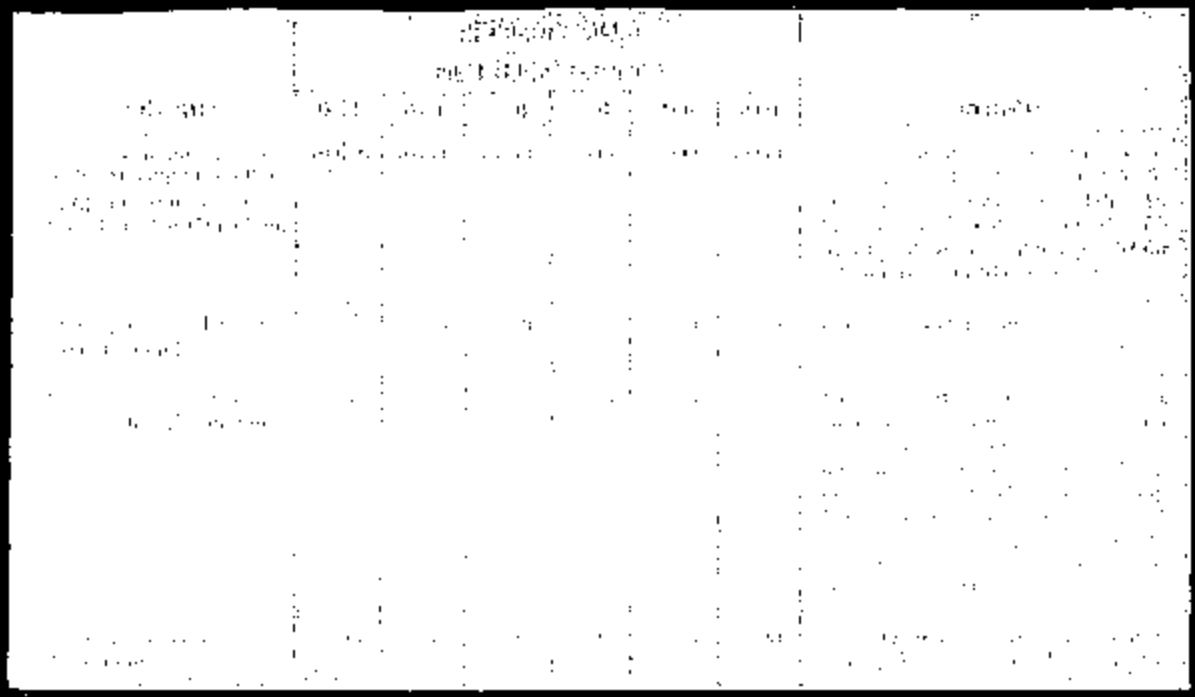
DUPONT

TI-NHTSA 018185

DB/NHTSA No. 1
80362

PROPERTIES OF TYPE HN FILM

MECHANICAL



ELECTRICAL

*1 hour for 30 and 50 gauge film.

Thermal Durability

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

Sheets of film 8½" x 11" are freely suspended in an oven at 400°C. The temperature of the oven is monitored with a thermocouple to insure a temperature accuracy of ±2°C. Sheets are removed after 2 hours* and tested on an Instron Tensile Tester as described above under "Elongation." The elongation (at 23.5°C.) of the film should not be less than 10% after this aging at 400°C. This conforms to the "Elongation after Aging at 400°C." test (paragraph

4,4,5) and "Elongation, percent, after 2 hour 400°C." requirement (Table 1) of MIL-P-46112 B (MR).

Underwriters Laboratories Inc. lists a thermal index of 200°C.–220°C. (depending on gauge and type) for mechanical properties and 220°C.–240°C. (depending on gauge and type) for electrical properties under their file no. E39505 for "Kapton" polyimide film.

*1 hour for 30 & 50 gauge film.

PROPERTIES OF TYPE FN FILM

A. Heat Seal Strength

1. Film to Film Seals

The heat seal peel strength between the coated and uncoated side of one side coated Kapton® polyimide film or the coated to coated side of one or two side coated "Kapton" is measured in the following manner: Seals are made in a jaw sealer at 350°C., 20 psi, 20 sec. dwell time. After cooling, the seals are cut to 1" wide strips using a Thwing-Albert JDC sample cutter or equivalent. The strength of the seal 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" polyimide film will be 600 gms./inch except for 120FN616 which will be 450 gms./in. The minimum peel strength between the coated and uncoated side of one side coated "Kapton" will be 450 gms./inch.

2. Film to Copper Seals for 120FN616 Film

The ability of 120FN616 film to adhere to copper is measured by using the same heat seal peel strength technique as described above.

The peel strength obtained when 120FN616 is sealed to the untreated side of ½ oz. GT copper foil (1 mil) will be a minimum of 250 gms./in.

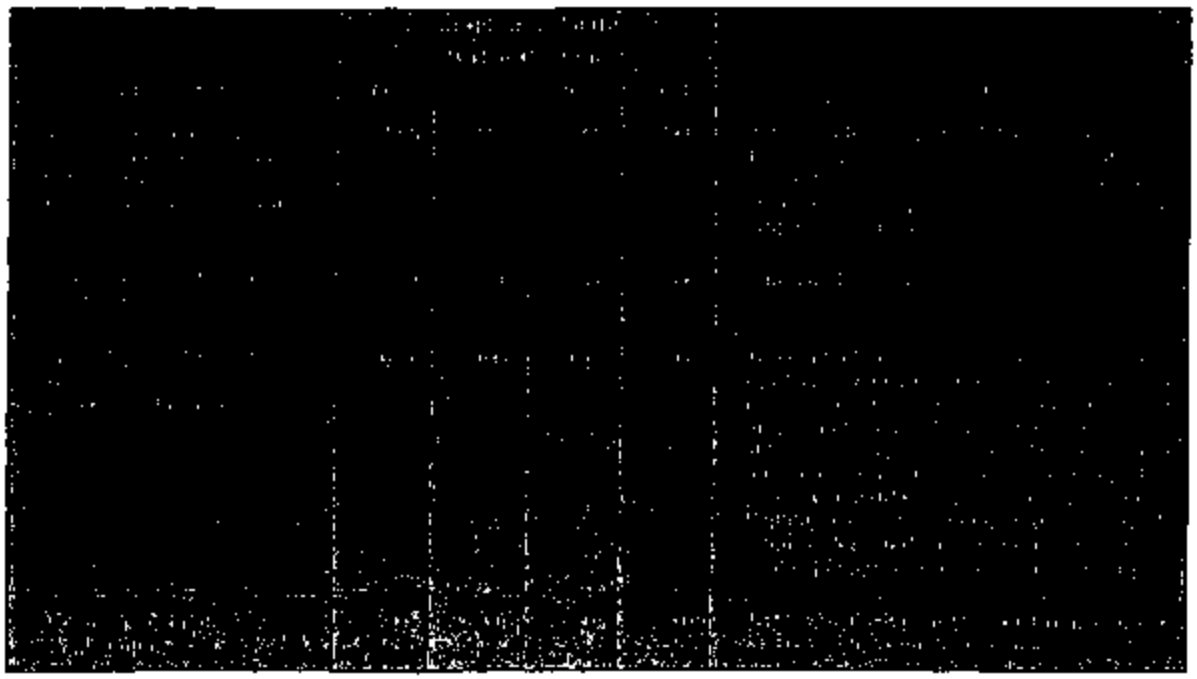
B. As-Received Strength (Cold peel) of Bonds Between the Type HN "Kapton" and "Teflon" Layers

The bond between the Type HN "Kapton" and Teflon® fluorocarbon resin layers on all type FN products except 120FN616 will have a minimum peel strength of 225 gms./in. as measured using an Instron type tensile tester and a 180° peel.

C. Dielectric Strength

PROPERTIES OF TYPE VN FILM

MECHANICAL



ELECTRICAL

Thermal Durability

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

Sheets of film 8½" × 11" are freely suspended in an oven at 400°C. The temperature of the oven is monitored with a thermocouple to insure a temperature accuracy of ±2°C. Sheets are removed after 2 hours and tested on an Instron Tensile Tester as described above under "Elongation." The elongation (at 23.5°C.) of the film should not be less than 10% after this aging at 400°C. This conforms to the "Elongation after Aging at 400°C." test (paragraph 4.4.5) and "Elongation, percent, after 2 hour 400°C." requirement (Table 1) of MIL-P-46112 B(MR).

Underwriters Laboratories Inc. lists a thermal index of 200°C.–220°C. (depending on gauge and type) for mechanical properties and 220°C.–240°C. (depending on gauge and type) for electrical properties under their file no. E39505 for "Kapton" polyimide film.

GENERAL

A. MATERIAL

Type HN and Type VN Film—A polyimide polymer in the form of a film.

Type FN Film—A combination of Kapton® polyimide film Type HN with Teflon® FEP fluorocarbon resin on one or both sides.

B. UNIFORMITY

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

C. CORES

Cores shall be of sufficient strength to prevent collapsing on handling. Standard core I.D.'s are 3" and 6" with the following specifications: 3" I.D. is 3.032" ± 0.008", 6" I.D. is 6.028" ± 0.010". Core material will be plastic for 3" I.D. cores less than ⅞" wide. Core material will be fibre for 3" I.D. cores wider than ⅞" and 6" I.D. cores. A split 3" I.D. fibre core is standard for all universal rolls. Core width for universal wind is 2¼".

If these cores are not suitable, further information on other options may be obtained from your Electronics Department marketing representative.

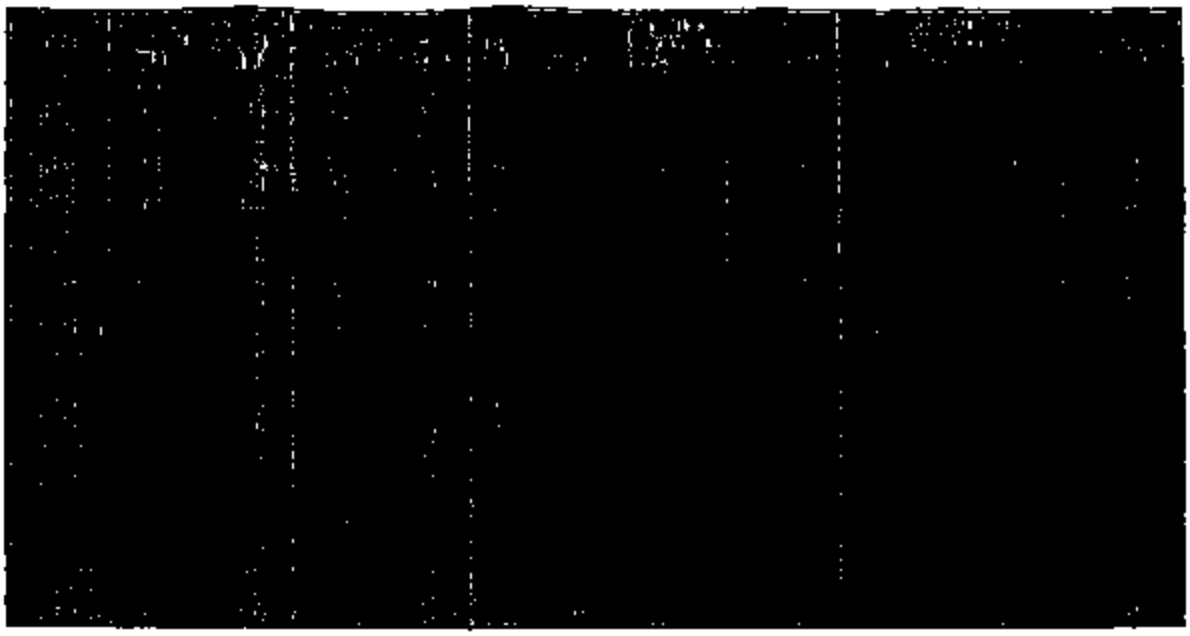
D. WIDTH TOLERANCE

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

Slit Width Range	Tolerance
⅞" or less Universal only	± 7 mils
1" or less	± 15 mils
1⅛"–4"	± 30 mils
4⅛" or wider	± 60 mils

E. ROLL TYPES

"Kapton" film is supplied in two types of rolls, pad and universal wind. Available film widths and roll O.D.'s are specified on the next page.



(1) 2" x 6" pad roll is available in widths up to ¼" only in 120HN, 250HN, 300HN, 500HN, 120FN616, 250FN029, 250FN031, 250FN032, 250FN035, 300FN031, 300FN032.
* O.D. Tolerance is ±¼" for pads and ±½" for universal.
* Type HN, FN and VN films in pads are supplied in width increments of ¼". Most films are supplied in width increments of ¼" in widths ¼" to 2".
* All universal rolls are available in ¼" width increments with ¼" maximum widths. The minimum width is ½" for 6" x 6" O.D. x O.D.E (the minimum width is ¼" for 3" x 6", and 3" x 12" O.D. x O.D.).

Specifications for pad rolls are:

1. Core width will be film width + 1/16", − 0".
2. Core edges shall not project more than 1/16" beyond roll face on either side.
3. Core shall not be recessed on either side.
4. The outside and starting ends of the film shall be fastened in such a manner as to prevent unwinding.
5. "Dishing" or "cupping" may not exceed 1/16" measured with a straight edge across the diameter of the roll.

Specifications for the universal rolls are:

1. The difference between the length of projecting core on each side shall not exceed 3/16".
2. Film shall not project from the main body of the roll more than 1/8".
3. The outside end starting ends of the film shall be fastened in such a manner as to prevent unwinding.
4. Roll face depression, the difference between the highest and lowest points unstressed, shall not exceed 3/16".
5. Width of traverse is 1¾", − ¼", + ⅛".

F. SPLICES

1. Description

Three types of splice are available.

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

Splices will be sufficiently smooth and wrinkle-free so as not to distort adjacent layers of film and approximately centered to ± ¼".

Tape splices are standard on all gauges of "HN" and "VN" film and also on all gauges of "FN" film more than 12" wide.

Tape splices are made as follows. A butt splice with film ends covered on both sides of the film with splice tape. For films less than 0.002" thick a 1" wide pressure sensitive tape is used. For films 0.002" thick and greater a 2" wide pressure sensitive tape will be used.

Heat seal splices are made as follows. On all films but 250FN029 the splice is an overlap splice a minimum of ¾" long. On 250FN029 a butt splice is made using 120FN616 as the joining tape applied on the FEP surface.

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

The 250FN029 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.

2. Maximum Splices per Slit Roll

The minimum average footage between splices for most rolls is shown in Table I. To calculate the maximum number of splices in a roll divide the nominal feet per roll by the minimum average length between splices and subtract one.

3. Splice Placement

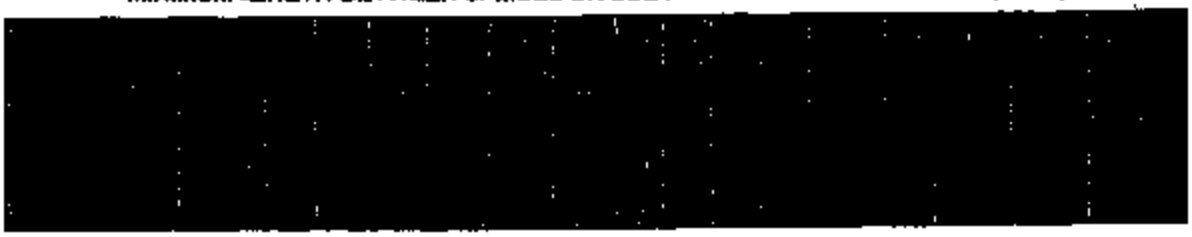
Table I shows the minimum length between splices and from the beginning and end of a roll, for most "Kapton" rolls. No splice is allowed, however, once a roll has reached the minimum O.D.

TABLE I

MINIMUM AVERAGE SPLICE FREE LENGTH (FEET)

NOTES: [redacted]

MINIMUM LENGTH BETWEEN SPLICES OR BEGINNING AND END OF A ROLL (FEET)



G. AVERAGE THICKNESS TOLERANCES (UNIT WEIGHT)

*Applies to Type VN films also.

Test Method and Sampling Procedure

Weigh test specimens equal to the width of slit roll and not less than ⅛ meter long to the nearest 0.10 gram on a torsion balance.

To confirm average thickness tolerances, obtain a sample consisting of a minimum of one specimen from each of several randomly selected slit rolls as follows:

Slit Roll Width	Minimum Number of Slit Rolls to be Sampled
Under 6"	25÷ slit roll width (in.)
6" and Over	4

H. MICROMETER THICKNESS

Thickness tolerances are based on a statistical analysis of routine process control data.

*Applies to Type VN films also.

Test Method

Make the following measurements to confirm that film from a single slit roll meets the micrometer tolerances:

1. Measure in accordance with ASTM-D-374-79, Method A or C.
2. Obtain the average of 10 randomly selected readings from a minimum area of 12 square inches. Recheck before rejecting any slit roll. Abnormal readings may occasionally result from dust particles or spot surface imperfections. Discard such readings as they will adversely affect the accuracy of measurements designated to indicate general sheet thickness.

Gauge Depression

To reduce web handling difficulties which would occur if film representing thickness extremes were shipped in the same roll, a gauge depression standard is applied.

Roll depression is the difference in diameter between the hardest and softest part of the roll or the difference between the undepressed and depressed (finger pressure) diameter at the softest part, whichever is greater.

Table II lists the maximum allowable depression for most pad rolls. There is no gauge depression standard for universal wind since that roll is limited to a maximum of 1/4" wide.

TABLE II

KAPTON® POLYIMIDE FILM GAUGE DEPRESSION STANDARDS—PAD ROLLS
(Maximum allowable depression in ¼" increments)

Kapton

POLYIMIDE FILM

ADHESION TO KAPTON®

KAPTON® polyimide film, made only by Du Pont, is available in three basic film types. Type H KAPTON is 100% polyimide film. Type F is coated on one or both sides with a TEFLON® FEP fluorocarbon adhesive and Type V is a plain polyimide film having superior dimensional stability properties. Typical property information for KAPTON is found in Bulletin E-72087, "Summary of Properties." Specifications are found in Bulletin E-87624, "Industry Specifications Bulletin FC-85-2." For flexible printed circuit applications the trade specification IPC-FC-231/Sheet 1, applies to KAPTON.

ADHESIVE SELECTION

For some applications KAPTON must be bonded to other materials, such as copper foil, which requires the use of an adhesive. Optimum adhesion results are usually obtained from commercially coated KAPTON which is available from a variety of suppliers such as those listed in Bulletin E-72091, "Suppliers of Adhesive Coatings on KAPTON." This listing represents most of those companies offering coated KAPTON but should not be regarded as a complete listing. Detailed information on the use of these adhesive coated products can be obtained from the supplier's bulletins. Specific requirements for copper laminates produced as substrates for flexible printed circuits are outlined in trade specifications:

- USA: IPC-FC-241
- British: BS-4584
- German: DIN-40802

When commercially coated film is not suitable for an application, most vendors offer a dry film form of their adhesives for use as a bonding film in laminations. However, better adhesion is normally obtained from commercial solution coatings than from the dry bonding film. The dry film adhesive does have the advantage that it can be cut to shapes which cover only that portion of the polyimide film where adhesion is desired.

If neither commercially coated polyimide film nor adhesive bonding film is suitable for the application, the remaining option is for the user to apply a solution adhesive. Some generic classes of adhesives which bond KAPTON include acrylics, epoxies, butyral-phenolics, polyesters, silicones, urethanes, fluorocarbons and blends of these materials.

Selection of an adhesive is usually dependent on the properties required of the adhesive and the demands of the application. Property considerations are the thermal rating, chemical resistance, -fill and flow characteristics, flexibility, peel strength, flammability, moisture resistance and insulation resistance. Also to be considered is the ease of processing, lamination temperature and whether the lamination is to be made in continuous roll equipment or in a platen press.

ADHESIVE PROPERTIES

Adhesives used with KAPTON Type H are usually a modified version of the generic adhesive family (e.g., modified-epoxy). These formulations are proprietary to the suppliers of coated KAPTON and require specific processing conditions to achieve the maximum bond strength. Always use the supplier's recommended lamination conditions for the specific adhesive you select.

Listed in Table I are several adhesive types along with information on typical lamination temperatures and maximum operating temperatures (short term exposure). When using an epoxy adhesive, anhydride curing agents are preferred. If an amine curing agent must be used, avoid an excess of curing agent as the free alkaline materials can degrade the polyimide.

TABLE 1

Adhesive Types	Lamination Temperatures °F (°C)	Maximum Operating Temperature °F (°C)
Fluorocarbons	550-600 (290-315)	to 500 (260)
Polyimides	600-700 (290-370)	to 650 (345)
Epoxies	73-450 (23-230)	to 600 (315)
Pressure Sensitive Silicones	73-300 (23-150)	to 500 (260)
Rubber-Phenolics	300-400 (150-205)	to 500 (260)
Acrylics	350-375 (175-190)	to 550 (290)
Polyesters	275-300 (135-150)	to 220 (105)

Solution forms of most of the adhesives above are available from suppliers of adhesives to the electronics industry. Listings of suppliers can be found in buyer's guides for electronic products. Bulletin E-74148, "Suppliers of Adhesives to the Electronics Industry," provides a representative listing of adhesive suppliers who can be consulted with for specific adhesive needs.

DUPONT

TI-NHTSA 018192

PACKAGING AND MARKING

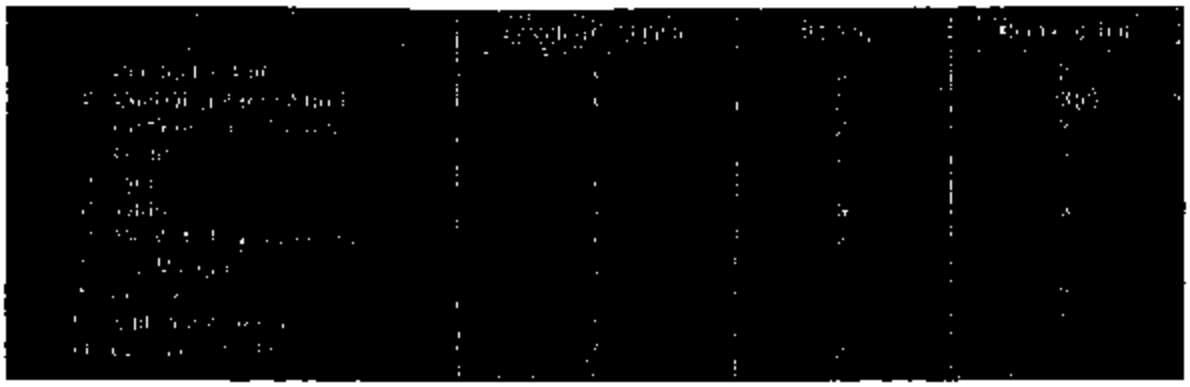
A. PACKAGING

"Kapton" shall be adequately packed to prevent loss of contents or damage during shipment.

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

B. MARKING

"Kapton" is identified as follows to allow complete traceability back to the raw materials and processing conditions:



(a) Affixed to the core on all cores, 2½" wide and over. Included with the package on all cores less than 2½" wide.
(b) Inside diameter of core and nominal outside diameter of roll.
(c) Available for up to 12 characters.

We believe this information is the best currently available on the subject and it is rendered gratis as a Du Pont service. It is based on technical data which Du Pont believes to be reliable, and it is intended for use by persons having the skill and know-how, at their own discretion and risk. Du Pont assumes no responsibility for results obtained or damages incurred from its use by the reader in whole or in part. Publication of such information is not to be taken as a license to operate under or intended to suggest infringement of any existing patent.

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Wilmington, DE 19898

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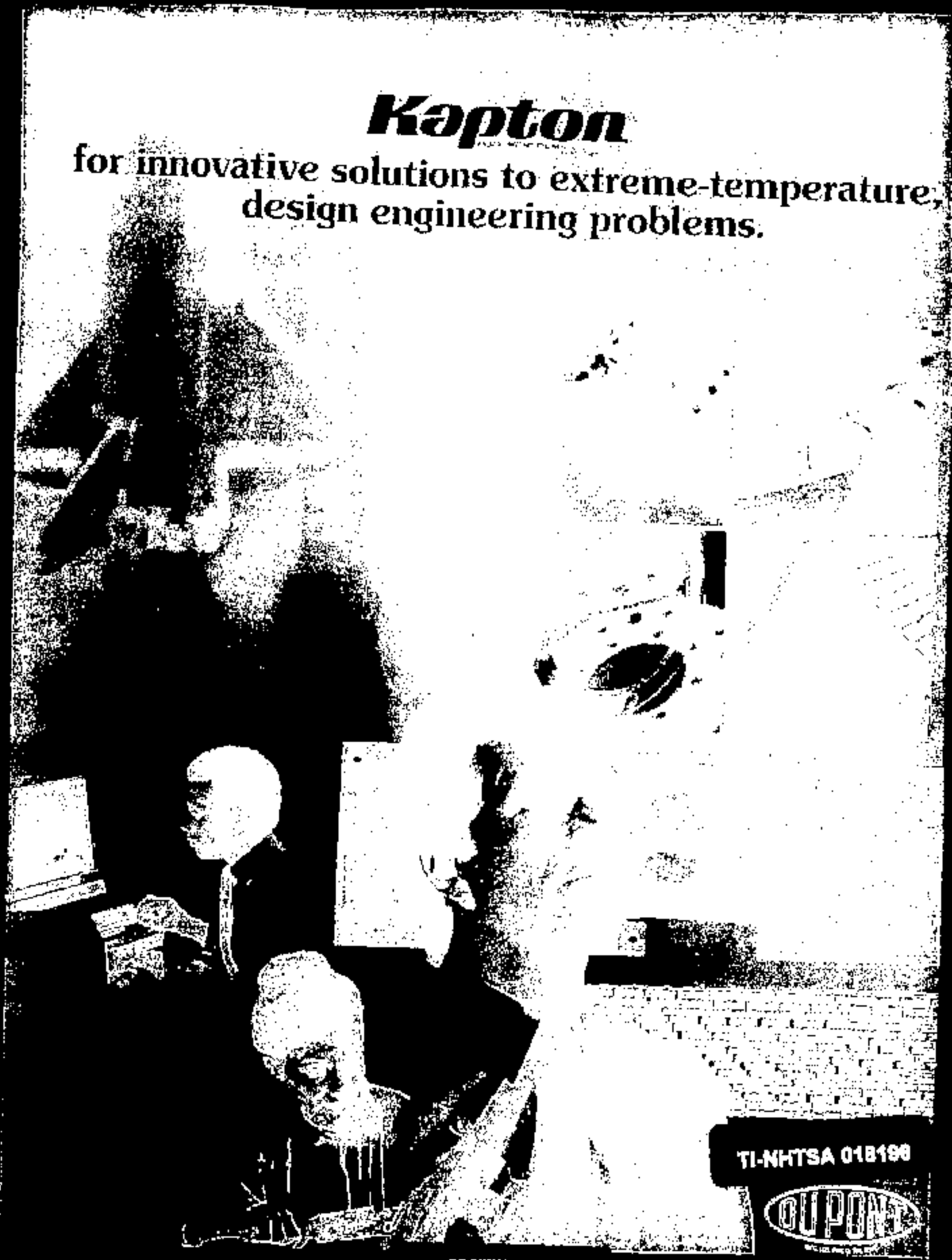
DU PONT

TI-NHTSA 018195

Kapton

for innovative solutions to extreme-temperature, design engineering problems.



TI-NHTSA 018198

DUPONT

KAPTON®: a versatile space-age material with down-to-earth applications.

The space shuttle's solar array; the Lunar Excursion Module; miniaturized electronic components; more efficient oil well pump motors; reliable flexible circuits; thin, lightweight electrical heaters; precise electrothermal fuel level sensors; high-temperature electrical insulation. For the past twenty years, KAPTON® has contributed to the innovative design and commercial success of a wide variety of new and improved products. The reason KAPTON was selected for such demanding applications is its unique combination of outstanding mechanical, electrical and chemical properties *and* its ability to retain these properties over a wide range of temperatures where other engineering materials do not function.

KAPTON has proved itself as the material of choice in applications that involve very high or low operating temperatures.

Designers are finding that the application potential for this unique industrial material has barely been tapped.

A variety of new application possibilities for KAPTON are now being explored by Du Pont and its customers, including semiconductor pads and microprocessor chip carriers. However, a number of uses for KAPTON are well established. Some examples from the electrical and electronics industries are: field coil insulation; substrates for flexible printed circuits; motor and generator armature slot liners; magnet wire insulation; transformer and capacitor insulation; magnetic recording and pressure-sensitive tapes and tubing; and wire and cable insulation.

Three types of KAPTON are commercially available.

- KAPTON Type H is an all-purpose, all-polyimide film that has been used successfully in applications reaching temperatures as low as −269°C and as high as 400°C. Type H film can be laminated, metallized, diecut, slit, formed, or adhesive-coated. It is available as 0.3, 0.5, 1, 2, 3, and 5 mil film.
- KAPTON Type V is an all-purpose, all-polyimide film with all of the properties of Type H film, plus superior *dimensional stability*. It is available in 1, 2, 3, and 5 mil thickness.
- KAPTON Type F is a Type H film coated on one or both sides with TEFLON® FEP fluoropolymer resin to impart *heat sealability*; provide a moisture barrier, and enhance chemical resistance. It is available in a variety of constructions.

One of the important benefits of KAPTON polyimide film is its ability to be bonded, laminated, coated, and otherwise converted to fulfill a broad range of high-performance operating requirements. This outstanding versatility — and the fact that all three types share the same unique balance of properties inherent in the basic material — allows KAPTON to be *custom-tailored* to fit an almost endless variety of applications.

Armed with 20 years' experience with a high-quality material and backed by the considerable resources of the Du Pont Company, we are committed to remaining the world leader in the manufacture and diversification of polyimide films. In response to the needs of our customers and their interest in films that can insulate or conduct electricity, heat shrinkable films, pigmented films, heat conductive films and new adhesive systems, we are making a significant investment in research, development and equipment — aimed at delivering higher quality, improved productivity and better end use products, to our customers.

When sufficient business potential exists, our resources can be made available for the joint development of custom-tailored products and programs to fulfill your most stringent design requirements — during the Eighties and beyond.

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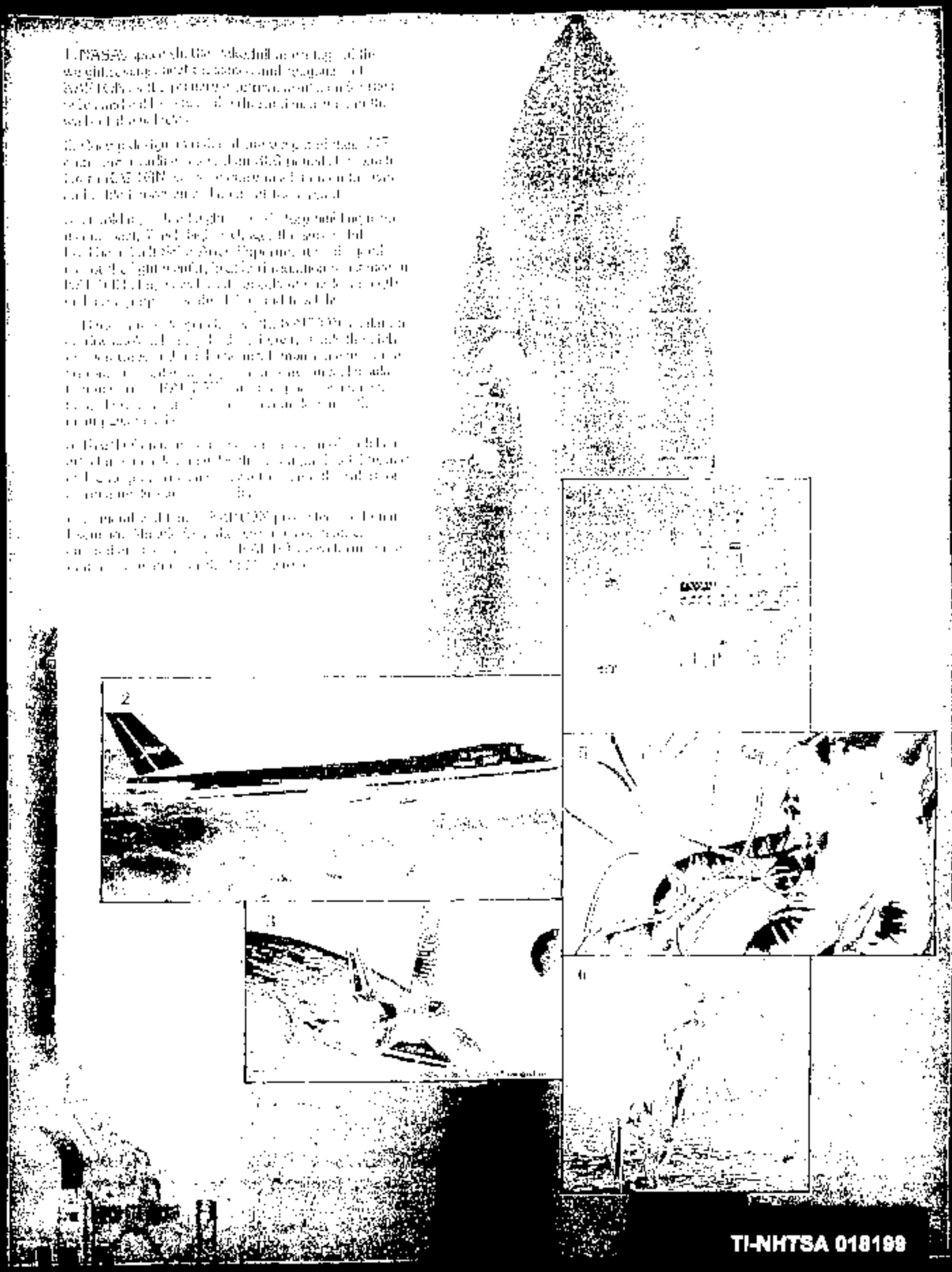


KAPTON® offers inherent heat and flame resistance and excellent thermal performance.

For all of its outstanding properties, KAPTON is probably best known for its ability to "take the heat." With a UL-94 rating of V-O for flammability — the best possible — KAPTON polyimide film will not sustain or propagate flame. Nor will it melt, drip or produce any significant smoke when exposed to flame.

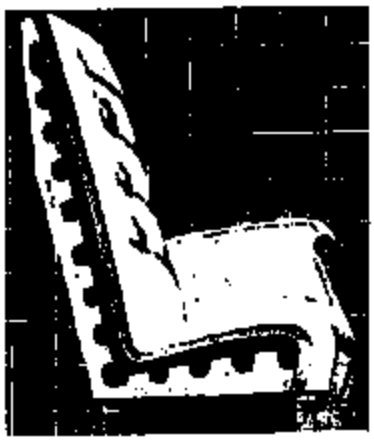
Rated at 240°C for continuous service, KAPTON can still function after exposure to temperatures up to 400°C for brief periods. Best of all — it retains its high dielectric strength even at elevated temperatures — 2,500 volts/mil at 300°C.

These outstanding thermal properties provide significant advantages to the designer. Insulation thickness on the windings of large coils for motors can be significantly reduced in size; flexible circuits can be wave-soldered without distortion; and, when used in combination with inorganic insulating tapes, high-performance cables will continue to operate in direct exposure to flame.

KAPTON polyimide film is compatible with a number of high-temperature impregnating varnishes used in modern electrical equipment manufacture — including polyimides, esterimides, epoxies, silicones, amides-imides, and organo-silicones. Magnet wire made with certain combinations of polyimide film and varnishes has a IEEE #57 thermal stability rating of 260°C.

But flame and heat resistance aren't the only thermal advantages of KAPTON. It also performs very well at the other end of the temperature scale. KAPTON film retains its flexibility at −269°C without embrittlement or significant loss of other properties.

Keeping people and equipment warm is a natural for KAPTON. As a strong, lightweight, flexible laminated sheet, it can be used to insulate and protect embedded heater wires for such diverse applications as car seat or ski-lift chair heaters, aircraft wing deicers, engine warmers, hot trays and electric blankets.



7. A strip of KAPTON Type H film is positioned over the pins in this IC socket to prevent wicking during wave soldering. The strip also provides a dielectric barrier between the leads and printed circuit.

8. A steel mill now gets 3,000 extra horsepower from the same size motor thanks to KAPTON as the coil insulation. The motor manufacturer reports that insulated windings of KAPTON last as much as 50 times longer at the 200°C rated operating temperature versus those with previously used insulations.

9. Used as insulation in rotor and stator windings, KAPTON reduced the weight of traction motors in the world's fastest train by 5%. It also helped reduce motor production costs and increased horsepower.

10. The low smoke properties of insulation of KAPTON permit its use as a cable jacket for plenum cable, eliminating the need for expensive metal conduit.

11. As a pin grid array, KAPTON allows insertion of all pins into a circuit board in a single, high-speed operation. Registration is perfect, and the need for expensive loading machinery is eliminated. KAPTON withstands the high temperatures of wave soldering and allows visual inspection of completed connections. After soldering, KAPTON can either be pealed away or left in place as additional support for pins during further processing and handling.

12. PC boards are identified for quality control and inventory purposes by bar code labels using an overlay of KAPTON. Since KAPTON can withstand the temperatures of wave soldering without significant shrinkage or distortion, it can be used for labelling on the underside of printed circuit boards where space is not at a premium.

KAPTON® has superior strength, toughness, abrasion resistance and workability.

KAPTON polyimide film can solve a host of parts' performance problems that fibers, resins, metals, composites, glass, ceramics, mica or asbestos and conventional films cannot. The high tensile strength and initial tear resistance of KAPTON provide the mechanical durability necessary for many critical manufacturing operations, such as printed circuit processing and installation. Its exceptional toughness and resistance to cut-through and abrasion make it especially useful as insulation for aerospace communications wire and cable where it can be pulled through even the tightest routing.

Since the outside diameter of a wire or cable insulated with KAPTON is smaller than conventional wiring using extruded insulations, more cables can be run through a given size conduit or plenum. Stripping and termination are easier, too.

The strength, toughness, flexibility and wear resistance of KAPTON film are leading to greater numbers of non-electrical applications as well. Applications such as drive belts, pressure switch diaphragms, wear strips, washers, and seals.

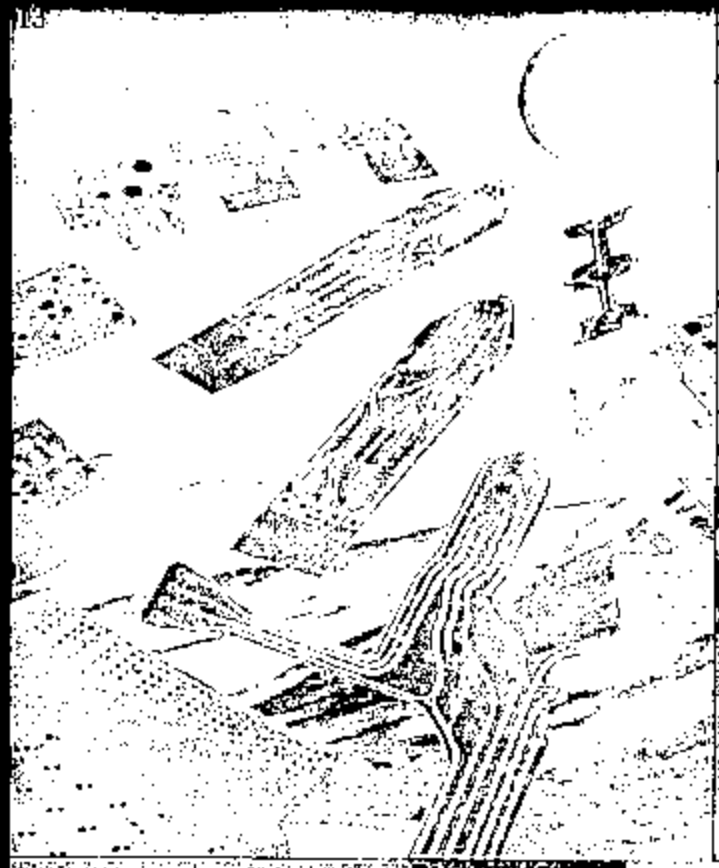
As a material for use in space, KAPTON has virtually no limitations. Designers already envision huge inflatable structures that could be used for a variety of purposes, including space station repairs, energy collection and transmission, and temporary protection of unassembled equipment components.

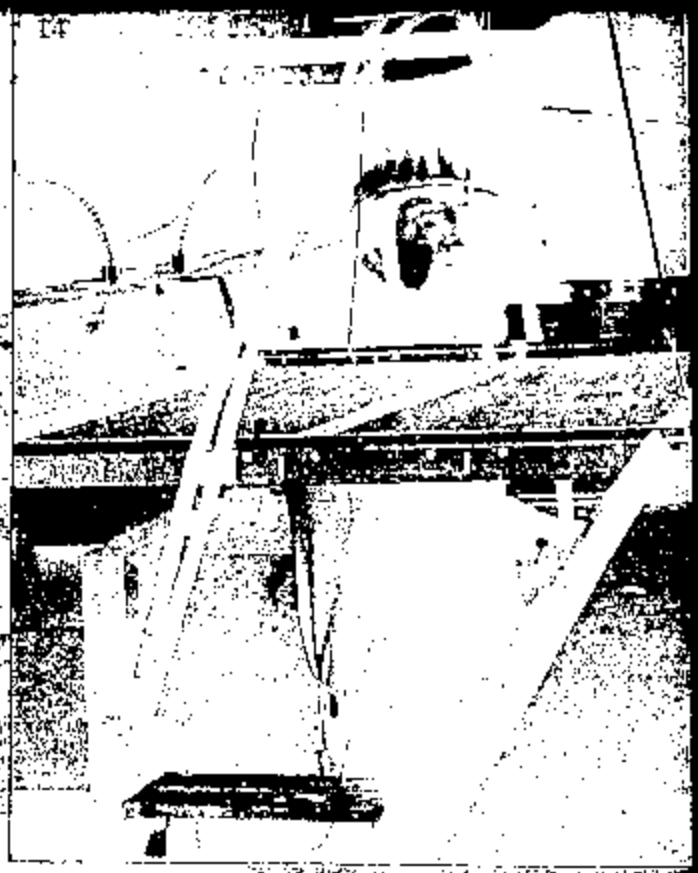
13. Flexible circuits of KAPTON can be bent, coiled, folded or twisted — and remain that way for the life of the product — without impairing circuit integrity while offering additional design freedom.

14. KAPTON protects plenum cables from damage by abrasion, kinking and snagging during installation when it is "fished" over sharp places in plenums and through ducting and conduit.

15. Automotive pressure sensing switches use KAPTON for the diaphragm because it is flexible, easily fabricated and withstands the dramatic temperature changes under the hood. KAPTON also resists most organic solvents, oils and greases.

16. KAPTON is an ideal material for tractor belts on high-speed computer printers. Because of its excellent toughness, dimensional stability and thermal properties, KAPTON stands up to the shock of abrupt start and stop operation and the heat of high-speed operation. The tractor belt teeth are injection molded directly into KAPTON film.





KAPTON® has outstanding electrical properties.

Next to its thermal properties, KAPTON polyimide film is selected by designers most frequently because of its excellent dielectric strength, dielectric constant, and dissipation factor. The dielectric strength of 1 mil KAPTON — 7,000 volts at room temperature (23°C) — is typically 2,500 volts even at an elevated temperature of 300°C. In fact, short-term exposure to temperatures as high as 400°C will not significantly affect the electrical properties of KAPTON.

The combination of high dielectric strength, thermal stability, uniform thickness and excellent mechanical properties allows designers of electrical equipment to specify thinner insulation on coils for transformer, generator or motor windings. This is very important because more conductors can be physically located within a given space, yielding greater power per unit. Or, if the power requirement is constant, the weight and dimensions of a given coil, stator or rotor can be substantially reduced.

In flexible circuits, the high dielectric constant of KAPTON and low dissipation factor combine to reduce signal loss to a minimum at relatively low operating voltages.

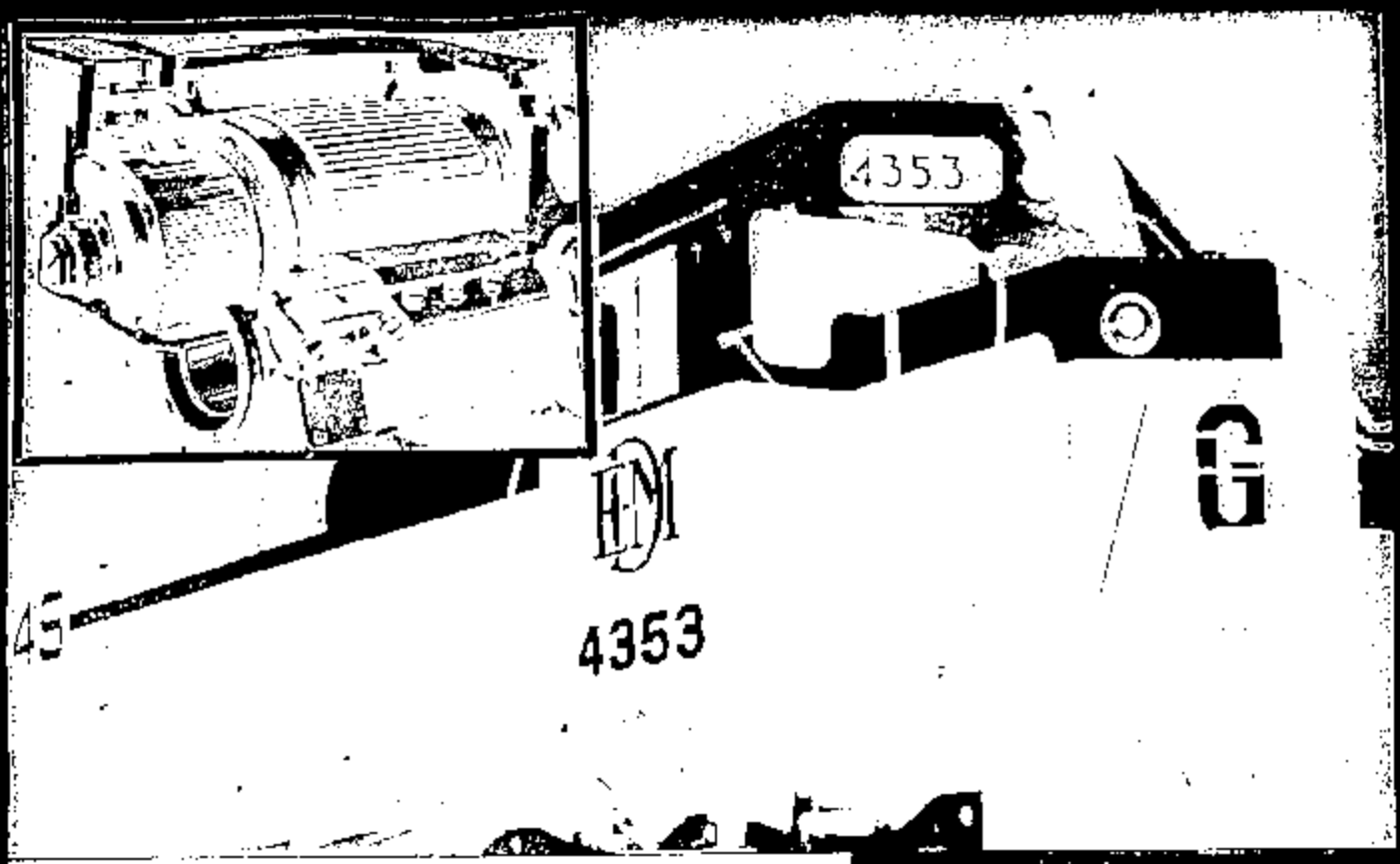
KAPTON film will play a major role in the world's largest linear particle accelerator. Proposed as the insulation for the research instrument's superconductive magnet wire, KAPTON is the only material — repeat, the only material — that can provide the extremely close tolerances, excellent dielectric strength and resistance to the liquid helium temperatures that are required for this unique application.

17. This electric locomotive, equipped with 3,000 volt DC traction motors, uses KAPTON Type F as an insulation on its motor windings. The KAPTON permitted an 8% increase in power over the conventional insulation material it replaced.

18. A thin, circular band of KAPTON provides outstanding electrical and thermal insulation for this high-frequency "super-tweeter" voice coil. KAPTON resists distortion at high operating temperatures, and is fully compatible with the epoxies, resins and paints used in speaker manufacture.

19. The elongation of KAPTON polyimide film is such that magnet wire insulated with KAPTON Type F sealable film can be easily bent to the desired shape without creating air gaps in the insulation, which could lead to dielectric failure or "hot spots".

20. By utilizing KAPTON on the coil winding of this electric utility line trap, the size and weight of the device can be reduced 30% — a significant advantage for substations in locations where real estate is at a premium.



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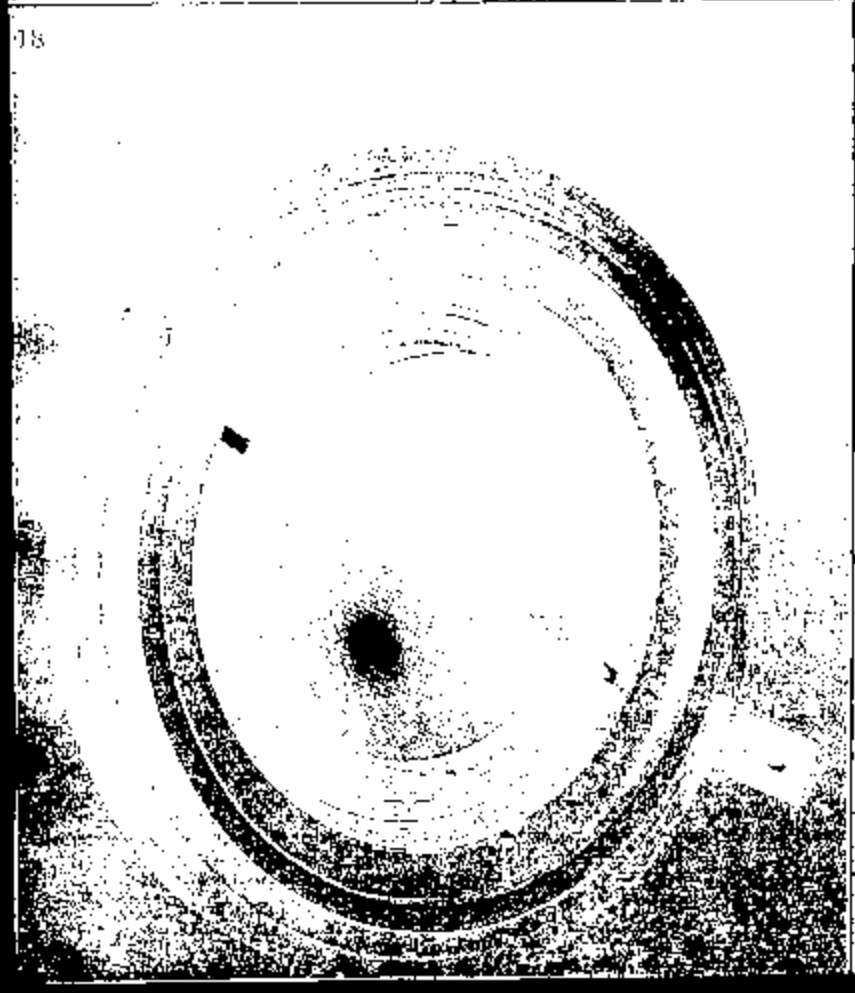

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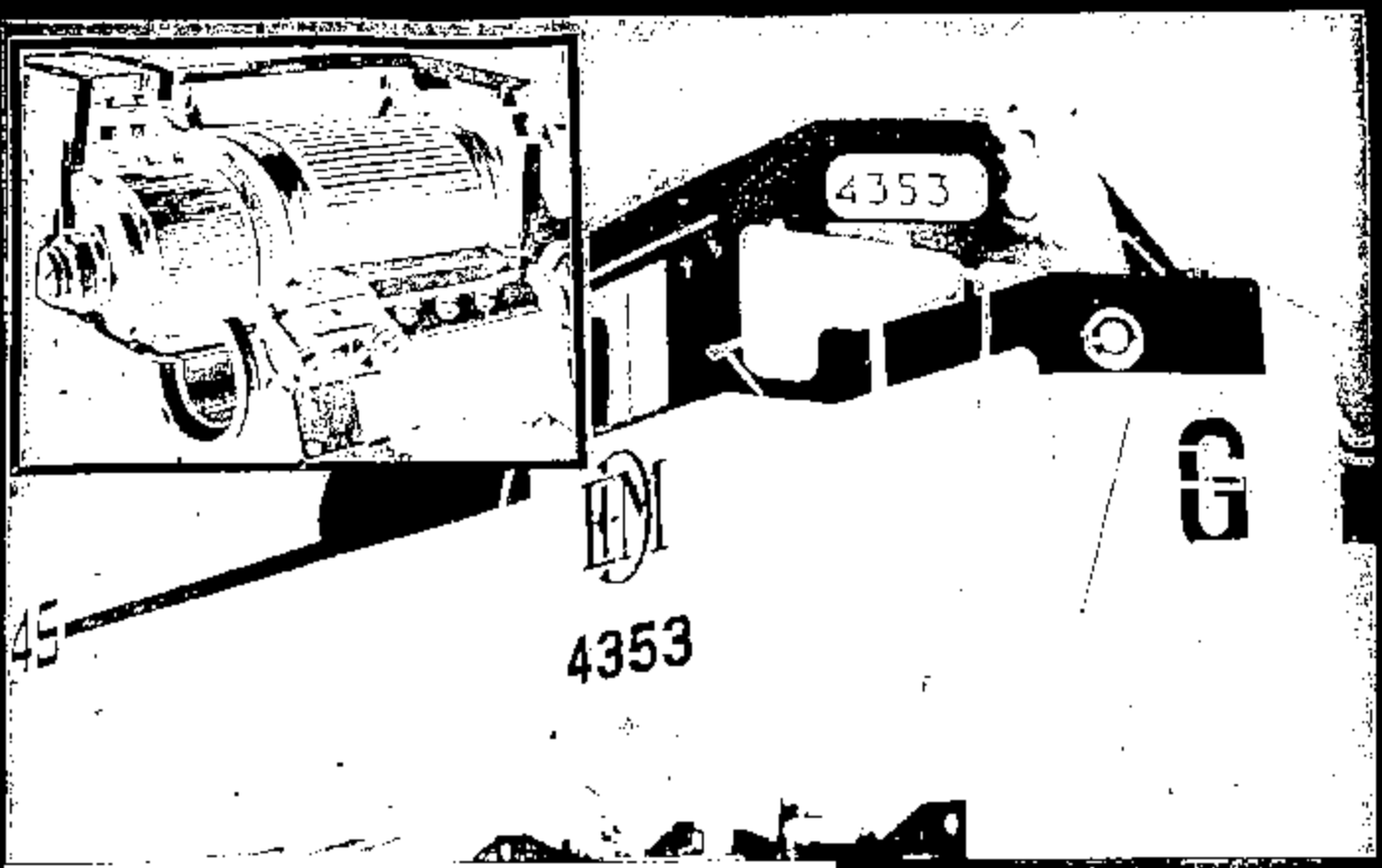
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KAPTON® has outstanding resistance to most chemicals, solvents, lubricants and fuels.

KAPTON is an ideal material for use in demanding environments in which a combination of hostile elements such as chemicals, gasses, radiation and high temperature is present. No matter whether you're talking about the motor windings insulation in an oil well pump operating in a pit of gas and brine 20,000 feet below the surface of the earth, a protective layer for a liquid level sensor submerged in an organic solvent, or in a pressure switch in the cooling system of an automobile — KAPTON can take the punishment and still deliver reliable performance.

In flexible circuitry, conductors bonded between layers of KAPTON polyimide film are protected against chemicals, moisture, gasses and foreign materials so they can operate reliably in demanding environments. In military and industrial applications, KAPTON film remains tough and flexible even after exposure to 10^9 RADS of gamma radiation. And, although it is unaffected by most organic chemicals, solvents, fuels and lubricants, KAPTON can be dissolved by certain strong bases — a fact that printed circuit manufacturers use to advantage in the chemical milling of holes in printed circuits.

As mobile research vehicles brave the hostile environments of distant planets and traverse their rugged surfaces gathering samples and data, they will undoubtedly have the protection of KAPTON film. In applications ranging from wire and cable insulation to surface protection — from tractor belts to solar panels — KAPTON will make these robot explorers lighter, stronger, more resistant to chemicals, radiation and abrasion, and ultimately — more reliable.

21. This 2,300 VAC submersible oil well pump uses KAPTON polyimide film in the magnet wire and slot liner insulation system. Motors of this type often operate at depths of 20,000 feet or more in hostile, high-temperature environments which contain brine, petrochemicals and hydrogen sulfide. Manufacturers report a 50% improvement in service life using motors insulated with KAPTON.

22. Specialty conductors metallized between sheets of KAPTON comprise a highly reliable and accurate automotive electrothermal fuel level sensor developed in Germany by VDO. In addition to its outstanding thermal and dielectric properties, KAPTON can be directly immersed in a wide variety of fuels, including blended ethanol and methanol.

23. KAPTON is an ideal substrate for this CTS throttle position transducer. Not only is it resistant to automotive chemicals and lubricants; it can also withstand both high underhood temperatures, and cold winter mornings while still performing reliably.

24. Critical fuel lines of satellites in space are kept from freezing at ultra-low temperatures by heater cables insulated with KAPTON. Nickel-chromium heating elements are encapsulated in a sandwich of KAPTON which provides both superior dielectric properties and full protection against the thermal shock of extremely high and extremely low temperatures.

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DD/NHTSA No. 3
00326

TI-NHTSA 018209

Kapton... only from Du Pont

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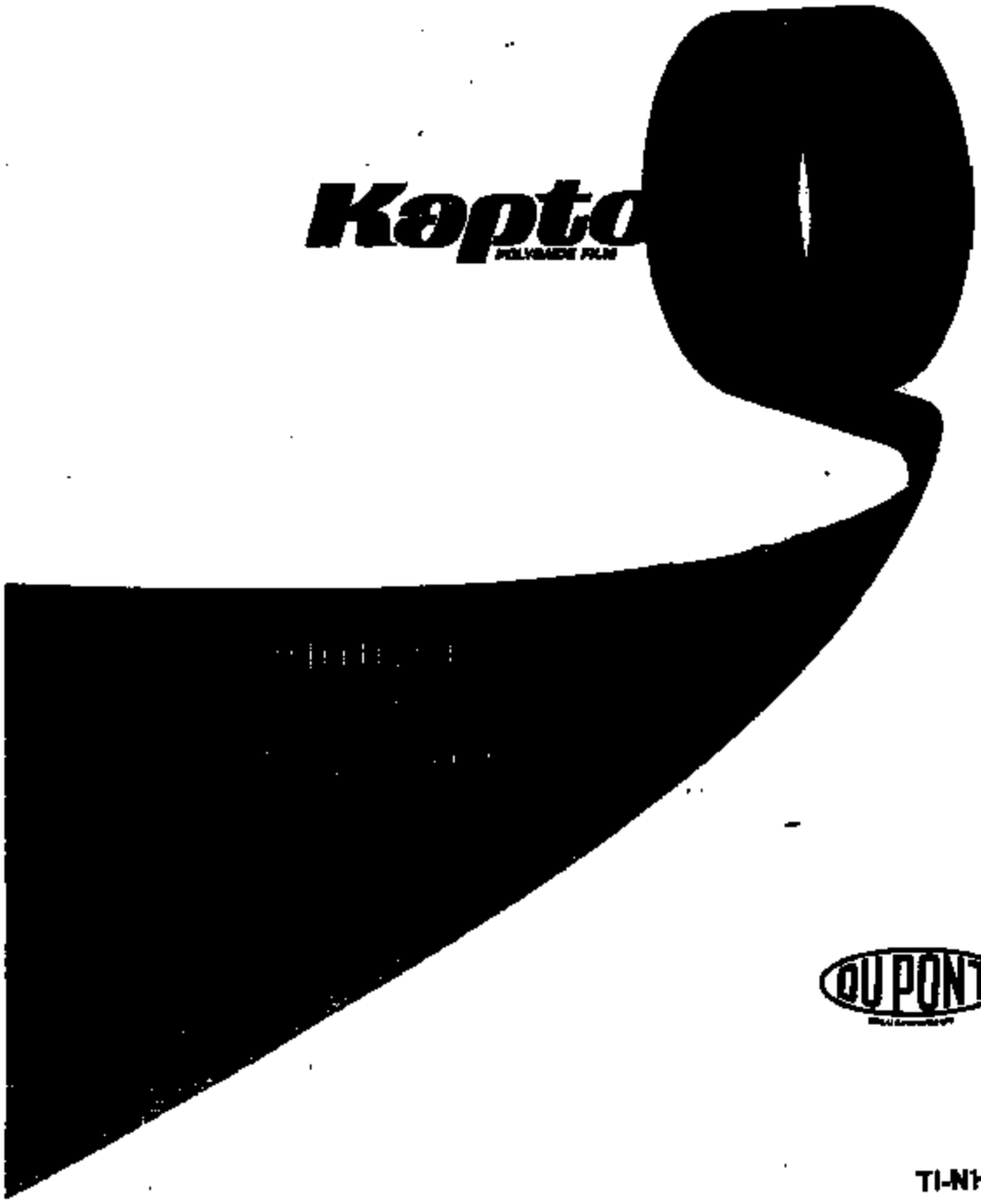

Kapton®
POLYIMIDE FILM

Summary of Properties

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Kapton®
POLYIMIDE FILM

GENERAL INFORMATION

KAPTON® polyimide film possesses a unique combination of properties previously unavailable among polymeric film materials. The ability of KAPTON to maintain its excellent physical, electrical, and mechanical properties over a wide temperature range has opened new design and application areas to plastic films. KAPTON has proved to be especially useful in applications involving high operating temperatures.

KAPTON is synthesized by a bipolycondensation reaction between an aromatic dianhydride and an aromatic diamine. There is no known organic solvent for the film and it is infusible and flame resistant. The outstanding properties of KAPTON permit it to be used at both high and low temperature extremes where other organic materials would not be functional.

Adhesives are available for bonding KAPTON to itself, to metals, to papers of various types, and to other films.

Applications for KAPTON polyimide film include a variety of electrical and electronic insulation applications: wire and cable tapes, formed coil insulation, substrates for flexible printed circuits, motor slot liners, magnet wire insulation, transformers and capacitor insulation, magnetic and pressure sensitive tapes and tubing. Many of these applications are based on the excellent electrical properties of KAPTON, such as dielectric strength and dissipation factor, which remain nearly constant over a wide range of temperature and frequency. Other applications make use of the film's radiation resistance or chemical resistance at elevated temperatures. It is this combination of useful properties at extremes in temperature that makes KAPTON a unique industrial material.

Du Pont makes three types of KAPTON:

- KAPTON Type HN, an all-purpose, all-polyimide film that has been used successfully in applications at temperatures as low as −269°C (−452°F) and as high as 400°C (752°F). Type HN film can be laminated, metallized, printed, formed, or adhesive coated. It is available as 0.5, 0.6, 0.75, 1, 2, 3, and 5 mil film.
- KAPTON TYPE VN, an all-purpose, all-polyimide film with all of the properties of Type HN, plus superior dimensional stability. Type VN is available in 0.5, 0.75, 1, 2, 3, and 5 mils.
- KAPTON Type FN, a Type HN film coated on one or both sides with TEFLON® FEP fluorocarbon resin to impart heat sealability, to provide a moisture barrier and to enhance chemical resistance. It is available in a variety of constructions.

Note: This bulletin provides a summary of typical properties for all three KAPTON polyimide films: Type HN, Type VN, and Type FN. Additional data should be obtained from your Du Pont representative for specification purposes.

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*Reg. U.S. Pat. Off.

PHYSICAL & THERMAL PROPERTIES

KAPTON® Type 100 HN Film 25 μm (1 mil)

PHYSICAL PROPERTIES

PHYSICAL PROPERTIES	TYPICAL VALUES 23°C (73°F)	TYPICAL VALUES 200°C (392°F)	TEST METHOD
Ultimate Tensile (MD) Strength, MPa (psi)	231 (33,500)	139 (20,000)	ASTM D-882-83, Method A[1]
Yield Point (MD) at 3%, MPa (psi)	69 (10,000)	41 (6,000)	ASTM D-882-83
Stress to Produce (MD) 5% Elongation, MPa (psi)	90 (13,000)	61 (9,000)	ASTM D-882-83
Ultimate Elongation (MD), %	72	83	ASTM D-882-83
Tensile Modulus, GPa (MD) (psi)	2.5 (370,000)	2.0 (290,000)	ASTM D-882-83
Impact Strength, Kg-cm (ft-lb)	6 (.56)		Du Pont Pneumatic Impact Test
Folding Endurance (MIT), cycles	285,000		ASTM D-2176-69 (1982)
Tear Strength (MD) – Propagating (Elmendorf), g	7		ASTM D-1922-67 (1978)
Tear Strength (MD) – Initial (Graves), g	720		ASTM D-1004-66 (1981)
Density, g/cm³	1.42		ASTM D-1505-68 (1979)
Coefficient of Friction – Kinetic (Film-to-Film)	.48		ASTM D-1894-78
Coefficient of Friction – Static (Film-to-Film)	.63		ASTM D-1894-78
Refractive Index (Becke Line)	1.66		ASTM D-542-50 (1977)
Poisson's Ratio	.34		Avg. 3 Samples Elongated at 5%, 7%, 10%
Low Temperature Flex Life	Pass		IPC TM 650, Method 2.6.18

(MD) – Machine Direction

[1]Specimen Size 25 × 150 mm (1" × 6"); Jaw Separation 100 mm (4"); Jaw Speed 50 mm/min (2"/min). Ultimate refers to the tensile strength and elongation measured at break.

THERMAL PROPERTIES

THERMAL PROPERTIES	TYPICAL VALUES	TEST CONDITION	TEST METHOD
Melting Point	NONE		ASTM E-794-81
Thermal Coefficient of Expansion	20 ppm/°C (11 ppm/°F)	−14 to 38°C (7 to 100°F)	ASTM D-696-79
Coefficient of Thermal Conductivity, W/m·K $\left(\frac{cal}{cm \cdot sec \cdot °C}\right)$	0.12 (2.87 × 10^{-4})	296°K (23°C)	University of Delaware Physics Department Method
Specific Heat	1.09 (.261)	J/g·K (cal/g·°C)	Differential Calorimetry
Flammability	94V-0		UL-94 (2-8-85)
Shrinkage, %	0.17 1.25	30 min @ 150°C 120 min @ 400°C	IPC TM 650, Method 2.2.4A
Heat Sealability	Not Heat Sealable		
Limiting Oxygen Index, %	37		ASTM D-2863-77
Solder Float	Pass		IPC TM 650, Method 2.4.13A
Smoke Generation	DM = less than 1	NBS Smoke Chamber	NFPA-258
Glass Transition Temperature (Tg)	A second order transition occurs in KAPTON between 360°C (680°F) and 410°C (770°F) and is assumed to be the glass transition temperature. Different measurement techniques produce different results within the above temperature range.		

KAPTON® Type VN Film

PHYSICAL AND THERMAL PROPERTIES

PROPERTY	TYPICAL VALUES FOR FILM THICKNESS 25 µm (1 mil)	50 µm (2 mil)	75 µm (3 mil)	125 µm (5 mil)	TEST METHOD
Ultimate Tensile Strength (MD), MPa (Kpsi)	231 (33,500)	234 (34,000)	231 (33,500)	231 (33,500)	ASTM D-882-83
Ultimate Elongation (MD), %	72	82	82	88	ASTM D-882-83
Tear Strength (MD) (Initial) Graves, g	720	1695	2651	4700	ASTM D-1004-66 (1981)
Tear Strength (MD) (Propagating) Elmendorf, g	7	21	39	59	ASTM D-1922-67 (1978)
Folding Endurance (MIT), K cycles	285	38	8	8	ASTM D-2176-69 (1982)
Density, g/cm³	1.42	1.42	1.42	1.42	ASTM D-1505-68 (1979)
Flammability	94V-0	94V-0	94V-0	94V-0	UL-94
Shrinkage, %	0.03	0.03	0.03	0.03	IPC TM 650 Method 2.2.4A
Limiting Oxygen Index, %	37	43	45	45	ASTM D-2863-77

KAPTON® Type FN Film

PROPERTIES OF FILM TYPES

PROPERTY	TYPICAL VALUES FOR FILM TYPE* 125FN616	150FN619	200FN620
Ultimate Tensile Strength (MD), MPa (psi)			
23°C (73°F)	207 (30,000)	162 (23,500)	200 (29,000)
200°C (392°F)	121 (17,500)	89 (13,000)	115 (17,000)
Yield Point at 3% (MD), MPa (psi)			
23°C (73°F)	51 (8,000)	49 (7,000)	58 (8,500)
200°C (392°F)	42 (6,000)	43 (6,000)	38 (5,500)
Stress at 5% Elongation (MD), MPa (psi)			
23°C (73°F)	79 (11,500)	65 (9,500)	76 (11,000)
200°C (392°F)	53 (8,000)	62 (9,000)	48 (7,000)
Ultimate Elongation (MD), %			
23°C (73°F)	75	70	65
200°C (392°F)	80	75	110
Tensile Modulus, (MD), GPa (psi)			
23°C (73°F)	2.86 (415,000)	2.28 (330,000)	2.62 (380,000)
200°C (392°F)	1.62 (235,000)	1.14 (165,000)	1.38 (200,000)
Impact Strength at 23°C (73°F)			
Kg-cm (ft-lb)	8 (.58)	7 (.51)	16 (1.16)
Tear Strength (MD) – Initial (Graves)			
g (lbf)	1,200 (2.6)	1,175 (2.6)	1,815 (4.0)
Tear Strength (MD) – Propagating (Elmendorf)			
g (lbf)	8 (.02)	48 (.11)	58 (.13)
Weight % Polyimide	80	57	73
Weight % FEP	20	43	27
Density, g/cm³	1.53	1.67	1.57

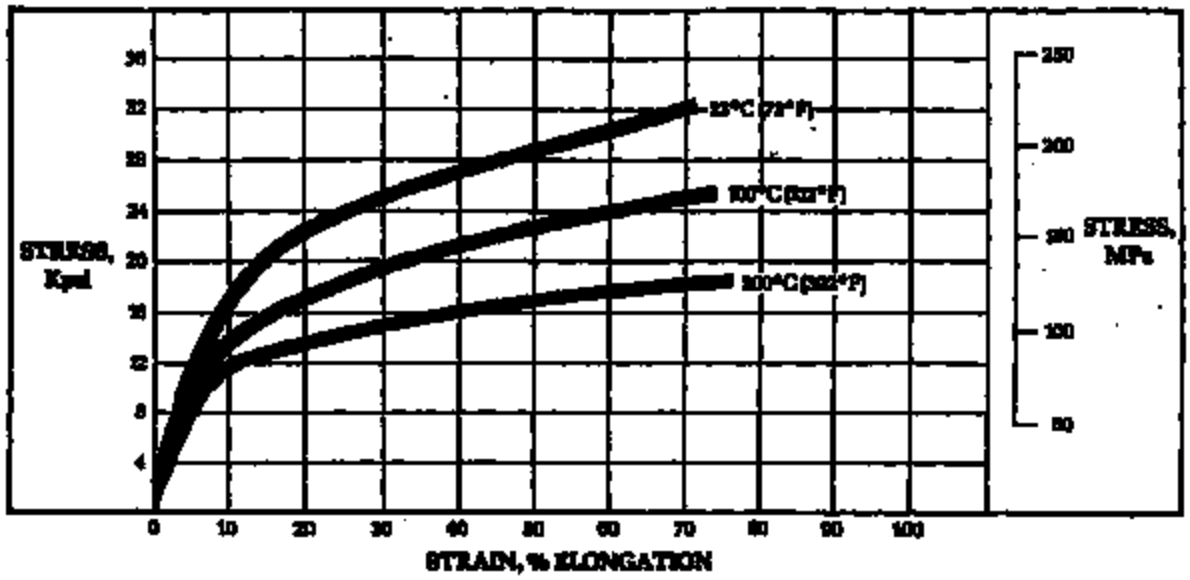
*Since a number of combinations of polyimide film and fluorocarbon coating add up to the same total gauge, it is necessary to distinguish among them. A three-digit system is used in which the middle digit represents the nominal thickness of the base KAPTON film in mils. The first and third digits represent the nominal thickness of the coating of TEFLON® FEP fluorocarbon resin in mils. The symbol 6 is used to represent 25 µm (1 mil) and 0 to represent 2.5 µm (.1 mil). Example: 125FN66 is a 150-gauge structure consisting of a 25 µm (1 mil) base film with a 2.5 µm (.10 mil) coating of TEFLON on each side. See page 24 for construction explanation.

MECHANICAL PROPERTIES

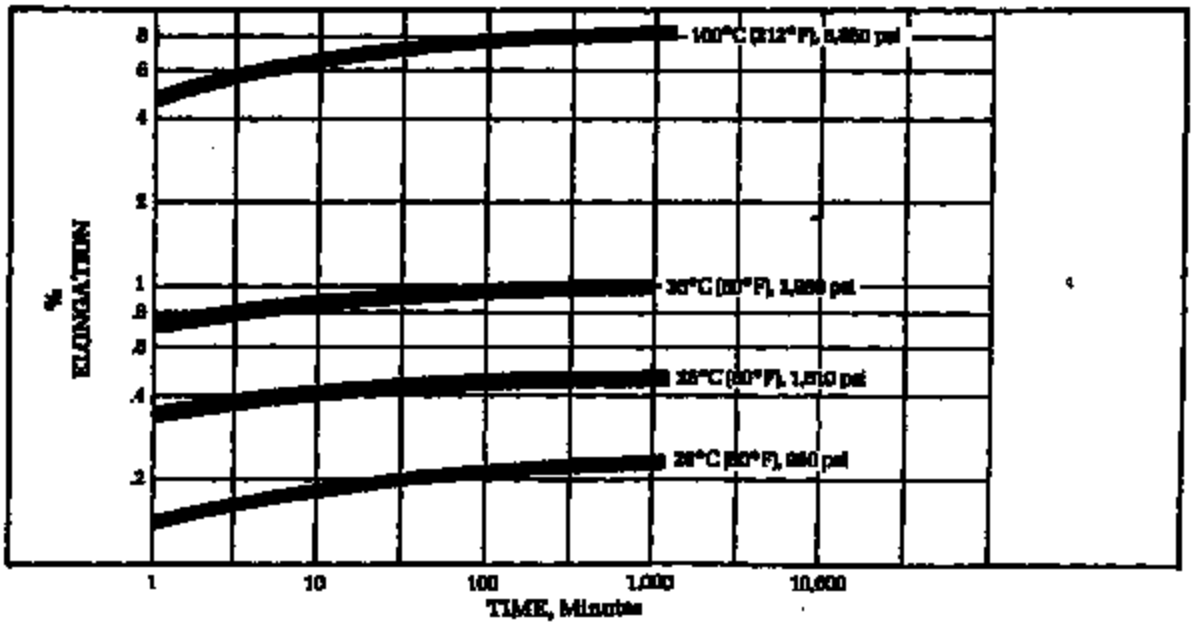
The usual values of tensile strength, tensile modulus, and ultimate elongation at various temperatures can be obtained from the typical stress-strain curves shown below. Both properties as tensile strength and modulus have an inverse relation with temperature, while elongation peaks to a maximum value at about 300°C (570°F). Other factors such as humidity, film thickness, and tensile elongation rate were found to have only a negligible effect on the shape of the 23°C (73°F) curve.

TENSILE STRESS STRAIN CURVES

(Type HN Film, 25 µm (1 mil))



TENSILE CREEP PROPERTIES



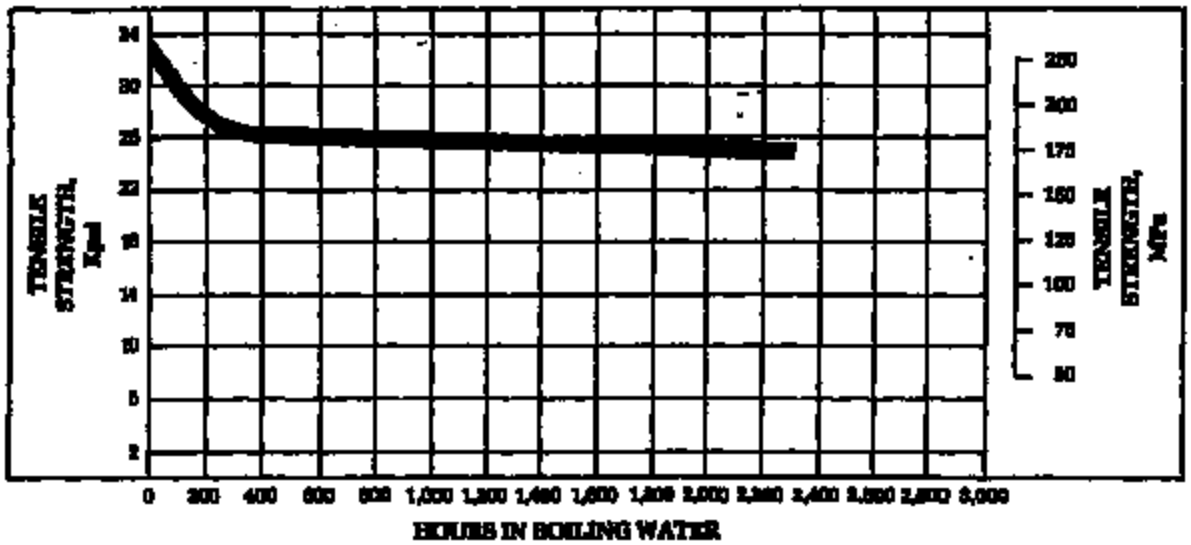
TI-NHTSA 018217

HYDROLYTIC STABILITY

KAPTON® polyimide film is made by a condensation reaction; therefore, its properties are affected by water. Although long-term exposure to boiling water, as shown in the curves below, will reduce the level of film properties, sufficient tensile and elongation remains to insure good mechanical performance. A decrease in the temperature and the water content will reduce the rate of KAPTON property reduction while higher temperatures and pressures will increase it.

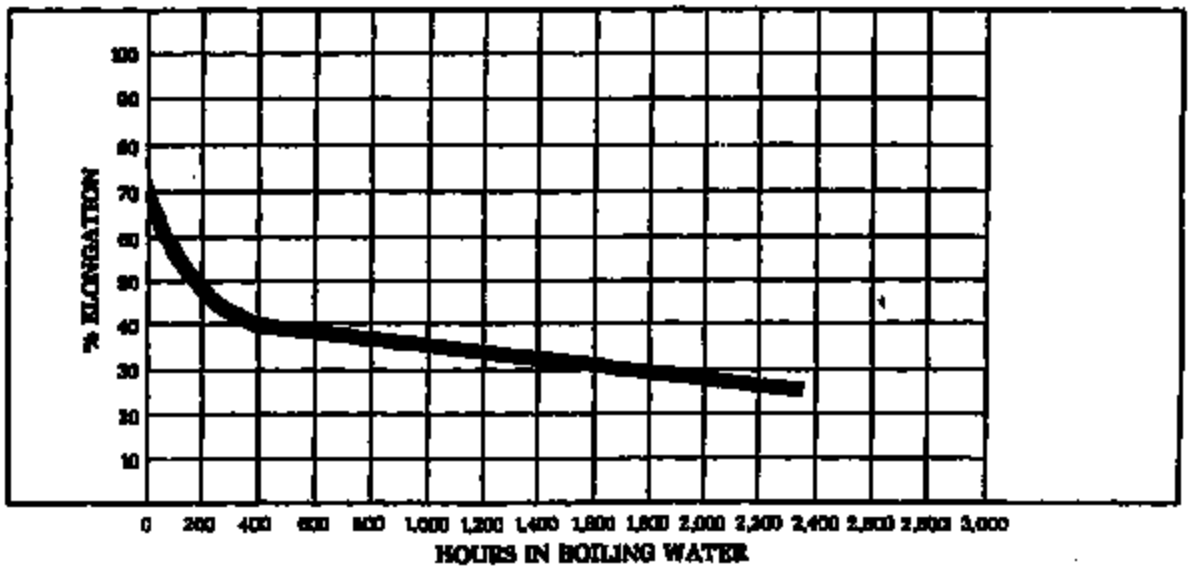
TENSILE STRENGTH AFTER EXPOSURE TO 100°C (212°F) WATER

(Type HN Film, 25 μm (1 mil))



ULTIMATE ELONGATION AFTER EXPOSURE IN 100°C (212°F) WATER

(Type HN Film, 25 μm (1 mil))



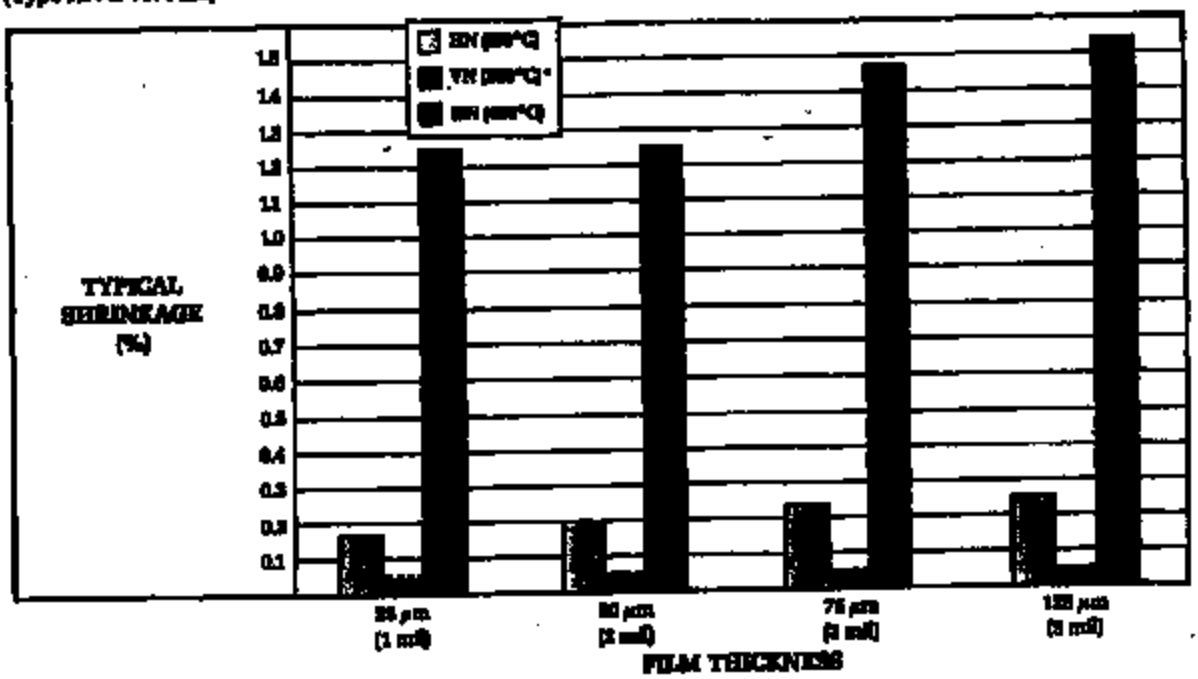
TI-NHTSA 018218

DIMENSIONAL STABILITY

The dimensional stability of KAPTON® polyimide film depends on two factors—the normal coefficient of thermal expansion and the residual stresses placed in the film during manufacture. The latter causes KAPTON to shrink on its first exposure to elevated temperatures as indicated in the bar graphs below. Once the film has been exposed, the normal values for thermal expansion listed on the bottom of this page can be expected.

RESIDUAL SHRINKAGE VS. EXPOSURE TEMPERATURE AND THICKNESS

(Type HN & VN Film)



*Type VN shrinkage is 0.03% for all thicknesses.

THERMAL COEFFICIENT OF EXPANSION

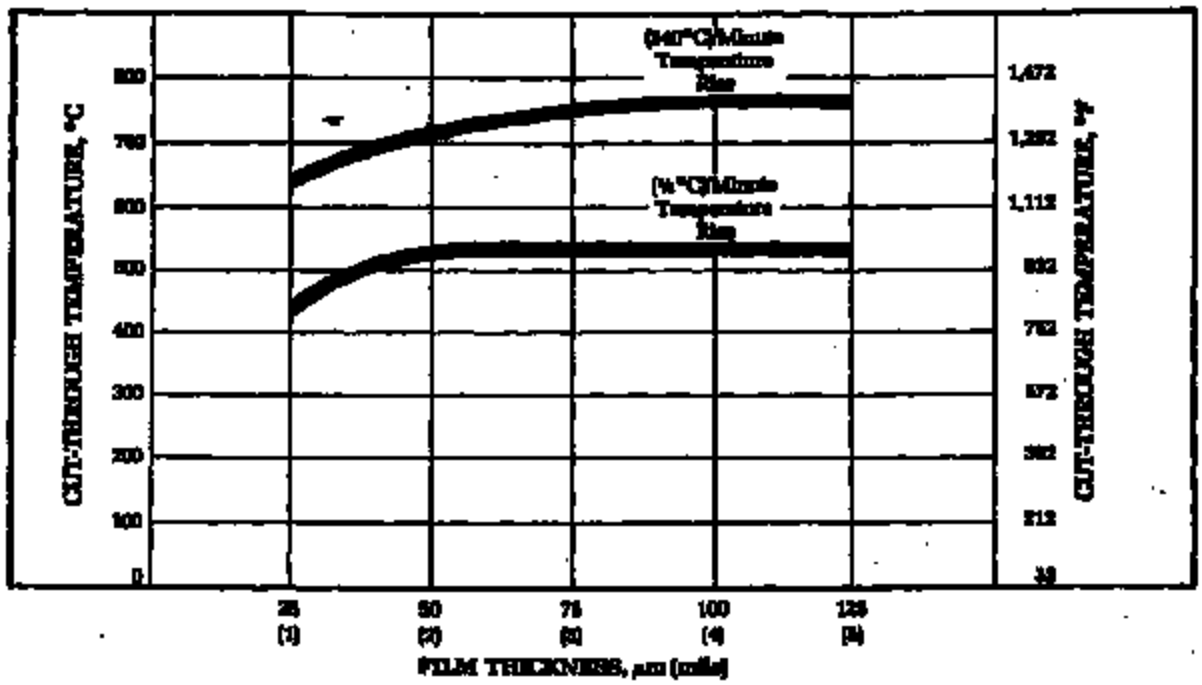
(Type HN Film, 25 µm (1 mil)) Thermally Exposed

Temperature Range	ppm/°C
23-100°C (73-212°F)	15
100-200°C (212-392°F)	31
200-300°C (392-572°F)	45
300-400°C (572-752°F)	75
23-400°C (73-752°F)	40

CUT-THROUGH RESISTANCE

Most organic films exhibit a tendency to flow or thin out under high compressive stresses, especially at elevated temperatures. KAPTON® polyimide film possesses an extremely high resistance to such stresses. Test procedures described in ASTM D-676-80 have been adopted to flat films to provide the data below. Stresses range from an infinitely high point load to 65 MPa (9,500 psi) at cut-through for a 25μm (1 mil) film.

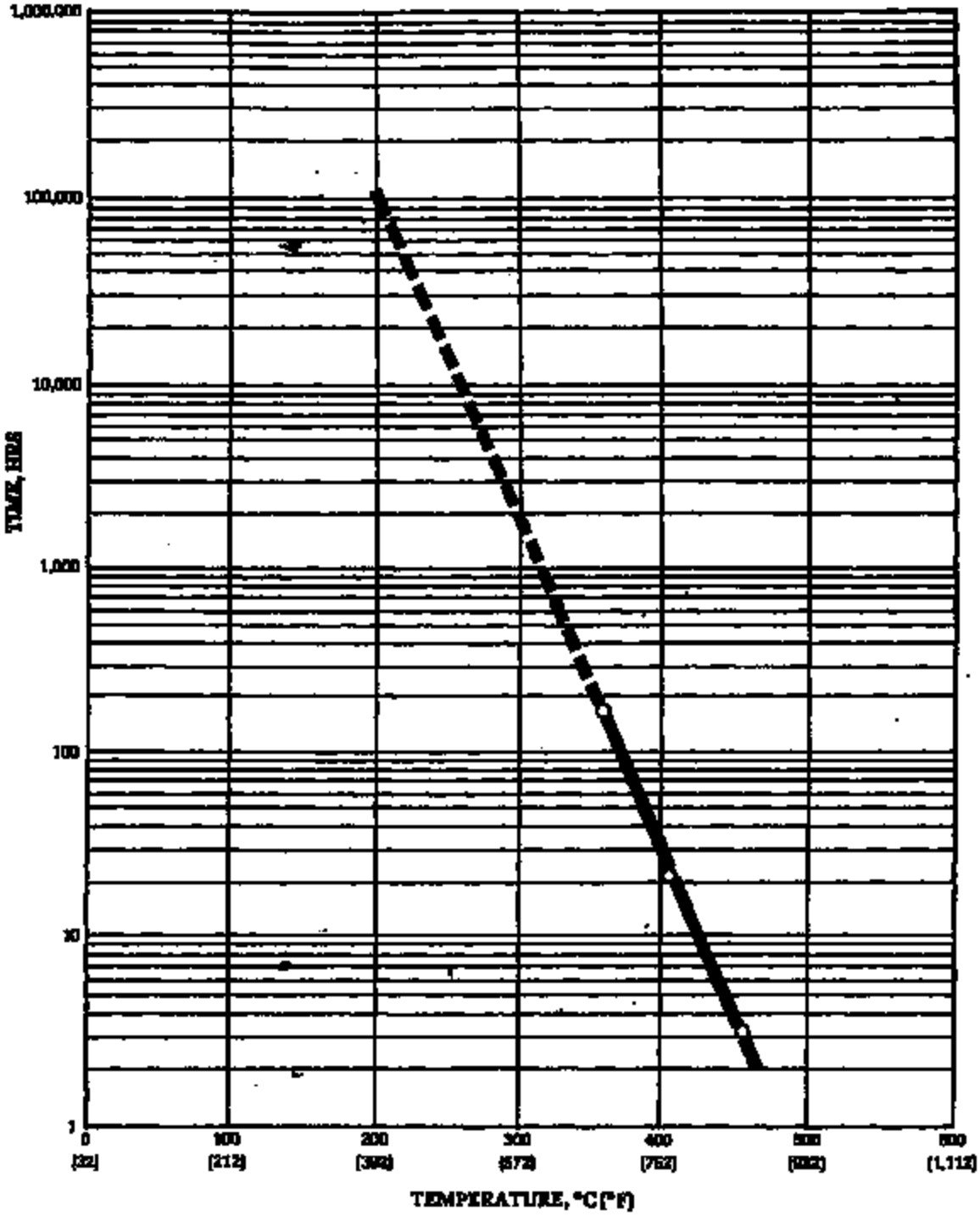
CUT-THROUGH TEMPERATURE VS. RATE OF TEMPERATURE RISE AND THICKNESS (Type HN Film)



TI-NHTSA 018220

RESISTANCE TO CUT-THROUGH VS. TEMPERATURE

(Type HN Film, 25 μm (1 mil))



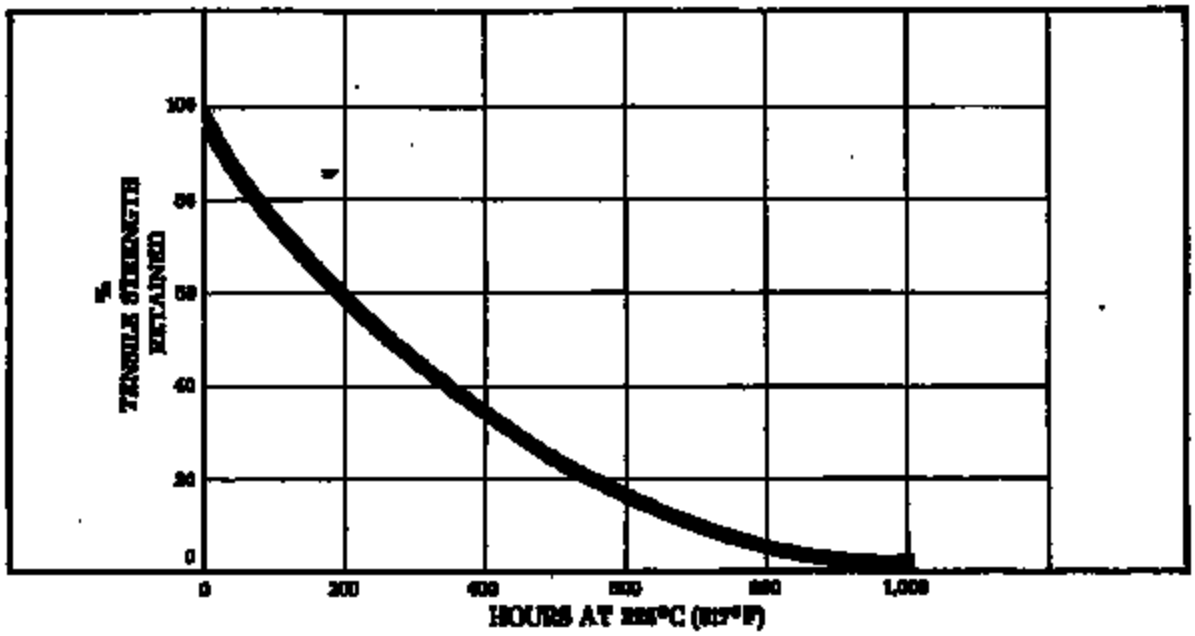
TI-NHTSA 018221

THERMAL AGING

The useful life of KAPTON® polyimide film is a function of both temperature and oxygen concentration. In accordance with UL 746B test procedures, the thermal life of KAPTON has been determined at various temperatures. At zero time and 325°C, the tensile strength is 234 MPa (34,000 psi) and the elongation is 87 percent. The results are graphed below.

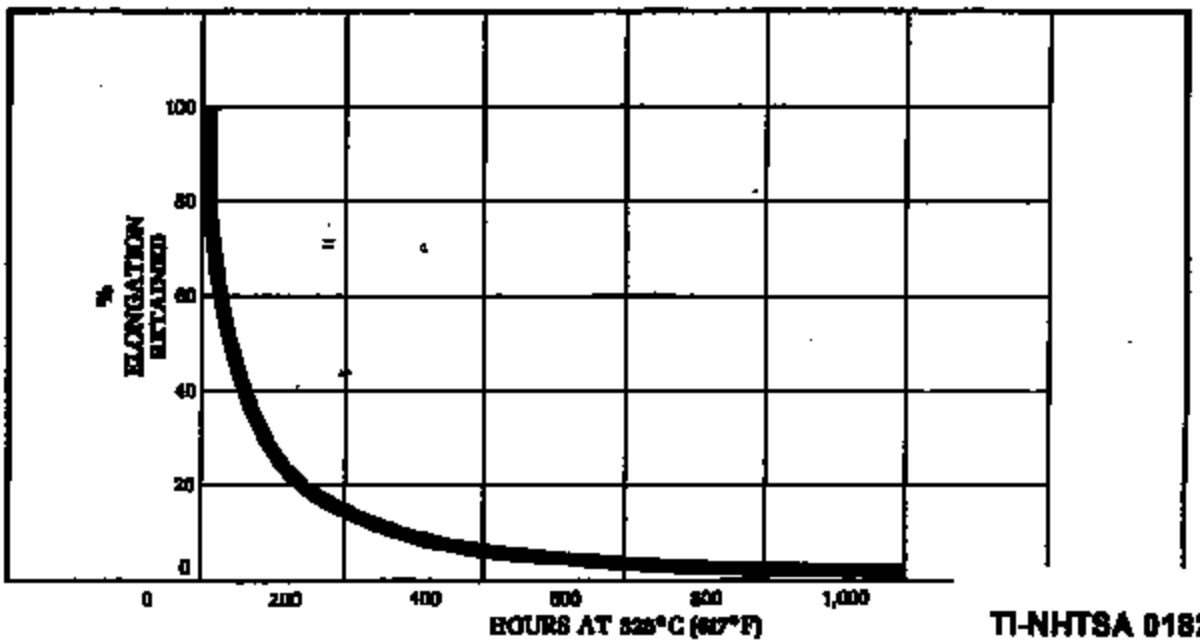
TENSILE STRENGTH VS. AGING IN AIR AT 325°C (617°F)

(Type HN Film, 25 µm (1 mil))



ULTIMATE ELONGATION VS. AGING IN AIR AT 325°C (617°F)

(Type HN Film, 25 µm (1 mil))



TI-NHTSA 018222

TIME REQUIRED FOR REDUCTION IN ULTIMATE ELONGATION FROM 70% TO 1%

(Type HN Film, 25 μm (1 mil))

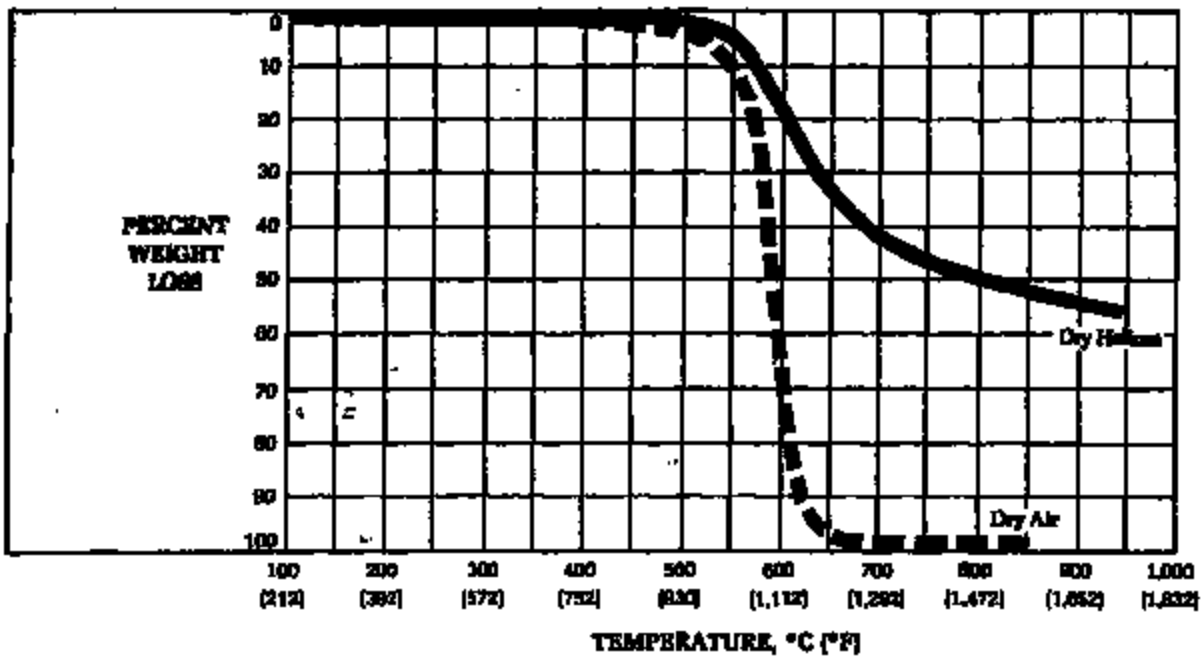
Temperature	Air Environment*
450°C (840°F)	2 hours
425°C (800°F)	5 hours
400°C (750°F)	12 hours
375°C (710°F)	2 days
350°C (660°F)	8 days
325°C (620°F)	1 month
300°C (570°F)	3 months
275°C (530°F)	1 year
250°C (480°F)	5 years

*KAPTON polyimide film is subject to oxidative degradation. Hence, when tested in a helium environment, KAPTON has shown a useful life of at least an order of magnitude greater than that in air.

WEIGHT LOSS AT (3°C)/MINUTE TEMPERATURE RISE

(Type HN Film, 25 μm (1 mil))

KAPTON® polyimide film has significantly extended life in reduced oxygen environments at high temperatures. Using a Du Pont 1090 Thermal Analyzer System, the weight loss characteristics of KAPTON in air and helium at elevated temperatures are shown below.



TI-NHTSA 018223

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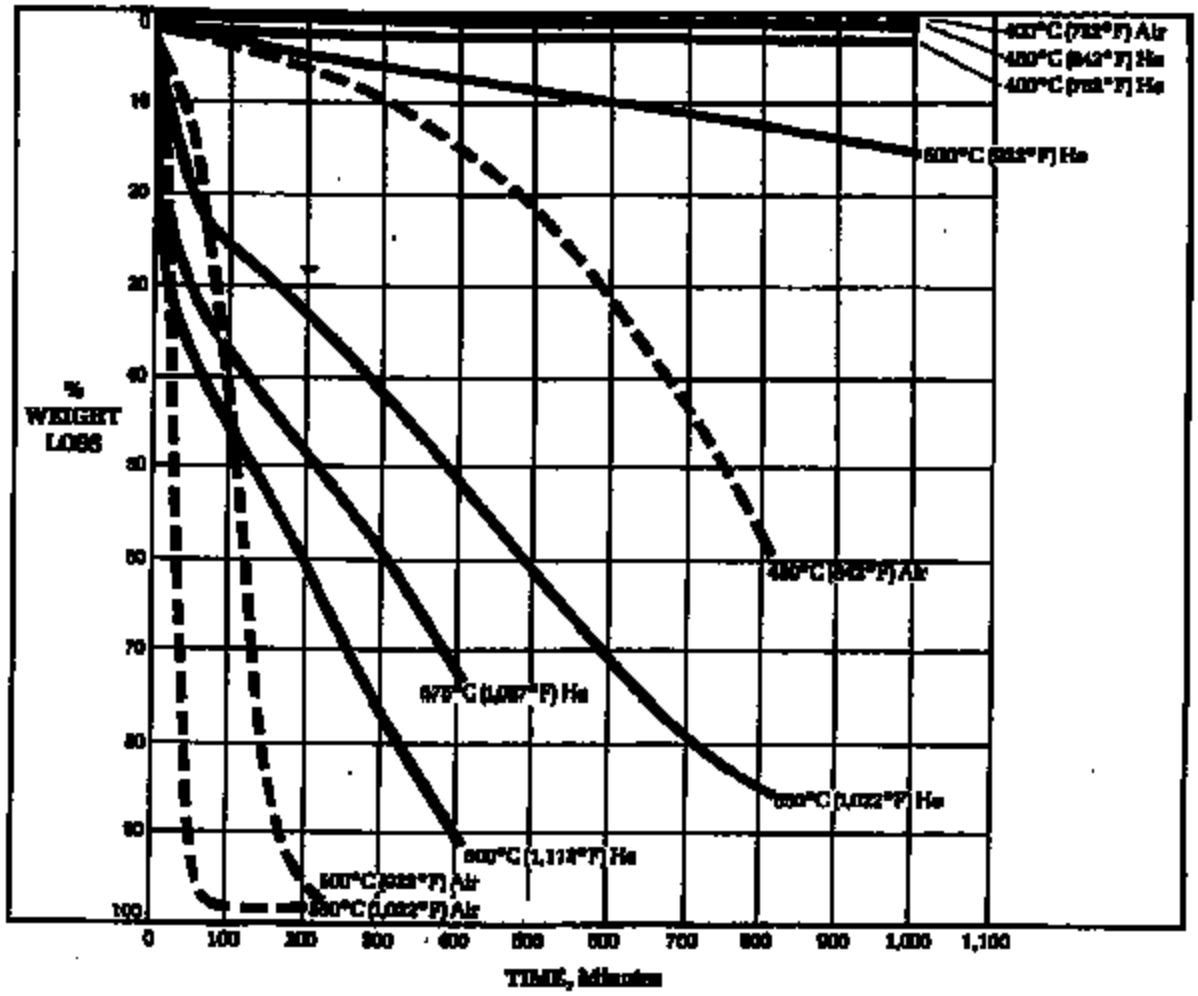
@0192

ISOTHERMAL WEIGHT LOSS

(Type HN Film, 25 μm (1 mil))



TI-NHTSA 018224

ELECTRICAL PROPERTIES

KAPTON® Type HN and VN Film

TYPICAL ELECTRICAL PROPERTIES

PROPERTY	TYPICAL VALUE	TEST CONDITION	TEST METHOD
Dielectric Strength			
25 µm (1 mil)	303 v/µm 7,700 v/mil		
50 µm (2 mil)	240 v/µm 6,100 v/mil	60 hertz	ASTM D-149-81
75 µm (3 mil)	205 v/µm 5,200 v/mil	¼" electrodes	
125 µm (5 mil)	154 v/µm 3,900 v/mil	500 volts/sec rise	
Dielectric Constant			
25 µm (1 mil)	3.4	1 kilohertz	ASTM D-150-81
50 µm (2 mil)	3.4		
75 µm (3 mil)	3.5		
125 µm (5 mil)	3.5		
Dissipation Factor			
25 µm (1 mil)	.0018	1 kilohertz	ASTM D-150-81
50 µm (2 mil)	.0020		
75 µm (3 mil)	.0020		
125 µm (5 mil)	.0026		
Volume Resistivity			
25 µm (1 mil)	1.5×10^{17} ohm-cm		ASTM D-257-78 (1983)
50 µm (2 mil)	1.5×10^{17} ohm-cm		
75 µm (3 mil)	1.4×10^{17} ohm-cm		
125 µm (5 mil)	1.0×10^{17} ohm-cm		

KAPTON® Type FN Film

TYPICAL ELECTRICAL PROPERTIES

PROPERTY	120FN519	150FN019	200FN029
Dielectric Strength			
Volts/mil	6,800	5,000	5,000
Volts/µm	272	197	197
Dielectric Constant	3.1	3.7	3.9
Dissipation Factor	.0015	.0013	.0013
Volume Resistivity			
ohm-cm @ 23°C (73°F)	1.4×10^{17}	2.3×10^{17}	1.9×10^{17}
ohm-cm @ 200°C (392°F)	4.4×10^{14}	8.8×10^{14}	8.7×10^{14}

EFFECT OF HUMIDITY

(Type HN Film, 25 μm (1 mil))

Because the water content of KAPTON® polyimide film can affect its electrical properties, electrical measurements were made on 1 mil film after exposure to environments of varying relative humidities at 23°C (73°F).

The results of these measurements are graphed below.

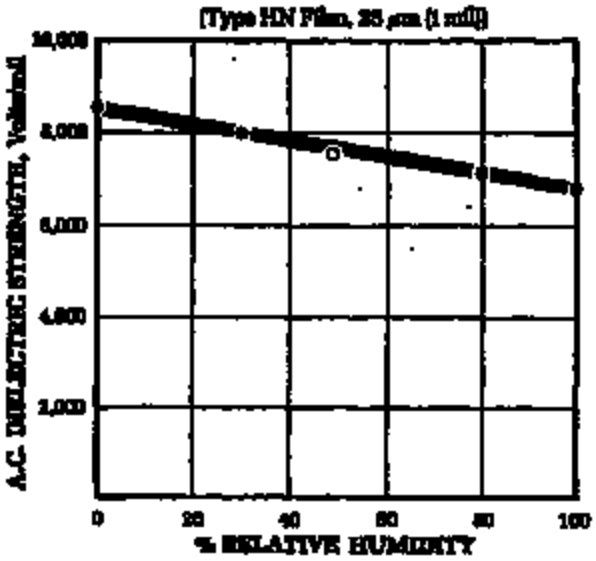
RELATIVE HUMIDITY VS. ELECTRICAL PROPERTIES OF KAPTON

% RELATIVE HUMIDITY	AC DIELECTRIC STRENGTH V/μm (V/mil)	DIELECTRIC CONSTANT	DISSIPATION FACTOR
0	330 (8400)	3.0	.0015
20	315 (8000)	3.2	.0017
50	303 (7700)	3.5	.0030
80	280 (7100)	3.7	.0037
100	295 (7500)	3.8	.0038

For calculations involving absolute water content, 50% RH in our study is equal to 1.8% water in the film and 100% RH is equal to 2.8% water, the maximum adsorption possible regardless of the driving force.

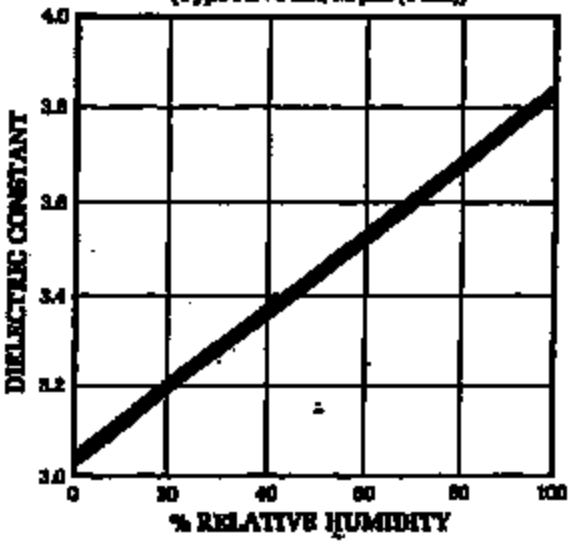
A.C. DIELECTRIC STRENGTH VS. RELATIVE HUMIDITY

(Type HN Film, 25 μm (1 mil))



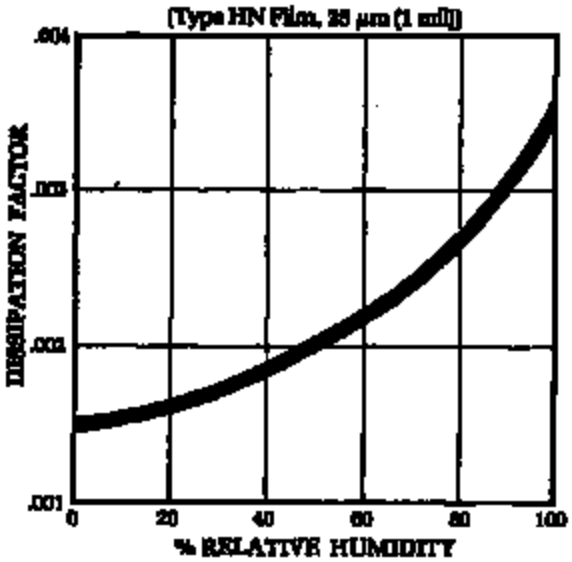
DIELECTRIC CONSTANT VS. RELATIVE HUMIDITY

(Type HN Film, 25 μm (1 mil))



DISSIPATION FACTOR VS. RELATIVE HUMIDITY

(Type HN Film, 25 μm (1 mil))



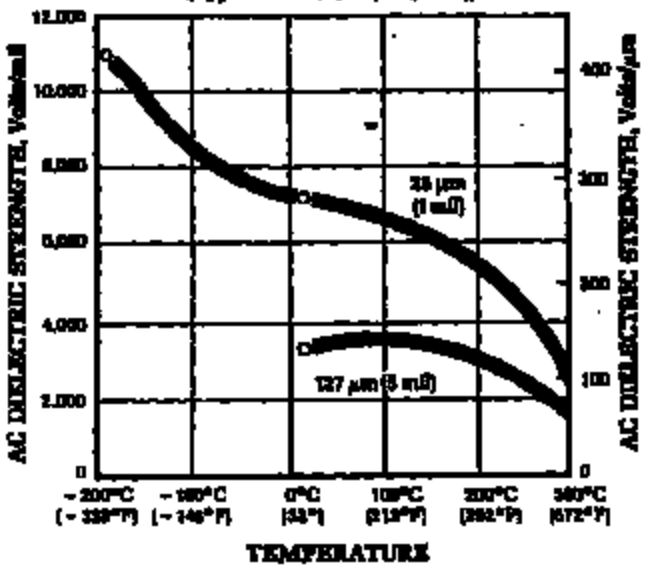
TI-NHTSA 018227

EFFECT OF TEMPERATURE

As the graphs below indicate, extreme changes in temperature have relatively little effect on the excellent room temperature electrical properties of KAPTON® polyimide film.

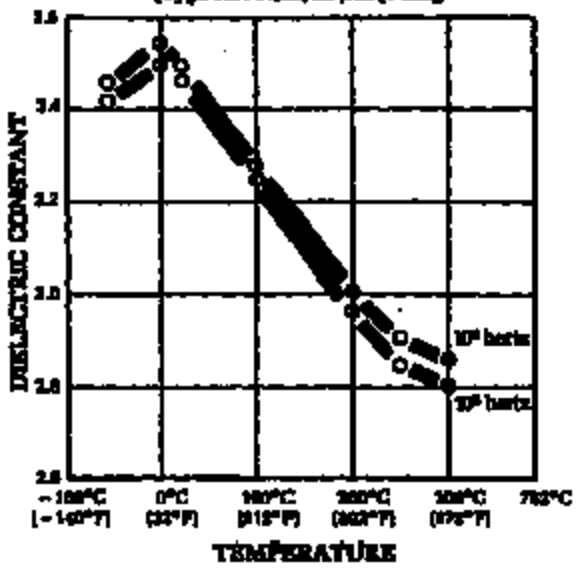
AC DIELECTRIC STRENGTH VS. TEMPERATURE

(Type HN Film, 25 μm (1 mil))



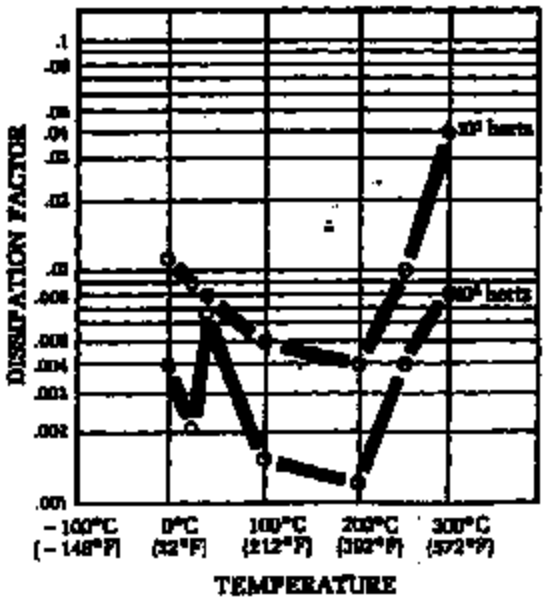
DIELECTRIC CONSTANT VS. TEMPERATURE

(Type HN Film, 25 μm (1 mil))



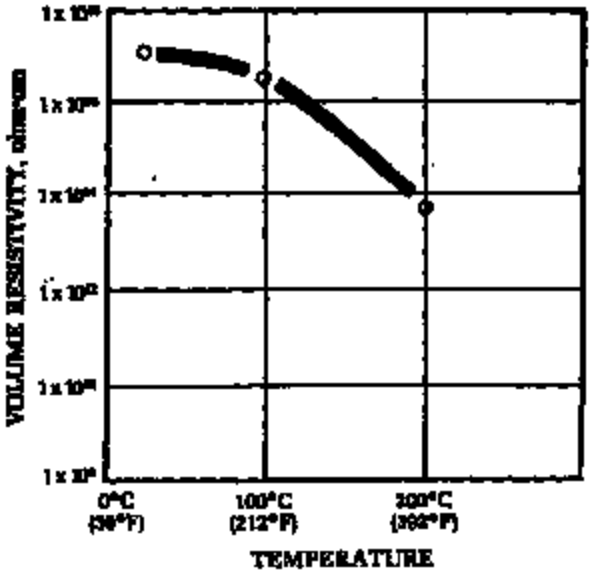
DISSIPATION FACTOR VS. TEMPERATURE

(Type HN Film, 25 μm (1 mil))



VOLUME RESISTIVITY VS. TEMPERATURE

(Type HN Film, 25 μm (1 mil))



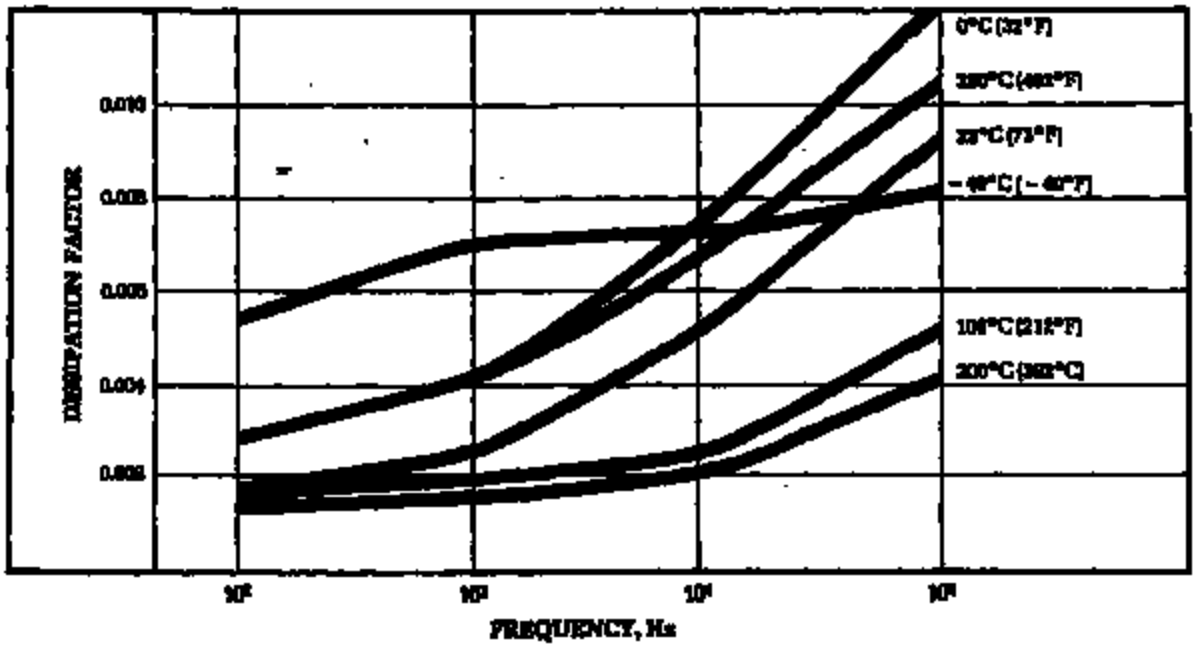
TI-NHTSA 018228

EFFECT OF FREQUENCY

The effects of frequency on the value of the dielectric constant and dissipation factor at various isotherms are shown below.

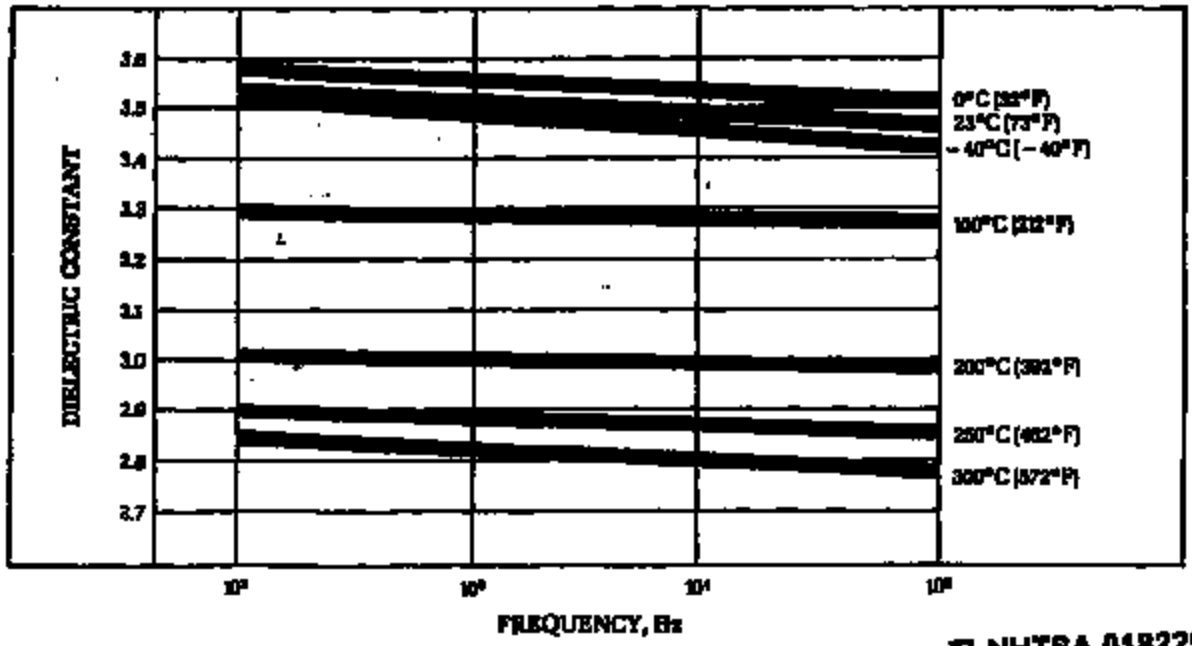
DISSIPATION FACTOR VS. FREQUENCY

(Type HN Film, 25μm (1 mil))



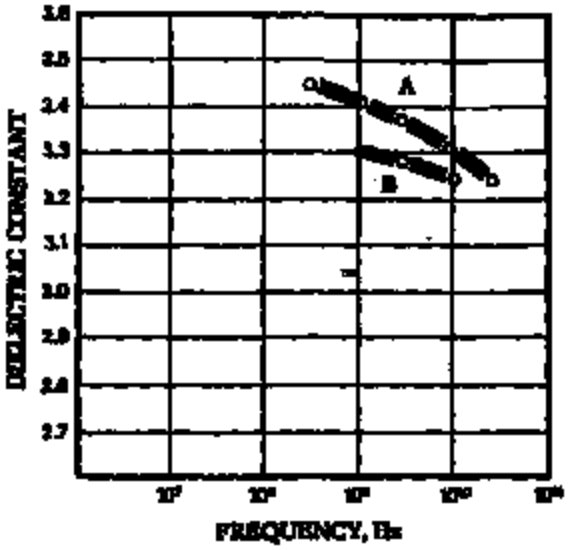
DIELECTRIC CONSTANT VS. FREQUENCY

(Type HN Film, 25 μm (1 mil))

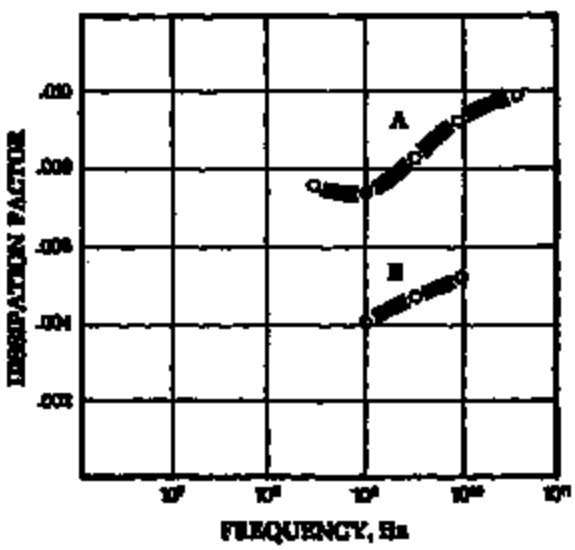


DIELECTRIC PROPERTIES IN GIGAHERTZ FREQUENCY RANGE

(Type HN Film, 125μ (5 mil))*



(Type HN Film, 125μm (5 mil))*



*Technical Report AFML-TR-72-39—Curve A is HN01 KAPTON as received and measured at 23°C and 45% RH with the electric field in the plane of the sheet. Curve B is the same measurement after conditioning the film at 100°C for 48 hours. Performance of 300HN is believed equivalent to HN01.

TRACKING RESISTANCE

A 125μm (5 mil) KAPTON® polyimide film, Type HN, has a tracking resistance of 161 seconds as measured by ASTM D-495-84. The failure was due to true tracking rather than erosion, etc.

CORONA LIFE

Like all organic materials, KAPTON is attacked by corona and will ultimately fail dielectrically when exposed continuously to corona. At moderate levels of corona exposure, devices insulated with KAPTON have survived up to 3,000 hours, giving reasonable assurance that brief exposures to corona will not significantly affect the life of a properly designed insulation system based on KAPTON.

Corona threshold voltage and corona intensity are functions of many parameters, including insulation thickness, air gap thickness, and device shape. Consult with a Du Pont technical representative on the suitability of KAPTON for specific applications where corona may be present.

CHEMICAL PROPERTIES

KAPTON® Type HN Film 25 µm (1 mil)

CHEMICAL PROPERTIES

PROPERTY	TYPICAL VALUES (25 µm (1 mil)) % Tensile Retained	% Elongation Retained	TEST CONDITION	TEST METHOD
CHEMICAL RESISTANCE				
Isopropanol	95	94	10 min @ 23°C	IPC TM-650 Method 2.3.2B
Toluene	86	91		
MEK	89	90		
Methylene Chloride/ Trichloroethylene (50/50)	95	93		
2N HCl	95	93		
2N NaOH	82	54		
FUNGUS RESISTANCE	Nonnutrient			IPC TM-650 Method 2.6.1
MOISTURE ABSORPTION	1.8% Type HN & VN		50% Relative Humidity at 23°C	ASTM D-570-81
	2.9% Type HN & VN		Immersion for 24 hrs at 23°C (73°F)	
HYGROSCOPIC COEFFICIENT OF EXPANSION	22 ppm/% RH		23°C (73°F), 20-60% Relative Humidity	
PERMEABILITY				
GAS	cc/(100 in²•24 hr•atm)		23°C (73°F), 50% Relative Humidity	ASTM D-1434-82
Carbon Dioxide	45			
Oxygen	25			
Hydrogen	280			
Nitrogen	8			
Helium	415			
VAPOR				
Water	g/(m²•d) 64	g/(100 in²•24 hr) 3.5		ASTM E-96-80

RADIATION RESISTANCE*

PROPERTY	TYPICAL VALUES (25 µm (1 mil)) % Tensile Retained	% Elongation Retained	TEST CONDITION	TEST METHOD
Gamma (Savannah River)	Still Flexible (180° Bend)		Exposure: 4.16×10^9 Gy	
Electron (Van de Graaf)	Retains 50% of Original Elongation		Exposure: 6×10^7 Gy	
Neutron Plus Gamma (Brookhaven)	Darkened but Tough		Exposure: 10^8 Gy	

*Due to its excellent radiation resistance, KAPTON is frequently used in high radiation environments where a thin, flexible insulating material is required, i.e. outer space. KAPTON is used both alone and in combination with other materials where radiation resistance at minimum weight is necessary. KAPTON is also used in nuclear reactors and linear accelerators. Many of these applications require testing that involves exposure to an adverse chemical environment in addition to radiation. For example, Loss of Coolant Accident (LOCA) tests for qualification to containment seals in power plants expose the system to steam and sodium hydroxide both of which tend to degrade KAPTON. Accordingly, while KAPTON is used in nuclear power systems that require conformation to IEEE-323 and -383, engineered designs which protect KAPTON from direct exposure to LOCA sprays are required.

KAPTON® Type VN Film

CHEMICAL PROPERTIES

Typical chemical properties for Type VN film are similar to Type HN.

KAPTON® Type FN Film

CHEMICAL PROPERTIES

PROPERTY	120FN616	150FN619	400FN621
Moisture Absorption			
@ 23°C (73° F), 50% R.H.	1.3%	0.8%	0.4%
90% R.H.	3.5%	1.7%	1.3%
Water Vapor Permeability			
g/m²-d	17.5	9.6	2.4
g/100 in²-24 hrs	1.13	.62	.16

KAPTON® FILM TYPE INFORMATION

TYPE AND THICKNESS

TYPE	NOMINAL THICKNESS µm	mils	AREA FACTOR m²/kg	ft²/lb
30 HN	8	0.3	84	410
50 HN	13	0.5	56	272
75 HN	19	0.75	42	204
100 HN	25	1.0	28	136
200 HN	50	2.0	14	68
300 HN	75	3.0	9.5	46
500 HN	125	5.0	5.5	27
50 VN	13	0.5	56	272
75 VN	19	0.75	42	204
100 VN	25	1.0	28	136
200 VN	50	2.0	14	68
300 VN	75	3.0	9.5	46
500 VN	125	5.0	5.5	27
100FN020	25	1.0	23	110
120FN018	30	1.2	21	104
150FN028	38	1.5	14	68
150FN019	38	1.5	16	77
200FN011	50	2.0	11	54
200FN019	50	2.0	11	54
250FN029	63	2.5	10	48
300FN021	75	3.0	8.0	38
300FN029	75	3.0	8.0	38
400FN022	100	4.0	5.5	27
400FN031	100	4.5	6.1	30
500FN131	125	5.0	4.7	23
500FN051	150	6.0	4.3	21

NOMINAL CONSTRUCTION, Type FN Film

In the KAPTON® Type FN order code of 3 digits, the middle digit represents the nominal thickness of the base KAPTON in mils. The first and third digits represent the nominal thickness of the coating of TEFLON® FEP fluorocarbon resin in mils. The symbol 0 is used to represent 13 µm (½ mil) and 5 to represent 2.5 µm (⅛ mil). Example: 150FN019 is a 150-gauge structure consisting of a 25 µm (1 mil) base film with a 2.5 µm (⅛ mil) coating of TEFLON on each side. Illustrated are several examples of the twenty types available.

TYPE	CONSTRUCTION FEP µm	FEP mils	KN µm	KN mils	FEP µm	FEP mils
100FN020			13	0.50	13	0.50
120FN018	2.5	0.10	25	1.00	2.5	0.10
150FN029	13	0.50	13	0.50	13	0.50
150FN019			25	1.00	13	0.50
200FN011			25	1.00	25	1.00
200FN019	13	0.50	25	1.00	13	0.50
250FN029			50	2.00	13	0.50
300FN021			50	2.00	25	1.00
300FN029	13	0.50	50	2.00	13	0.50
400FN022			50	2.00	50	2.00
400FN031			75	3.00	25	1.00
500FN131	25	1.00	75	3.00	25	1.00
500FN051			125	5.00	25	1.00

SAFETY AND HANDLING

Unheated KAPTON® polyimide film is insoluble in most common organic solvents after immersion for up to a year. However, KAPTON is dissolved by strong acids such as fuming nitric and concentrated sulfuric acid, particularly on heating, and is hydrolyzed by alkali and superheated steam.

KAPTON Type FN exhibits better chemical and oxidative resistance than Types HN and VN.

KAPTON film can be used safely at elevated temperatures with proper ventilation. At elevated temperatures, KAPTON can release small amounts of dimethyl acetamide residual solvent. Adequate ventilation in accordance with OSHA (29 CFR 1910.1000) will provide safe handling and use.

For additional information, users should refer to the following bulletin:

KAPTON® Polyimide Film – Safe Handling H-72994

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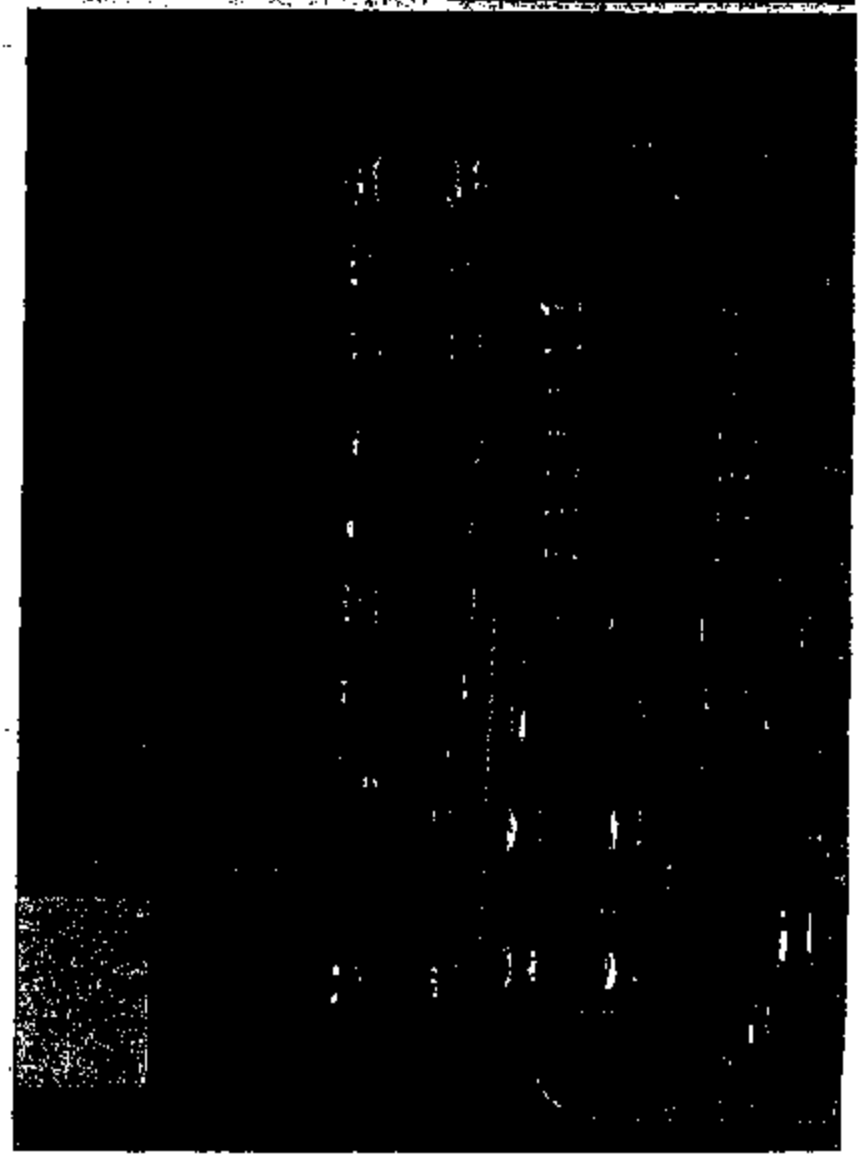
Kapton® Polyimide Film
FPC-E for
Fine Line and Metallized FPC

DuPont
Electronics

High Performance Films

- New E-Polymer Formulation
- Designed for Metallization
- Tailored Dimensional Properties (Thermal Expansion Matched to Copper)
- Low Absorption and Less Expansion in Water
- High/Durable Adhesion (85°C/85% RH)
- Low Level of Surface Contamination
- High Modulus

Available:
100FPC-E
200FPC-E
300FPC-E



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TI-NHTSA 018239

DD/NHTSA No. 3
00288

Kapton® FPC-E for High Resolution and Metallized FPC

Market Coordinator-Harland Tate	Technical Service-Steve Simpson
Industry Need	Typical Kapton® FPC-E Feature (Average)
■ Tailored dimensional properties	■ CTE = 17 PPM/°C (35-260°C) CHE = 9 PPM/% RH Shrinkage = 0.03% (200°C)
■ Low water absorption	■ 2.2%
■ High/durable adhesion	■ >8 pli 90+% retension, 250 hrs at 85°C/85% RH
■ High modulus	■ 800 Kpsi
■ Higher productivity	■ Fast drying rate Fast adhesive cure rate Better stiffness for stability during processing

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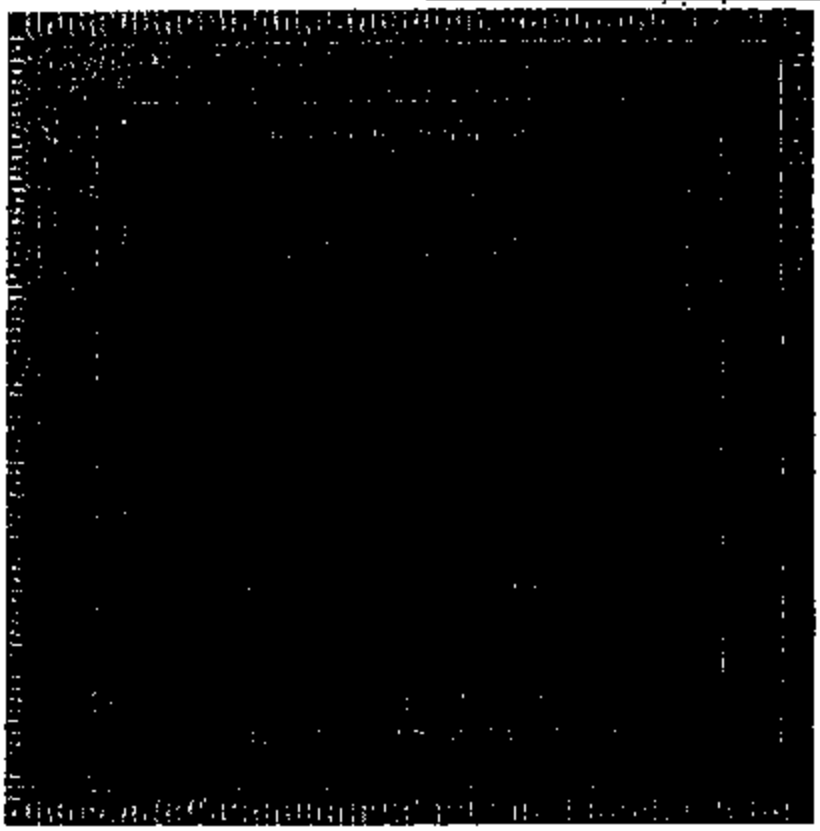
Kapton® Polyimide Film
TAB-E for
High Resolution TAB

DuPont
Electronics

High Performance Films

- New E-Polymer Formulation
- Substrate Film for either 2-layer (metallised) or 3-layer (adhesive coated) TAB
- High Modulus
- Tailored Dimensional Properties (Thermal Expansion Matched to Copper)
- Low Absorption and Less Expansion in Water
- High/Durable Adhesion (85°C/85% RH)
- Easily Etchable
- Fast Drying Rate
- Fast Adhesive Cure Rate



Available:
200TAB-E
300TAB-E

TI-NHTSA 018241

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Kapton® TAB-E for High Resolution TAB	
Market Coordinator-Harland Tate	Technical Service-Steve Simpson
Industry Need	Typical Kapton® TAB-E Feature (Average)
■ High modulus	■ 800 Kpsi
■ Tailored dimensional properties	■ CTE – 17 PPM/°C (35-260°C) CHE – 9 PPM/% RH Shrinkage – 0.03% (200°C)
■ Low water absorption	■ 2.2%
■ High/durable adhesion	■ >8 pli 90+% retention, 250 hrs at 85°C/85% RH
■ Etchable	■ Common caustic solutions
■ Higher productivity	■ Fast drying rate Fast adhesive cure rate Better stiffness for stability during processing

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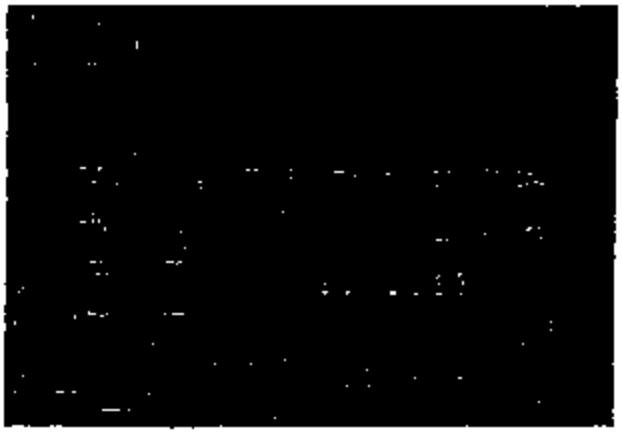
KAPTON® Polyimide Film
Advanced Flexible Dielectric Substrates For FPC/TAB Applications

DuPont Electronics

High Performance Films

J.A. Kreuz, S.N. Milligan, and R.F. Sutton

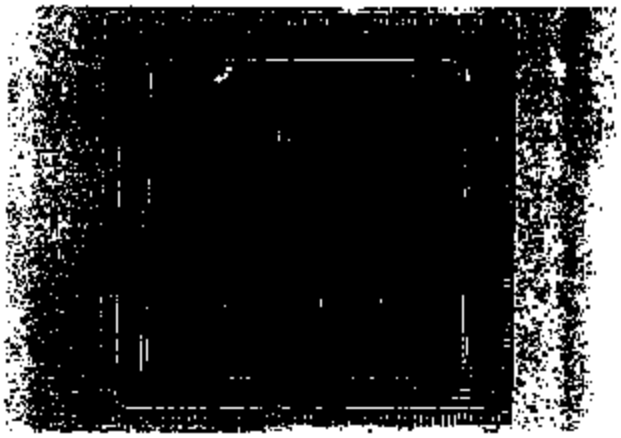
Flexible Printed Circuits



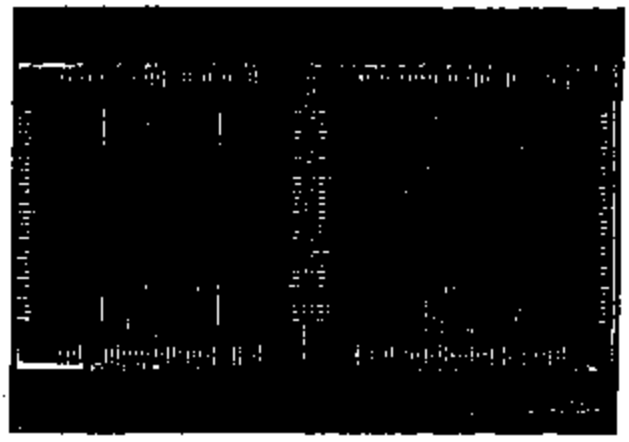
Fine Line

Roll Clads

Tape Automated Bonding



High Resolution TAB



TAB

Introduction and Background

KAPTON polyimide film is a substrate used in flexible printed circuits (FPC), that provides significant advantages for both processing of circuitry and functionality of circuitry. Processing advantages include the capability to fabricate from roll to roll, high mechanical strength, and unique distortional resistance to harsh environments such as high temperature bonding stations and corrosive aqueous etchants.

Historically, functionality advantages have included several areas. Circuitry is dielectrically very reliable with excellent adhesion of the conductors. Its thinness and flexibility allow it to be installed into small volumes, requiring intricate and severe folding. These time-tested advantages have led to numerous applications. Examples are FPC's for electronic cameras, calculators, computers, communications equipment, distance detectors, aircraft harnesses, solar panels, space vehicles, missiles, etc. (Ref. 1). Additionally, a very specialized use in FPC's, where polyimide film has been utilized predominantly, is in Tape Automated Bonding (TAB). KAPTON polyimide film was in fact a component of the original TAB product when it was introduced by GE as the Minimod process in the early 1970's (Ref. 2 & 3). Still another form of FPC's is multilayer FPC's, which place additional demands on substrate mechanical and chemical properties.

Performance demands of polyimide film as a dielectric substrate for FPC applications have intensified greatly since its commercial introduction in 1965. These greater demands have stemmed from the design impetus for all circuitry, which is the progression to ultra-miniaturization of solid state memory and logic devices with increasingly greater lead counts. Continually higher circuit density is required to permit leading to these various devices. As technology progresses, the design engineer, in desire for less expensive substrates, seeks thinner dielectrics, which will not distort under mechanical stresses of processing, and also dimensionally inert materials that defy exposure to heat and chemicals of processing. Along with greater functionality, there is the attendant quest for higher production yields.

Assessments of those properties of dielectric substrates which need improvements have been the subject of several recent papers, and of market studies by Du Pont. Holsinger (Ref. 4 & 5) has considered TAB substrate materials from the aspects of their functionality. Monsinger (Ref. 6) has further defined the properties needed. Even though most literature addresses the needs of the TAB substrate, the properties of an ideal FPC substrate, including multilayer flex, are probably about equivalent. The incentive for emphasis on TAB is that it offers an inexpensive route to gang bonding IC chips, and appears to be a commercially emerging technology, despite its 20 year age.

The general conclusion is that low CTE, low shrinkage to heat, low moisture absorption, high tensile modulus, and good chemical etchability are critical to advanced functionality. Additionally, the new substrates must not be inferior in electrical properties, nor in adhesiveless plating behavior, as compared to existing aromatic polyimide films. Indeed, we concur that these are the key properties requiring improvement. Accordingly, the most important *quantitative* property levels that have represented our product goals are summarized in Table 1.

Table 1

Properties of an Ideal TAB and High Performance FPC Substrate

Property	Goal Level
Shrinkage, 200°C, mils/in.	0.1
CTE, 35°-250°C, ppm/°C	17
Modulus, 23°C, Kpsi	750
H_2O Absorption, %	1.5
Chemically Etchable	Yes

Rationale for the properties of an ideal TAB/FPC substrate, shown in Table 1, are often dependent on subjective criteria, but some explanation for the quantitative values is in order. Shrinkage was established at 0.1mil/in, because it affords excellent ability to to precisely and repetitively align personality windows for the TAB process. It also affords precise registration of through-holes for multilayer applications, and of installation holes for large circuits. Further, low shrinkage provides consistent registration of the artwork pattern in circuitry connections. The CTE of 17ppm was chosen because of its match to copper from room temperature to solder bath temperatures (Ref. 7), for without such a match the stresses during a thermal change of several hundred degrees Celsius would cause excessive distortions. A modulus of 750Kpsi is believed to be an economic incentive, because it allows the design engineer to obtain adequate stiffness with 3-3mil film as an alternative to 5mil film with a modulus of 400Kpsi. A stiffer film is also easier to process into laminate.

Water absorption is a subjective goal to some extent, but the specific value of 1.5% is about at the limit of aromatic polyimides; another step forward to other polymeric structures is believed to be required to dramatically lower moisture absorption. Furthermore, moisture content of about 2% is about the limit of tolerance of most polyimide copper clads to sudden excursions to 250-300°C during TAB bonding without blistering.

Chemical etchability, with common polyimide etchants such as NaOH, or KOH, is advantageous, because some processes use etchants to make various holes in substrates. Caustic etching of holes is often used on two layer TAB, which consists of only polyimide/metal, and which is processed by forming holes in the substrate after the conductive layer (copper usually) is applied. If the product were not caustic etchable, its use would either be limited to three layer TAB (where the adhesive coated substrate is punched before the copper is laminated), or exotic etchants would be required with the attendant environmental problems.

Approaches to Attain Properties

All approaches to fabricate an advanced TAB/FPC substrate have emphasized alteration of the polyimide backbone structure. Out of these studies have come two new production films, which we believe have definite processing advantages, that are a direct consequence of the specific properties built into the films. These two films are designated as KAPTON-K and KAPTON-E, and they will be sold into both FPC and TAB end-uses. The Type-K is targeted at one and two sided circuitry eie roll cladding. It is also intended for 3-layer TAB applications (use of adhesives) of medium complexity; e.g. 40-200 leads. The Type-E is targeted at multilayer and fine line circuitry where the conductor is bonded adhesivelessly. TAB applications are believed to lie in higher complexity systems with greater than 200 leads, as well as two conductor TAB.

Developmental Work to Achieve New Films

In order to acquire a high modulus and low CTE, random copolymerization of stiff diamine segments into the pyromellitic dianhydride/4,4'-oxydianiline polyimide was demonstrated. Polymerization of these stiff segments is under continued study, where the stiff polyimide segments are introduced into the chain as blocks rather than as random units. The advantage of such a method, is that it is likely to enhance the effect of stiff segments at much lower concentrations than if the segments were introduced in a random fashion. The main difficulty with the block copolymer approach is the one of authentically maintaining the block throughout the course of polymerizations/processing, and doing such a feat on a reproducible basis. In this regard, investigation in this area of polyimide chemistry, in addition to continuing, will be reported elsewhere at a later date.

Since the moisture absorption of copolymer formulations is not predictable, several empirical attempts were made to lower the moisture absorption as well as the dielectric constant, which is affected by moisture and is a recurring concern to circuit designers. In addition, adherability is a constant issue with any new substrate, and a part of this ongoing effort is to incorporate functional groups into the polymer chain which will promote adhesion either to various flexible printed circuit adhesives, or directly to copper in adhesiveless products.

Specific effects of stiff codiamine segments were demonstrated by investigation of parraphenylenediamine (PPD), introduced into the chain in a random fashion. A gradual increase in modulus with a corresponding decrease in CTE was found to be dependent on the PPD content. Figures 1 & 2 clearly define the behavior of these mechanical properties as a function of the mole percentage of PPD. In effect, this film has become known as Type-K.

In much the same fashion by which the formulation of Type-K was achieved, the systematic introduction of cosegments into the polymer chain was done to arrive at Type-E. Statistical design of the various compositions was utilized in order to reduce the total number of compositions that were investigated. At the same time, attention was given to alteration of promising compositions so that film manufacture was possible.

Fig. 1

Moduli of Experimental Copolyimide Films

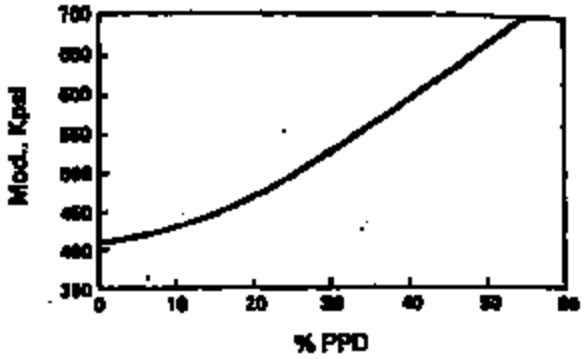
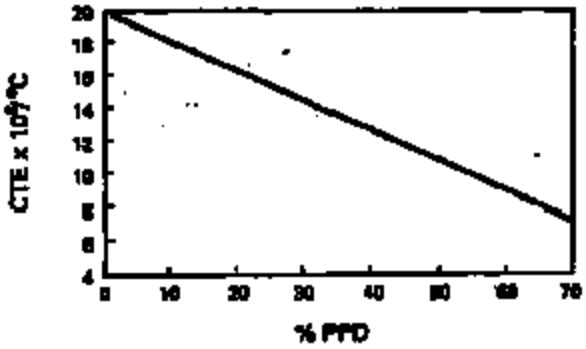


Fig. 2

Coefficients of Thermal Expansion Experimental Copolyimide Films



Typical Property Results

Selected typical properties of the goal level properties given in Table 1, are shown in Table 2. Table 3 provides additional properties of the two new films which are believed to be significant for both processability and for functionality. As indicated previously, Type-K is believed to be more functional than KAPTON Type-V for FPC roll to roll processing and for TAB, since it will provide greater stiffness at equivalent gage and even allow probable reduction in gage for many applications. The CTE match to copper is evident, and this too will afford greater utility without distortion in thermal excursions. The water absorption is actually higher that KAPTON, but when this fact is coupled with the surprising result that the film will expand and contract less than KAPTON during relative humidity changes (CHE), the trade-off appears to lean toward the Type-K. The caustic etchability of the film is actually more than KAPTON, whereas the electrical properties are about equivalent.

Film Type-E is a very high performance film that will serve the high technology demands of exceptional stiffness at thinner gages, and yet maintain a CTE match to copper. The lower water absorption will insure use of the film at high humidities in solder baths without blistering and the very low CHE will maintain excellent dimensional stability under a wide range of humidity conditions. Caustic etchability of the film will open its use to designers who wish to chemically mill holes in their circuits during processing. It will insure development and fabrication of two-conductor TAB with very high lead counts. Electrical properties are maintained to provide a very high level of circuitry performance.

Table 2

Typical Properties vs Goal Properties of Advanced Polyimide Substrates for FPC/TAB/Multilayer Flex Applications*

Property	Goal	Type-V	Type-K	Type-E
Shrink., 200°C, mils/in.	0.1	0.3	0.3	0.3
CTE, ppm/°C	17	38	17	17
Modulus, 23°C, Kpsi	750	400	650	800
H_2O Absorb., %	1.5	3.0	3.7	2.4
Etchable, OH^-	Yes	Yes	Yes	Yes

* All are 75mμ (3.0mil) films.

Table 3

Unique Properties of New Polyimide Films Types-K & E for FPC/TAB/Multilayer Flex Applications*

	Type-V	Type-K	Type-E
CHE, ppm/%RH	17	14	9
H_2O, Permeability, gm/m²/day	22	28	4
OXYGEN, Permeability, cc/m²/day	114	105	4

* All are 75mμ (3.0mil) films.

Additional typical properties are shown in Table 4 to gain a better perspective on the behavior of these films relative to KAPTON Type-V. Characterization is continuing and available results show the hydrolytic stability of the Type-E films, as measured by change in elongation after 1000 hours exposure to 85% RH and 85°C, to be essentially equivalent after the aging period and under the conditions imposed. Thermal durability testing indicates that the new films have the same order of thermal life as does conventional KAPTON Type-V. Retentions of greater than 10% elongation after 100,000 hours at 200°C in an air atmosphere are anticipated.

Table 4

Additional Properties of New Polyimide Films 3 Mil Types-K & E for FPC/TAB/Multilayer Flex Applications*

Property	Type-V	Type-K	Type-E
Tenacity, Kpsi	34	40	40
Elongation, %	80	80	40
Initial Tear (Graves), lb/mil	2.4	2.6	2.4
Propagating Tear (Elm.), gm/mil	12	17	6.5
Adhesion, pli	12	17	14
L-Color	33	34	49
Density, gm/cc	1.42	1.45	1.46
Diel. Str., v/mil	4500	5000	6000
Diel. Const.,			
100 Khz, 10% RH	3.1	3.1	3.2
100 Khz, 50% RH	3.5	3.6	3.4
Diss. Factor,			
100 Khz, 10% RH	0.0012	0.0022	0.0023
100 Khz, 50% RH	0.0065	0.0062	0.0064
Volume Resistivity, ohm-cm			
10% RH	3.6xE17	2.4xE17	3.1xE17
50% RH	1.8xE17	1.8xE17	1.3xE17
Surface Resistivity, ohm			
10% RH	9.3xE17	8.9xE17	13.0xE17
50% RH	0.1xE17	3.1xE17	1.3xE17

* All are 75μ (3.0mil) films.

Conclusions

New polyimide films based on different polymer backbones have been developed for use in FPC and TAB applications. KAPTON Type-K offers increased modulus, a thermal coefficient match with copper, low shrinkage, and chemical etchability for one and two sided circuits via roll cladding and three layer TAB applications of medium complexity. KAPTON Type-E offers the same advantages with a higher modulus and reduced water absorption and hygroscopic expansion for multilayer and fine line circuitry.

References

(1) Marketing Bulletin, "Flexible Circuitry", E.I. du Pont de Nemours & Co., Inc., Electronics Department, H-05332

(2) Marketing Bulletin, General Electric, Integrated Circuit Product Department, Electronic Components Division, March, 1971.

(3) T.J. Matuvich, "Microcircuit Interconnection Techniques and Applications", Am. Ceram. Soc. Bull. (USA), Vol.51, #4, 358 (1972).

(4) S.T. Holsinger, "TAB Types and Material Choices", EXPO SMT '88 Technical Proceedings, 247, (1988).

(5) S.T. Holsinger, "TAB: Mechanical, Chemical, and Thermal Considerations for Three Layer TAB Materials", EXPO SMT International '89 Technical Proceedings, 149, (1989).

(6) M. Mansinger, "Advantages of Polyimide Film in TAB Packaging", Surface Mount Technology, 61, October (1989).

(7) L.R. Williams, J.D. Young, and E.H. Schmidt, "Design and Development Engineering Handbook of Thermal Expansion Properties Aerospace Materials at Cryogenic and Elevated Temperatures", Rocketdyne Division Contract No. NAS-8-19, March 30, 1967.

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KAPTON® Polyimide Film
General Specifications
Bulletin GS-90-5

DuPont Electronics

High Performance Films

INTRODUCTION

The Electronics Department of the Du Pont Company manufactures and sells a variety of high quality plastic film products.

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

Any aspects of the specifications requiring further interpretation or clarification should be discussed with representatives of the Du Pont Electronics Department.

Types of Kapton Polyimide Film

Du Pont makes three types of "Kapton" polyimide film, Type HN, Type FN and Type VN.[1]

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'-diaminodiphenylether. "Kapton" HN is available in 30, 50, 100, 200, 300 and 500 gauges. Available by special request are other thicknesses such as 75 and 400 gauge.

Type FN Film

"Kapton" Type FN film is a heat sealable grade which retains the unique balance of properties that "Kapton" Type HN possesses over a wide temperature range. This is achieved by combining Type HN "Kapton" and Teflon® FEP fluorocarbon resin together in a composite structure. Listed below are those combinations commercially available at this time. Other combinations are available. Consult your Electronics Department marketing representative for further information.

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 30, 75, 100, 200, 300 and 500 gauges.

Certification

"Kapton" is certified to meet the requirements of the military specification MIL-P-46112 B (MR) in addition to the items covered by this specifications bulletin. Written confirmation is available with each delivery upon request.

	Construction (mils)		
Designation	FEP	HN	FEP
120FN616	0.10	1.00	0.10
100FN099		0.50	0.50
150FN999	0.50	0.50	0.50
150FN019		1.00	0.50
200FN919	0.50	1.00	0.50
200FN011		1.00	1.00
250FN029		2.00	0.50
300FN929	0.50	2.00	0.50
300FN021		2.00	1.00
400FN022		2.00	2.00
400FN031		3.00	1.00
500FN131	1.00	3.00	1.00
500FN051		5.00	1.00

[1] The specifications in this bulletin also apply to the alternative special versions of these standard types, Type A, Type V and Type F.

PROPERTIES OF TYPE HN FILM

Mechanical

Property	Property Value — Film Thickness (mils)						Method
	0.92	0.59	1.09	2.08	3.00	5.09	
Tensile Strength psi, at 23°C. Machine Direction (MD) and, Transverse Direction (TD). (Minimum)	16,000	20,000	24,000	24,000	24,000	24,000	ASTM D-882-81, Method A using an Instron Tensile Tester (specimen size: 1/2" x 8", jaw separation: 4", jaw speed: 2"/min.). Calculate the average of 5 specimens based on original measured thickness.
Elongation, % MD and TD (Minimum)	25	35	40	45	50	50	Same as above method.
Shrinkage, % MD and TD at 400°C (Maximum)	4.0	4.0*	3.5	2.5	2.0	2.0	MIL-P-46112E (MR). The percent shrinkage is obtained for either the MD or TD by using the average of three measurements in either direction before and after conditioning. Prior to measurement the 5-1/2"x11" specimen is conditioned by freely suspending for 2* hours in an oven controlled to 400° ± °C.
Moisture absorption, % (Maximum)	4.0	4.0	4.0	4.0	4.0	4.0	ASTM D-570-81, using 24 hour immersion at 23°C. Average of 3 specimens.

*1 hour for 30 & 50 gauge film.

Electrical

Property	Property Value — Film Thickness (mils)						Method
	0.92	0.59	1.09	2.08	3.00	5.09	
Dielectric Strength, AC volts/mil, (Minimum)	3,000	3,000	5,000	5,000	4,500	3,000	ASTM D-149-81. (Average of 10 specimens.) Flat sheets in air placed between 1/4" diameter brass electrodes with 1/32" edge radius subjected to 60 cycles AC voltage at 500 volts/sec. rate of rise to the breakdown voltage.
Volume Resistivity, ohm-cm at 200°C (Minimum)	10^{18}	10^{18}	10^{17}	10^{17}	10^{17}	10^{17}	ASTM D-257-78
Dielectric constant at 1 kHz (Maximum)	4.0	4.0	3.9	3.9	3.9	3.9	ASTM D-150-81. Use conducting silver paint electrodes, two terminal system of measurement at standard conditions. Results are based on an average of 5 tests using measured thickness of specimens.
Dissipation factor at 1 kHz (Maximum)	.0070	.0060	.0035	.0030	.0030	.0035	Same as above method.

Thermal Durability

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

Sheets of film 8-1/2" x 11" are freely suspended in an oven at 400°C. The temperature of the oven is monitored with a thermocouple to insure a temperature accuracy of ±2°C. Sheets are removed after 2 hours* and tested on an Instron Tensile Tester as described above under "Elongation." The elongation (at 23.5°C) of the film should not be less than 10% after this aging at 400°C. This conforms to the "Elongation after Aging at 400°C" test (paragraph 4.4.5) and "Elongation, percent, after 2 hour 400°C" requirement (Table 1) of MIL-P-46112 B (MR).

Underwriters Laboratories Inc. lists a thermal index of 200°C–220°C (depending on gauge and type) for mechanical properties and 220°C–240°C (depending on gauge and type) for electrical properties under their file no. E20505 for "Kapton" polyimide film.

PROPERTIES OF TYPE FN FILM

Heat Seal Strength

Film to Film Seals

The heat seal peel strength between the coated and uncoated side of one side coated "Kapton" polyimide film or the coated to coated side of one or two side coated "Kapton" is measured in the following manner: Seals are made in a jaw sealer at 360°C, 20 psi, 20 sec. dwell time. After cooling, the seals are cut to 1" wide strips using a Thwing-Albert JDC sample cutter or equivalent. The strength of the seal 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" polyimide film will be 600 gms./inch except for 120FN616 which will be 450 gms./in. The minimum peel strength between the coated and uncoated side of one side coated "Kapton" will be 450 gms./inch.

Film to Copper Seals for 120FN616 Film

The ability of 120FN616 film to adhere to copper is measured by using the same heat seal peel strength technique as described above.

The peel strength obtained when 120FN616 is sealed to the untreated side of 3/4 oz. GT copper foil (1 mil) will be a minimum of 250 gms./in.

As-Received Strength (Cold peel) of Bonds Between the Type HN "Kapton" and "Teflon" Layers.

The bond between the Type HN "Kapton" and Teflon® fluorocarbon resin layers on all type FN products except 120FN616 will have a minimum peel strength of 225 gms./in. as measured using an Instron type tensile tester and a 180° peel.

Dielectric Strength

Gauge Construction	Min. Breakdown (Volts/mil)	Test Method
120FN616	4900	Average of 10 samples tested per ASTM D-149-81. Flat sheets in air placed between 1/4" diameter brass electrodes with 1/32" edge radius subjected to 60 cycles AC voltage. Rise is 500 volts/sec. to the breakdown voltage.
100FN059	3900	
150FN999	3000	
150FN019	3500	
200FN919	3000	
200FN011	3000	
250FN029	2600	
300FN929	2500	
300FN021	2500	
400FN922	2000	
400FN031	2700	
600FN131	2200	
600FN051	2100	

*1 hour for 30 & 50 gauge film.

PROPERTIES OF TYPE VN FILM

Mechanical

Property	Property Value — Film Thickness (mils)						Method
	0.50	0.75	1.00	2.00	3.00	5.00	
Tensile Strength, psi, at 23°C, Machine Direction (MD) and Transverse Direction (TD) (Minimum)	20,000	20,000	24,000	24,000	24,000	24,000	ASTM D-882-81, Method A using an Instron Tensile Tester (specimen size: 1/2" x 8", jaw separation: 4", jaw speed: 2"/min.). Calculate the average of 5 specimens based on original measured thickness.
Elongation, % MD and TD (Minimum)	35	35	45	50	50	50	Same method as above.
Shrinkage, % MD and TD after 60 min. at 200°C (Maximum)	0.10	0.10	0.10	0.05	0.05	0.05	The percent shrinkage is obtained for either the MD or TD by using the average of three measurements in either direction before and after conditioning. Temperature exposure 200° ± 2°C for one hour. Measurements must be made at the same temperature and humidity conditions before and after conditioning. To assure sample/ambient equilibrium before and after conditioning, specimens should be exposed for three hours.
Moisture absorption, % Maximum	4.0	4.0	4.0	4.0	4.0	4.0	ASTM D-570-81, using 24 hour immersion at 23°C. Average of 3 specimens.

Electrical

Property	Property Value — Film Thickness (mils)						Method
	0.50	0.75	1.00	2.00	3.00	5.00	
Dielectric Strength, volts/mil, AC (Minimum)	3,000	3,000	6,000	5,000	4,000	3,000	ASTM D-149-81. (Average of 10 specimens.) Flat sheets in air placed between 1/4" diameter brass electrodes with 1/32" edge radius subjected to 60 cycles AC voltage at 500 volts/sec. rate of rise to the breakdown voltage.
Volume Resistivity, ohm-cm at 200°C. (Minimum)	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}	10^{15}	ASTM D-257-78
Dielectric constant at 1 kHz (Maximum)	3.5	3.5	3.5	3.5	3.5	3.5	ASTM D-150-81. Use conducting silver paint electrodes, two terminal system of measurement at standard conditions. Results are based on an average of 5 tests using measured thickness of specimens.
Dissipation factor at 1 kHz (Maximum)	0.0050	0.0050	.0038	.0036	.0036	.0036	Same method as above.

Thermal Durability

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

Sheets of film 8-1/2" x 11" are freely suspended in an oven at 400°C. The temperature of the oven is monitored with a thermocouple to insure a temperature accuracy of ±2°C. Sheets are removed after 2 hours and tested on an Instron Tensile Tester as described above under "Elongation." The elongation (at 23.5°C) of the film should not be less than 10% after this aging at 400°C. This conforms to the "Elongation after Aging at 400°C" test (paragraph 4.4.5) and "Elongation, percent, after 2 hour 400°C" requirement (Table 1) of MIL-P-46112 B(MR).

Underwriters Laboratories Inc. lists a thermal index of 200°C–220°C (depending on gauge and type) for mechanical properties and 220°C–240°C (depending on gauge and type) for electrical properties under their file no. E32505 for "Kapton" polyimide film.

GENERAL

Material

Type HN and Type VN Film—A polyimide polymer in the form of a film.

Type FN Film—A combination of "Kapton" polyimide film Type HN with Teflon® FEP fluorocarbon resin on one or both sides.

Uniformity

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

Cores

Cores shall be of sufficient strength to prevent collapsing on handling. Standard core I.D.'s are 3" and 6" with the following specifications: 3" I.D. is 3.032" ± 0.006", 6" I.D. is 6.020" ± 0.010". Core material will be plastic for 3" I.D. cores less than 5/8" wide. Core material will be fibre for 3" I.D. cores wider than 5/8" and 6" I.D. cores. A split 3" I.D. fibre core is standard for all universal rolls. Core width for universal wind is 2-3/4".

If these cores are not suitable, further information on other options may be obtained from your Electronics Department marketing representative.

Width Tolerances

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

Slit Width Range	Tolerance
7/8" or less Universal only	±7 mils
1" or less	± 15 mils
1-1/16"–4"	± 30 mils
4-1/16" or wider	± 60 mils

Type	Nominal Thickness Mils	Nominal Thickness µm	Width Range Min. in.	Width Range Max. in.	Pad Rolls (I.D. x O.D.) (in.) 3x6"	3x8-1/2	6x8-1/2	6x11	6x14	Universal Rolls (I.D. x O.D.) (in.) 3x6	3x8	3x12	Area Factor (ft²/lb)
30HN	0.3	8	3/16	60			•						410
50HN	0.5	13	3/16	62	•		•						272
100HN	1.0	25	3/16	60	•	•		•			•	•	136
200HN	2.0	50	3/16	60	•	•		•	•		•	•	66
300HN	3.0	75	3/16	60	•	•		•	•				45
500HN	5.0	125	3/16	60	•	•		•	•				27
50VN	0.5	13	7/8	62				•					272
75VN	0.75	18	7/8	60				•					181
100VN	1.0	25	7/8	60				•	•				135
200VN	2.0	50	7/8	60				•	•				68
300VN	3.0	75	7/8	60				•	•				45
500VN	5.0	125	7/8	60				•	•				27
100FN000	1.0	25	1/8	36	•					•			110
120FN010	1.2	30	1/8	36	•	•		•		•	•	•	104
150FN009	1.5	38	1/8	36	•					•			65
150FN019	1.5	38	2/8	36	•	•		•		•	•	•	77
200FN011	2.0	50	3/16	36	•	•					•		54
200FN019	2.0	50	3/16	36	•	•					•		54
250FN029	2.5	63	1/8	36	•	•					•	•	43
300FN021	3.0	75	3/16	36	•	•				•	•		39
300FN029	3.0	75	3/16	36	•	•				•	•		39
400FN022	4.0	100	3/16	36		•		•					27
400FN031	4.0	100	3/16	36		•		•					30
500FN131	5.0	125	3/16	36		•		•					23
600FN051	6.0	150	1/2	36		•		•					21

[1] 3"x6" pad roll is available in widths up to 7/8" only in 100HN, 200HN, 300HN, 500HN, 150FN019, 200FN011, 200FN019, 250FN029, 300FN021, 300FN029.
[2] O.D. Tolerance is ± 1/4" for pads and ± 1/2" for universal.
[3] Type HN, FN and VN films in pads are supplied in width increments of 1/16". Most films are supplied in width increments of 1/32" in widths 2/16" to 2".
[4] All universal rolls are available in 1/32" width increments with 7/8" minimum widths. The minimum width is 1/8" for 3" x 6" (I.D. x O.D.); the minimum width is 3/16" for 3" x 8", and 3" x 12" I.D. x O.D.

Roll Types

Kapton® film is supplied in two types of rolls, pad and universal wind. Available film widths and roll O.D.'s are specified below.

Specifications for pad rolls are:

1. Core width will be film width + 1/8", -0".
2. Core edges shall not project more than 1/16" beyond roll face on either side.
3. Core shall not be recessed on either side.
4. The outside and starting ends of the film shall be fastened in such a manner as to prevent unwinding.
5. "Dishing" or "cupping" may not exceed 1/16" measured with a straight edge across the diameter of the roll.

Specifications for the universal rolls are:

1. The difference between the length of projecting core on each side shall not exceed 3/16".
2. Film shall not project from the main body of the roll more than 1/8".
3. The outside and starting ends of the film shall be fastened in such a manner as to prevent unwinding.
4. Roll face depression, the difference between the highest and lowest points unstressed, shall not exceed 3/16".
5. Width of traverse is 1-3/4",-1/4", +1/8".

Splices

Description

Three types of splice are available.

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

Splices will be sufficiently smooth and wrinkle-free so as not to distort adjacent layers of film and approximately centered to ± 1/4".

Tape splices are standard on all gauges of "HN" and "VN" film and also on all gauges of "FN" film more than 12" wide.

Tape splices are made as follows. A butt splice with film ends covered on both sides of the film with splice tape. For films less than 0.005" thick a 1" wide pressure sensitive tape is used. For films 0.005" thick and greater a 2" wide pressure sensitive tape will be used.

Heat seal splices are made as follows. On all films but 250FN029 the splice is an overlap splice a minimum of 3/8" long. On 250FN029 a butt splice is made using 120FN616 as the joining tape applied on the FEP surface.

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

The 250FN029 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.

Maximum Splices per Slit Roll

The minimum average footage between splices for most rolls is shown in Table 1. To calculate the maximum number of splices in a roll divide the nominal feet per roll by the minimum average length between splices and subtract one.

Splice Placement

Table 1 shows the minimum length between splices and from the beginning and end of a roll, for most "Kapton" rolls. No splice is allowed, however, once a roll has reached the minimum O.D.

Table 1. Splice Data—Kapton® Polyimide Film

Core I.D. (in.)	Roll I.D. (in.)	Wind	Minimum Average Splice Free Length (Feet)																	
3 6	6 9-1/2	Pad	300	500	600	800	200	200	100	200	100	200	400	200	200	100	100	100	100	
3 6	9-1/2 11	Pad	—	—	600	1,000	400	200	200	400	300	300	375	200	300	300/200	200	100	100	
3	9 12	Universal	—	—	—	500	100	—	—	500	200	400	400	400	200	400/200	200	100	—	
			Minimum Length Between Splices or Beginning and End of a Roll (Feet)																	
3 6	6 9-1/2	Pad	—	100	100	100	100	100	—	100	100	100	100	100	100	100	100/75	75	—	
3 6	9-1/2 11	Pad	—	—	100	100	100	100	75	—	100	—	100	100	100	100	100/75	75	75	
3	6 12	Universal	—	—	—	100	100	100	75	100	100	100	100	100	100	—	—	—	—	

NOTES: [1] To 60" wide for 300H, 52" wide for 500H
[2] To 60" wide
[3] To 4" wide
[4] To 18" wide. For widths greater than 18" to the maximum, the minimum average footage will be one half that shown in the table.
[5] 1/2" to 7/8" wide

Average Thickness Tolerances (Unit Weight)

Test Method and Sampling Procedure
Weigh test specimens equal to the width of slit roll and not less than 1/2 meter long to the nearest 0.10 gram on a torsion balance.

To confirm average thickness tolerances, obtain a sample consisting of a minimum of one specimen from each of several randomly selected slit rolls as follows:

Slit Roll Width	Minimum Number of Slit Rolls to be Sampled
Under 6"	25 ÷ slit roll width (in.)
6" and Over	4

Type HN Film Thickness (mils)	Unit Weight (g/m²) Minimum	Maximum
0.30	7.8	14.0
0.50*	14.0	26.0
0.75*	21.8	32.8
1.00*	32.7	38.7
2.00*	66.8	77.9
3.00*	101.9	116.4
5.00*	169.5	192.5

* Applies to Type VN films also.

Type FN Film Gauge & Construction		
120FN018	41	58
100FN020	37	58
180FN030	61	85
180FN010	62	74
200FN018	77	104
200FN011	77	104
280FN020	87	113
300FN021	111	142
300FN029	111	142
400FN022	153	200
400FN031	148	178
500FN131	195	239
500FN051	211	259

Micrometer Thickness

Thickness tolerances are based on a statistical analysis of routine process control data.

Test Method
Make the following measurements to confirm that film from a single slit roll meets the micrometer tolerances:

1. Measure in accordance with ASTM-D-374-79, Method A or C.
2. Obtain the average of 10 randomly selected readings from a minimum area of 12 square inches. Recheck before rejecting any slit roll. Abnormal readings may occasionally result from dust particles or spot surface imperfections. Discard such readings as they will adversely affect the accuracy of measurements designated to indicate general sheet thickness.

Type HN Gauge	Nominal Thickness (mils)	Thickness Tolerances (mils) Minimum	Maximum
30	0.30	0.24	0.36
50*	0.50	0.38	0.65
75*	0.75	0.60	0.90
100*	1.00	0.85	1.15
200*	2.00	1.75	2.25
300*	3.00	2.72	3.28
500*	5.00	4.65	5.35

*Applies to Type VN films also.

Type FN Gauge	Nominal Thickness (mils)	Thickness Tolerances (mils) Minimum	Maximum
120FN018	1.20	1.10	1.40
100FN020	1.00	0.75	1.25
180FN030	1.50	1.25	1.60
180FN010	1.80	1.25	1.75
200FN018	2.00	1.75	2.30
200FN011	2.00	1.75	2.30
280FN020	2.50	2.35	2.65
300FN021	3.00	2.60	3.40
300FN029	3.00	2.60	3.40
400FN022	4.00	3.60	4.40
400FN031	4.00	3.60	4.40
500FN131	5.00	4.60	5.60
500FN051	5.00	5.40	6.60

Gauge Depression

To reduce web handling difficulties which would occur if film representing thickness extremes were shipped in the same roll, a gauge depression standard is applied.

Roll depression is the difference in diameter between the hardest and softest part of the roll or the difference between the undepressed and depressed (finger pressure) diameter at the softest part, whichever is greater.

Table 2 lists the maximum allowable depression for most pad rolls. There is no gauge depression standard for universal wind since that roll is limited to a maximum of 7/8" wide.

Table 2. Kapton® Polyimide Film Gauge Depression Standards—Pad Rolls

Pad-Up		Maximum allowable depression in 1/32" increments												
		Roll Width (in.)												
I.D. (in.)	O.D. (in.)	1/2–1	1-1/16–1-3/4	1-7/8–2-1/2	2-5/8–3	3-1/32–3-1/2	3-13/16–4-1/2	4-15/16–5-1/2	5-17/32–6	6-1/16–6-1/2	6-5/8–7	7-1/32–7-1/2	7-5/32–7-1/2	7-5/8 & Wider
3	6	3	3	3	5	5	6	7	7	7	7	8	9	9
6	8-1/2													
3	8-1/2	6	7	8	9	9	9	9	11	11	13	13	13	15
6	11													
3	13	–	9	9	9	11	11	13	13	15	15	15	17	17
6	14													

PACKAGING AND MARKING

Packaging

Kapton® 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 follows to allow complete traceability back to the raw materials and processing conditions:

	Shipping Container	Package	Core Label[a]
1. Scheduled Date	X	X	X
2. Customer Order Number	X	X	X[c]
3. Du Pont Order Number	X	X	X
4. Gauge	X	X	X
5. Type	X	X	X
6. Width	X	X	X
7. No. of Rolls per Container	X	X	
8. Net Weight	X	X	
9. Footage			X
10. Mill Roll Number	X	X	X
11. I.D. and O.D.[b]	X	X	

[a] Affixed to the core on all cores, 2-1/4" wide and over. Included with the package on all cores less than 2-1/4" wide.
[b] Inside diameter of core and nominal outside diameter of roll.
[c] Available for up to 12 characters.

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Kapton
POLYIMIDE FILM

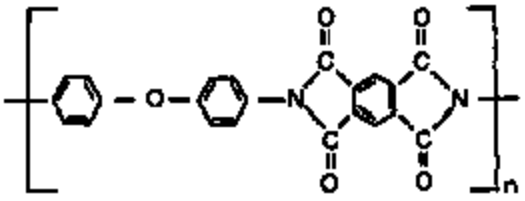
safe handling

Industrial Films Division

SAFETY IN HANDLING AND USE

Introduction

KAPTON polyimide film is a strong, tough, transparent amber-colored plastic film exhibiting excellent physical, chemical and electrical properties over an extremely wide temperature range. It has the structure:



KAPTON is produced in three forms, Type H, Type V, and Type F. Type H is the basic uncoated polyimide film. Type V is similar to Type H but has superior dimensional stability. Type F is coated on one or both sides with Teflon® FEP fluorocarbon resin which imparts heat sealability, provides a moisture barrier, and enhances chemical resistance.

KAPTON is used as insulation for wire and cable, formed coils, magnet wire and transformers, and motor slot liners, among other uses. It also is used as a substrate for flexible printed circuits.

This booklet provides guidelines for the safe handling of KAPTON during processing, use, and disposal.

Users of Type F KAPTON should also refer to DuPont bulletin "Teflon® Fluorocarbon Resins — Safety in Handling and Use."

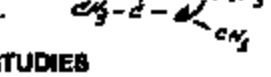
I. GENERAL PROPERTIES

KAPTON Type H and Type V, exhibits no melting point or softening point. A one-mil thick film has a zero-strength temperature of 815°C (1500°F). Zero-strength is measured as the maximum temperature at which the film will sustain a load of 138 KPa (20 psi) for 5 seconds.

KAPTON is insoluble in most common organic solvents after immersion for up to a year (Ref. 1). The hydrolytic stability of KAPTON Type H has been measured after 166 days exposure to boiling water. The film retained 66% of its tensile properties and 20% of its elongation. KAPTON is dissolved by strong acids (Ref. 2, 3) such as fuming nitric and concentrated sulfuric acid, particularly on heating, and is hydrolyzed by alkali and super-heated steam.

KAPTON Type F exhibits better chemical, hydrolytic, and oxidative resistance than Types H and V.

KAPTON may contain up to 1% by weight of dimethyl acetamide residual solvent. At elevated temperatures, some of the solvent may be released and must be removed by exhaust ventilation or diluted to safe levels. OSHA (29 CRF 1910.1000) has established the safe level for dimethyl acetamide as ten parts per million.



II. PYROLYSIS STUDIES

Studies (Ref. 4, 5) have shown the outstanding thermal stability of polyimide film. Its rate of degradation is dependent upon the availability of oxygen. In air at about 500°C (932°F) KAPTON decomposes and completely disappears after twelve hours. At 450°C in air, carbon monoxide may be formed in significant amounts. In a vacuum or inert atmosphere, 60 to 65% of the film remains after prolonged aging at 1000°C (1832°F). The residue retains its original shape but has lost its mechanical strength. The major off-gases are carbon dioxide and carbon monoxide. (See chart)

*Reg. U.S. Pat. & T.M. Off.

Kapton®
POLYIMIDE FILM

ADHESION TO KAPTON®

KAPTON® polyimide film, made only by Du Pont, is available in three basic film types. Type H KAPTON is 100% polyimide film. Type F is coated on one or both sides with a TEFLON® FEP fluorocarbon adhesive and Type V is a plain polyimide film having superior dimensional stability properties. Typical property information for KAPTON is found in Bulletin E-72087, "Summary of Properties." Specifications are found in Bulletin E-67624, "Industry Specifications Bulletin FC-65-2." For flexible printed circuit applications the trade specification IPC-FC-231/Sheet 1, applies to KAPTON.

ADHESIVE SELECTION

For some applications KAPTON must be bonded to other materials, such as copper foil, which requires the use of an adhesive. Optimum adhesion results are usually obtained from commercially coated KAPTON which is available from a variety of suppliers such as those listed in Bulletin E-72091, "Suppliers of Adhesive Coatings on KAPTON." This listing represents most of those companies offering coated KAPTON but should not be regarded as a complete listing. Detailed information on the use of these adhesive coated products can be obtained from the supplier's bulletins. Specific requirements for copper laminates produced as substrates for flexible printed circuits are outlined in trade specifications:

- USA: IPC-FC-241
- British: BS-4584
- German: DIN-40802

When commercially coated film is not suitable for an application, most vendors offer a dry film form of their adhesives for use as a bonding film in laminations. However, better adhesion is normally obtained from commercial solution coatings than from the dry bonding film. The dry film adhesive does have the advantage that it can be cut to shapes which cover only that portion of the polyimide film where adhesion is desired.

If neither commercially coated polyimide film nor adhesive bonding film is suitable for the application, the remaining option is for the user to apply a solution adhesive. Some generic classes of adhesives which bond KAPTON include acrylics, epoxies, butyral-phenolics, polyesters, silicones, urethanes, fluorocarbons and blends of these materials.

Selection of an adhesive is usually dependent on the properties required of the adhesive and the demands of the application. Property considerations are the thermal rating, chemical resistance, fill and flow characteristics, flexibility, peel strength, flammability, moisture resistance and insulation resistance. Also to be considered is the ease of processing, lamination temperature and whether the lamination is to be made in continuous roll equipment or in a platen press.

ADHESIVE PROPERTIES

Adhesives used with KAPTON Type H are usually a modified version of the generic adhesive family (e.g., modified-epoxy). These formulations are proprietary to the suppliers of coated KAPTON and require specific processing conditions to achieve the maximum bond strength. Always use the supplier's recommended lamination conditions for the specific adhesive you select.

Listed in Table I are several adhesive types along with information on typical lamination temperatures and maximum operating temperatures (short term exposure). When using an epoxy adhesive, anhydride curing agents are preferred. If an amine curing agent must be used, avoid an excess of curing agent as the free alkaline materials can degrade the polyimide.

TABLE 1

Adhesive Types	Lamination Temperatures °F (°C)	Maximum Operating Temperature °F (°C)
Fluorocarbons	550-600 (290-315)	to 500 (260)
Polyimides	500-700 (260-370)	to 650 (345)
Epoxies	73-450 (23-230)	to 600 (315)
Pressure Sensitive Silicones	73-300 (23-150)	to 500 (260)
Rubber-Phenolics	300-400 (150-205)	to 500 (260)
Acrylics	350-375 (175-190)	to 550 (290)
Polyesters	275-300 (135-150)	to 220 (105)

Solution forms of most of the adhesives above are available from suppliers of adhesives to the electronics industry. Listings of suppliers can be found in buyer's guides for electronic products. Bulletin E-74149, "Suppliers of Adhesives to the Electronics Industry," provides a representative listing of adhesive suppliers who can be consulted with for specific adhesive needs.

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III. FLAMMABILITY

Lewis and Stabler (Ref. 6) report the flammability characteristics of polyimide film as "self-extinguishing." KAPTON has a 94 VTM-O rating, the highest given in the U.L. 94 vertical burning test for thin films. The oxygen index is 37% for 100 H film (ASTM 2863).

IV. HANDLING PRACTICES

Safe handling of Type H and V KAPTON polyimide films at high temperatures requires adequate ventilation. If small quantities of KAPTON are involved, as is often the case, normal air circulation will be all that is needed in case of overheating. Whether or not existing ventilation is adequate at higher temperatures will depend on the combined factors of film quantity, temperature, and exposure time. For additional information on the Teflon® FEP coatings used on Type F KAPTON, refer to the booklet — "Teflon® Fluorocarbon Resins — Safety in Handling and Use."

A. Soldering and Hot Wire Stripping

Major uses for all types of KAPTON include electrical insulation for wire and cable and other electronic equipment. In virtually all of these applications, soldering is a routine fabricating procedure as is the use of a heated element to remove insulation. Soldering operations rarely produce sufficient off-gases to be of toxicological significance.

Ventilation practices should follow the same common sense rules applicable to any soldering procedure. Normal ventilation provided for worker comfort usually provides adequate safety. During hot-wire stripping, it is recommended that exhaust ducts be used at the workbench.

There have been no reports of ill effects during soldering or hot-wire stripping of wire and cable insulated with KAPTON.

B. Welding and Flame Cutting

Direct application of welding arcs and torches can quickly destroy most plastics, including all types of KAPTON film. For practical reasons, therefore, it is best to remove all such parts from equipment to be welded. Where removal is not possible, such as in welding or cutting coated parts, mechanical ventilation should be provided.

Because KAPTON is rated for use at very high temperatures, parts made from it may survive at locations close to the point of direct flame contact. Thus some in-place welding operations can be done. Since the quantity of film heated is usually relatively small (less than one pound), ventilation requirements seldom exceed those for normal welding work. Because of the possibility of inadvertent overheating, however, the use of a small fan or elephant-trunk exhaust is advisable.

C. Scrap Disposal

Disposal of scrap KAPTON polyimide films presents no special problem to the user. Small amounts of scrap may be incinerated along with general plant refuse. The incinerator should have sufficient draft to exhaust all combustion products to the stack. Care should be taken to avoid breathing smoke and fumes from any fire. Because KAPTON is so difficult to burn, it is often best to dispose of scrap film in a landfill. KAPTON can be expected to be stable in landfills.

D. Fire Hazards

Whether in storage or use, KAPTON is unlikely to add appreciably to the hazards of fire. Bulk quantities of KAPTON (over 100 pounds) should be stored away from flammable materials.

In the event of fire, personnel entering the area should use a fresh air supply or a respirator. This type of equipment is standard in fighting many types of fire. All types of chemical extinguishers may be used to fight fires involving KAPTON. Large quantities of water also may be used to cool and extinguish a fire.

E. Static Electricity

The processing of KAPTON polyimide film can cause the generation of a strong static charge. Unless this charge is bled off as it forms through the use of ionizing radiation or metal tinsel, it can build to many thousands of volts and discharge to people or to metal equipment. In dust or solvent-laden air, a flash fire or explosion could result. Precautions for static charges should also be taken when removing plastic films used as protective packaging for KAPTON.

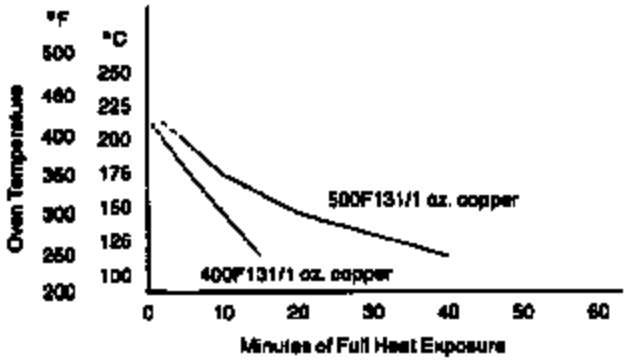
REFERENCES

1. J. T. Milek, "Polyimide Plastics: A State-of-the-Art-Report," Electronic Properties Information Center, S-8, October 1, 1965, Air Force Systems Command, Contract AF33 (615)-2480, Proj. 7361: Task 738103.

2. C. E. Sroog, A. L. Endrey, S. V. Abrams, C. E. Berr, W. M. Edwards, and K. L. Oliver, J. Poly. Sci. A-3(4), 1373-90 (1965).

Given in Figure 3 are minimum times to dry laminates of Type F to copper prior to dip soldering. The times are different than in Figure 2 due to the presence of the copper foil.

FIGURE 3
DRYING CONDITIONS FOR KAPTON TYPE F LAMINATES PRIOR TO DIP SOLDERING



SOLDERING AND PRESS CONDITIONS FOR TYPE H LAMINATES

The recommended predrying conditions prior to dip soldering and platen pressing laminates based on type H film will vary according to type of thermoset adhesive used in addition to factors mentioned for Type F laminates. The moisture retention and permeability of the film and adhesive must be considered along with the impermeability of the copper foil layers. Consult your laminate supplier for recommended predrying conditions specific to the combination of materials supplied.

EFFECTS OF HUMIDITY ON PEEL STRENGTH

Humidity can have a large effect on peel strength with certain adhesive systems, and RH ought to be controlled in peel strength measurements. A summary of our investigation into this phenomenon is given in Table III. Results show that those adhesives having functional groups capable of absorbing water vapor will promote high peel strengths at high RH and low peel strengths at low RH. Between an RH of 10% and an RH of 70%, the effect can be as large as 8 lbs. per lineal inch (10.5 N/cm). Those adhesives which do not have hygroscopic functional groups are not affected by RH changes in terms of peel values.

TABLE III
EFFECTS OF RELATIVE HUMIDITY ON PEEL STRENGTH

	Peel Strength, lb./in. (N/cm)	
Adhesive Type	10% RH	70% RH
Acrylic	5.8 (10.2)	11.5 (20.1)
Epoxy-Amide	5.4 (9.5)	10.0 (17.5)
Epoxy-Novolac	2.0 (3.5)	2.1 (3.7)
Phenolic-Butyral	3.8 (6.7)	5.2 (9.1)
Phenolic-Nitrile	4.7 (8.2)	4.3 (7.5)

EFFECT OF SURFACE ON PEEL STRENGTH

The top surface of KAPTON is referred to as the "bright" or "shiny" side. The bottom side is "dull" and purposely roughened in the manufacture of the film to improve film handling characteristics. Most adhesives bond better to the dull side of the film. The affect is generally 1-2 lbs. per lineal inch (1.8-3.5 N/cm) but can be as high as 4 lbs. per inch (7.0 N/cm) or negligible depending on the adhesive system used.

Experience has also shown that peel strength normally increases with the thickness of the film. Within a laminate based on a given film thickness, a range of peel strengths can also be expected, which is inherent in the film surface, the adhesive system and the test method applied. For example, a typical peel strength range for an acrylic adhesive is 8 lbs./in. (10.5 N/cm). For 100H this range can result in values as low as 2 lbs./in. (3.5 N/cm).

Unless specifically recommended by the adhesive supplier, the surface of KAPTON should be used as received. If the film has been contaminated with grease or oils, it should be cleaned with solvent (such as methylethyl ketone or toluene). Metal surfaces should be thoroughly cleaned. For best adhesion, they should be roughened mechanically or by chemical treatment.

When higher adhesion levels are required for a given adhesive system, the range of the peel strength values for the laminate may usually be reduced if the surface of the film is mechanically or chemically abraded, light pumice scrubbing or caustic etching. Caution must be exercised with any such treatment to avoid damaging the film.

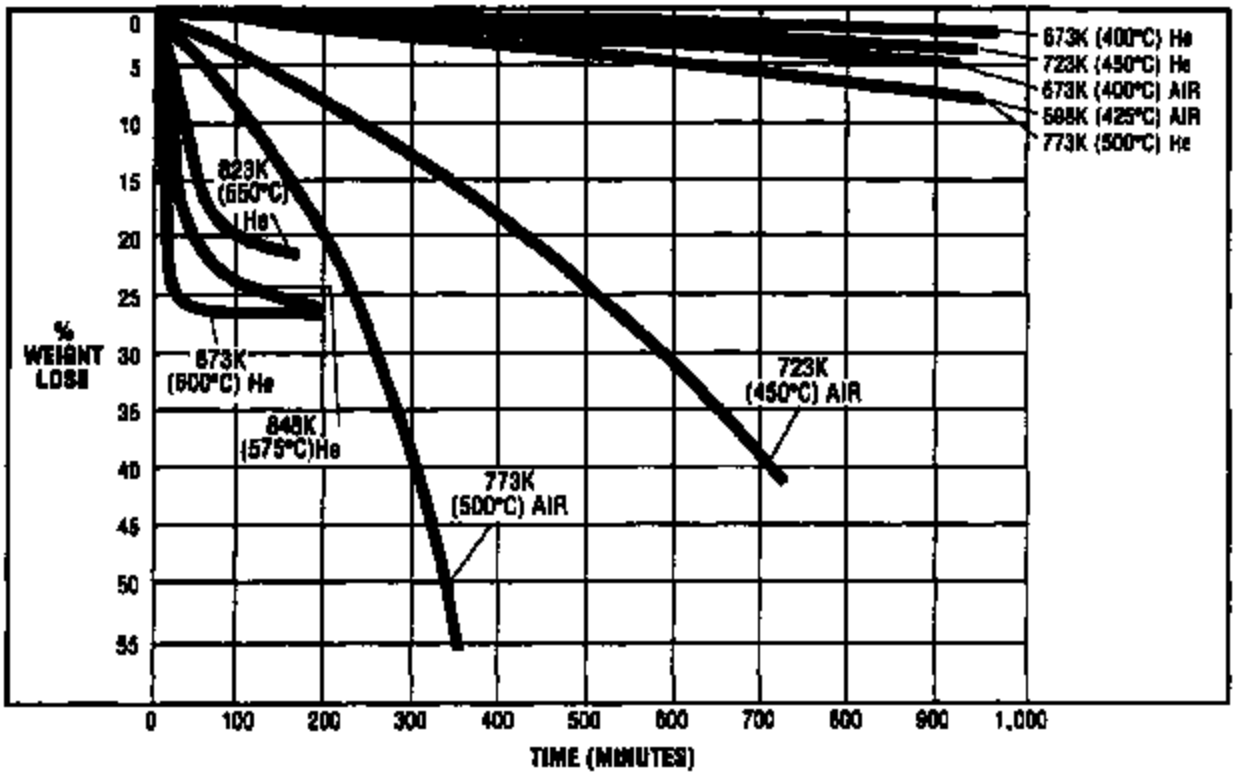
EFFECT OF THERMAL TREATMENT ON PEEL STRENGTH

High thermal treatment of KAPTON will often improve bondability. Temperatures of about 400°C for as long as 5-10 minutes are required, and structural changes probably occur.

Studies of adherability of typical printed circuit adhesives to heat treated KAPTON and standard KAPTON have shown that heat treatment provides an advantage with most adhesives. The greatest advantage was gained with acrylic, epoxy, phenolic butyrals and phenolic nitriles. Improvement over standard film averaged from 40% to 97% for these adhesive types.

ISOTHERMAL WEIGHT LOSS

(Type H Film 25 μm (1 mil))



3. N. A. Androva, M. I. Bessonov, L. A. Laius, and A. P. Rudakov, "Polyimides — A New Class of Thermally Stable Polymers," Progress in Matls. Sci. Series, Vol. VII, Technomic Publ. Co., Stamford, Conn., 1970, p. 79-85.

4. 1968 Listing of Plastic Materials, etc., P. 10, March 1968, National Sanitation Foundation.

5. General Electric Co. Res. Lab., Research of Dielectric Materials, Rept. #ML-TDR-64-57, May 1964, DDC AD-602 436, NASA N64-26909.

6. R. F. Stabler and L. L. Lewis, "KAPTON Polyimide Film — A New Insulation for Aerospace Wire and Cable," Paper presented at Soc. of Aerospace Materials and Process Engineers Meeting, San Francisco, May 26, 1965.

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Technical Bulletin

Suppliers of Adhesives to the Electronics Industry

DuPont Electronics

High Performance Substrates and Materials

September 1989

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Du Pont Electronics

DU PONT

MATERIAL SAFETY DATA SHEET

IDENTIFICATION

NAME
HFC-134a

FORMULA
CH_2FCF_3

MANUFACTURER/DISTRIBUTOR
E. I. du Pont de Nemours & Co. (Inc.)

ADDRESS
Wilmington, DE 19898

CHEMICAL FAMILY
Halogenated Hydrocarbon

TSCA INVENTORY STATUS
Reported/Included

PRODUCT INFORMATION PHONE
(800) 441-9450

MEDICAL EMERGENCY PHONE
(800) 441-3637

TRANSPORTATION PHONE
CHEMTREC (800) 424-9300

PHYSICAL DATA

BOILING POINT
-26.5°C (-14.5°F) @ 736 mmHg

LIQUID DENSITY
1.21 g/cc @ 25°C (77°F)

VAPOR DENSITY (AIR = 1)
3.18

FORM
Liquefied Gas

COLOR
Colorless

PERCENT VOLATILE BY VOLUME
100

VAPOR PRESSURE
96 psig @ 25°C (77°F)

SOLUBILITY IN WATER
0.15% by wt at 25°C (77°F) & 14.7 psia

APPEARANCE
Clear

ODOR
Slight Ethereal

HAZARDOUS COMPONENTS

MATERIAL(S)	CAS NO.	APPROXIMATE %
Ethane,1,1,1,2-Tetrafluoro	811-97-2	100

HAZARDOUS REACTIVITY

STABILITY
Material is stable. However, avoid open flames and high temperatures.

INCOMPATIBILITY
Alkali or Alkaline earth metals—powdered Al, Zn, Be, etc.

DECOMPOSITION
HFC-134a can be decomposed by high temperatures (open flames, glowing metal surfaces, etc.) forming hydrofluoric acid—possibly carbonyl fluoride.

POLYMERIZATION
Will not occur.

FIRE AND EXPLOSION DATA

FLASH POINT
Will not burn. **METHOD** TOC

FLAMMABLE LIMITS IN AIR, % BY VOL.
LOWER Not applicable.
UPPER Not applicable.

AUTOIGNITION TEMPERATURE
Not determined.

FIRE AND EXPLOSION HAZARDS
Cylinders may rupture under fire conditions. Decomposition may occur.

EXTINGUISHING MEDIA
As appropriate for combustibles in area.

SPECIAL FIRE FIGHTING INSTRUCTIONS
Cool cylinders with water spray. Self-contained breathing apparatus (SCBA) may be required if cylinders rupture or release under fire conditions.

HEALTH HAZARD INFORMATION

PRINCIPAL HEALTH HAZARDS

Inhalation of high concentrations of vapor is harmful and may cause heart irregularities, unconsciousness or death. Intentional misuse can be fatal. Vapor reduces oxygen available for breathing and is heavier than air. Liquid contact can cause frostbite

Inhalation 4 Hour ALC: 567,000 ppm in rats

The compound is untested for skin and eye irritancy and is untested for animal sensitization.

Acute Toxicity in Animals
The effects in animals from short exposure by inhalation include no toxic effects observed at vapor concentrations up to 81,000 ppm. Lethargy and rapid respiration were observed at a vapor concentration of 205,000 ppm.

Pulmonary congestion, edema, and central nervous system effects occurred at a vapor concentration of 750,000 ppm. Cardiac sensitization occurred in dogs at 75,000 ppm from the action of exogenous epinephrine.

Subchronic Toxicity in Animals
Inhalation: The effects in animals from exposure by inhalation for two weeks include no observable adverse effects. Ingestion: No adverse effects were observed in male and female rats administered 300 mg/kg/day of HFC-134a for 52 weeks.

No acceptable information is available to confidently predict the effects of excessive human exposure to this compound.

CARCINOGENICITY
HFC-134a is not listed as a carcinogen by IARC, NTP, OSHA, ACGIH, or Du Pont.

EXPOSURE LIMITS

PEL (OSHA): Not established.
TLV* (ACGIH): Not established.

SAFETY PRECAUTIONS
Avoid breathing vapor and liquid contact with skin or eyes. Provide adequate ventilation for storage, handling, and use, especially for enclosed and low spaces.

*TLV is a registered trademark of the American Conference of Governmental Industrial Hygienists.

HEALTH HAZARD INFORMATION (con't)

FIRST AID

IF HIGH CONCENTRATIONS ARE INHALED: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

IN CASE OF EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

IN CASE OF SKIN CONTACT: Flush skin with water after excessive contact. Wash contaminated clothing before reuse. Treat for frostbite if necessary.

IF SWALLOWED: Ingestion is not considered a potential route of exposure.

NOTE TO PHYSICIANS

Because of possible disturbances of cardiac rhythm, catecholamine drugs, such as epinephrine, should be considered only as a last resort in life-threatening emergencies.

PROTECTION INFORMATION

GENERALLY APPLICABLE CONTROL MEASURES

Normal ventilation for standard manufacturing procedures is generally adequate. Local exhaust should be used when large amounts are released. Mechanical ventilation should be used in low places.

PERSONAL PROTECTIVE EQUIPMENT

Lined butyl gloves and chemical splash goggles should be used when handling liquid. Under normal manufacturing conditions, no respiratory protection is required when using this product. Self-contained breathing apparatus (SCBA) is required if a large release occurs.

DISPOSAL INFORMATION

SPILL, LEAK OR RELEASE

Ventilate area—especially low places where heavy vapors might collect. Remove open flames. Use self-contained breathing apparatus (SCBA) if large spill or leak occurs.

WASTE DISPOSAL

Contaminated HFC-134a can be recovered by distillation or removed to a permitted waste disposal facility. Comply with Federal, State, and local regulations.

SHIPPING INFORMATION

DOT (172.101)

PROPER SHIPPING NAME
Refrigerant Gas, N.O.S.
(Tetrafluoroethane)

HAZARD CLASS
Nonflammable gas

UN NO.
1078

DOT/IMO (172.102)

PROPER SHIPPING NAME
Refrigerant Gas, N.O.S.
(Tetrafluoroethane)

HAZARD CLASS
Nonflammable gas, 2.2

UN NO.
1078

IMO LABEL
Nonflammable gas

OTHER INFORMATION

SHIPPING CONTAINERS
Cylinders, ton tanks, tank cars and tank trucks

STORAGE CONDITIONS
Clean, dry area. Do not heat above 125°F.

ADDITIONAL INFORMATION AND REFERENCES

NFCA - HMIS RATINGS

Health	1
Flammability	0
Reactivity	1
Personal Protection	-

Personal Protection rating to be supplied by user depending on use conditions.

DATE OF LATEST REVISION/REVIEW: 4/88

PERSON RESPONSIBLE FOR MSDS:
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Du Pont Co.
C&P Dept., Chestnut Run-709
Wilmington, DE 19898
(302) 999-3018

138337A