aptiv®

VICTREX® PEEK FILM TECHNOLOGY

APTIV® 1000 Series Films for Electrical Insulation

Description

APTIV® 1000 series films are made from VICTREX® PEEK polymer in an unfilled semi-crystalline format over a wide range of thicknesses. These films provide a high performance electrical insulation solution for applications involving extreme environmental conditions, often beyond the capabilities of conventional polymeric insulation products.

Film thicknesses range from 8µm to 750µm, allowing APTIV film to be used for a broad range of wrapped wire, interlayer insulation and general electrical insulation applications. Such applications may include: transformer magnet wire insulation, motor diamond wire primary insulation, slot liners and other electrical insulation applications for nuclear, mass transport, mining, semiconductor electronics, circuit board manufacturing and petrochemical industries.

Compared with polyimide electrical insulation films such as Kapton® HN, FN and CR films, APTIV film offers better tear resistance, better chemical resistance, better barrier performance against oxygen and water vapour, lower moisture absorption and substantially improved resistance to hydrolysis and so is more readily suited to hot and humid environments.

APTIV Film	Kapton Film
▲ Readily available	▲ Absorbs more moisture which can adversely effect electrical and mechanical properties
▲ Low moisture absorption	▲ Lower tear strength than VICTREX PEEK polymer
▲ Tough and strong even at high temperatures	▲ Not thermoformable
▲ Can be thermoformed	▲ Can be prone to pin-holing
▲ Lower shrinkage/good dimensional stability	▲ Attacked by strong acids, alkalis and high pressure steam and hot water
▲ VICTREX PEEK polymer has better chemical resistance	
▲ Wear and abrasion resistance	



The principal benefits of APTIV film compared with other common electrical insulation materials are: mechanical properties, thermal performance and chemical and hydrolysis resistance.

APTIV 1000 film has a unique combination of properties providing a thinner, lighter weight, or space saving solution to difficult electrical insulation problems over a wide range of end use conditions.

Specific features of APTIV film include:

- ▲ Stable excellent electrical insulation properties
- ▲ Corona resistance
- ▲ Minimal added weight and insulation thickness
- ▲ High heat resistance
- ▲ Excellent thermal conductivity
- ▲ Excellent hydrolysis resistance
- ▲ Low moisture absorption
- ▲ Broad chemical resistance
- ▲ Radiation resistance
- ▲ Excellent barrier properties to gases and water vapor
- ▲ Excellent tribological properties
- ▲ High strength and toughness
- ▲ Good flammability performance without the use of flame retardants
- ▲ Inherently halogen-free
- ▲ Low smoke and toxic gas emissions
- ▲ High purity
- ▲ Recyclable
- ▲ Can be melt-processed (PEEK polymer is a thermoplastic)
- ▲ Can be heat laminated to other polymer films, metal foils and ceramic (mica)

Thermal Properties

Table 1 illustrates the excellent thermal properties of APTIV PEEK polymer film, including high thermal conductivity and melting point. The continuous use temperature is ≥200°C for mechanical and electrical applications, as independently verified by Underwriter Laboratories.

Table 1: Typical Thermal Properties of APTIV 1000-025 Film (25µm film) vs. Kapton® HN Film

Thermal	Units	Test Method	Typical APTIV Film @ 23°C	Kapton HN Film*
Thermal Conductivity	W/(m.K)	ASTM E1461	0.250	0.12
Thermal Diffusivity	mm2/s	ASTM E1461	0.189	
Specific Heat	J/(g.K)	ASTM E1461	1.191	1.09
Flammability		UL94	HB	V0
Shrinkage at 200°C	%	Victrex Test Method	<2	0.17 (150°C)
Melting Point	°C	DSC	343	None
Glass Transition Temperature	°C	DSC	143	>360
Continuous Use Temp. (Mechanical w/o Impact)	°C	UL 746B	≥200	200

*Data from DuPont Kapton HN polyimide film data sheet. Some test methods vary.

APTIV film has excellent resistance to thermal degradation as shown in Figure 1 which illustrates the breakdown voltage for 25µm thick APTIV film as a function of ageing time at 300°C (method ISO 2578). These results show that even under these extreme ageing conditions there is no degradation in the electrical performance of APTIV film.

Figure 1: Voltage Breakdown of APTIV Film as a Function of Ageing Time at 300°C in Air

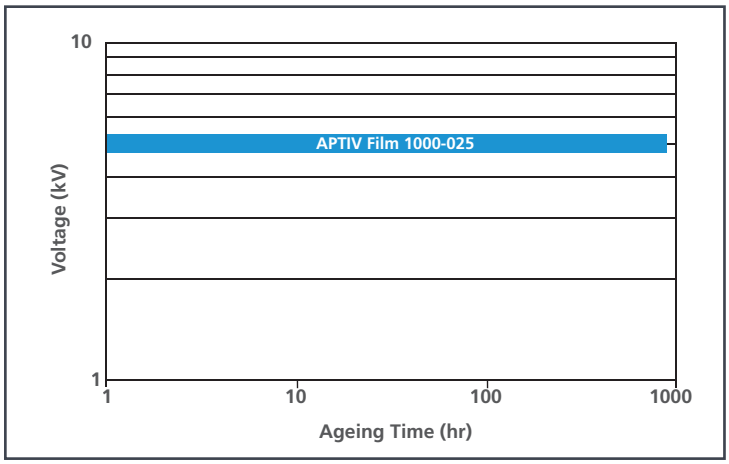


Table 2 illustrates some typical properties of APTIV film.

Table 2: Typical Properties of APTIV 1000-025 Film (25µm film) vs. Kapton® HN Film

Property	Units	Test Method	APTIV 1000-025Film	Kapton HN Film*
Specific Gravity	g/cc	ISO 1183	1.30	1.42
Tensile Strength (at Break) at 23°C at 200°C	MPa	ISO 527	 120 77	 231 139
Elongation (at Break) at 23°C at 200°C	%	ISO 527	 220 274	 72 83
Tensile Modulus at 23°C at 200°C	GPa	ISO 527	 2.8 0.1	 2.5 2.0
Yield Stress at 3% Elongation at 23°C at 200°C	MPa	ISO 527	 73 3.3	 69 41
Stress to Produce 5% Elongation at 23°C at 200°C	MPa	ISO 527	 89 6.5	 90 61
Puncture Resistance	kJ/m²	Def Stan 81-75	26	18⁺
Tear Strength	N/mm	ISO 6383-1	6.7	3.0⁺
Coefficient of Friction, Dynamic (film to film)		ASTM D1894	0.41	0.48
Coefficient of Friction, Static (film to film)		ASTM D1894	0.40	0.63
Taber Abrasion Resistance	mg/1000 Cycles	ASTM D1044	6	
MIT Fold Endurance	Cycles	ASTM D2176-89	>2,000,000	285,000

*Data from DuPont Kapton HN polyimide film data sheet. Some test methods vary.
⁺ Victrex test results on Kapton film.



Electrical Properties

Table 3 shows the electrical properties of APTIV film, confirming it as an excellent material for electrical insulation applications including wire wrap and interlayer insulation. As with all polymers, these values will vary with film thickness, temperature and voltage frequency. In common with best engineering practice, specific material performance should, therefore, be tested by the responsible authority on a case-by-case basis.

Table 3: Typical Electrical Properties of APTIV 1000-025 Film (25µm film) vs. Kapton® HN Film

Electrical	Units	Test Method	Typical APTIV Film @ 23°C	Kapton HN Film*
Corona Resistance, hr at 20kV/mm at 50 Hz	hrs	IEC60343	100	100
50kV/mm at 50Hz			15	10
Dielectric Strength, 25µm Film	kV/mm (V/mil)	ASTM D149	270 6,750	303 7700
Dielectric Constant (at 10MHz)		ASTM D150	3.5	3.4
Dissipation Factor (at 10MHz)		ASTM D150	0.002	0.0018
Volume Resistivity (100V)	Ω.cm	ASTM D257	$4x10^{16}$	$1.5x10^{17}$
Surface Resistivity	Ω/sq	ASTM D257	$2x10^{16}$	

*Data from DuPont Kapton HN polyimide film data sheet. Some test methods vary.

Broad Range of Thicknesses

APTIV film is made over a broad range of thicknesses. Standard thicknesses available (in microns) are: 8, 12.5, 18, 25, 38, 50, 63, 75, 100, 125, 150, 200, 250, 300 and 500. The maximum commercially available thickness is 750µm.

Thin standard films and good dielectric strength allow space saving, and/or lower weight insulation solutions. The excellent thermal conductivity of APTIV film in combination with a thin form factor allows efficient removal of waste heat. Table 4 illustrates the electrical properties of APTIV films at different thicknesses.

Table 4: Typical Electrical Properties of APTIV Film at Different Thicknesses

Property	Units	Test Method	≤25µm	50µm	125µm	250µm
Dielectric Strength,	kV/mm	ASTM D149	>270	190	120	70
Breakdown Voltage	kV		>6.8	9.5	15.0	17.5

Magnet Wire Insulation

The results of APTIV film wrapped magnet wire insulation tests are shown in Table 5. These include conditioned samples heated to 240°C and held for 30 minutes before being bent flatwise and edgewise and electrically tested in accordance with the principles of IEC 851 method of testing winding wires.

Copper Magnet Wire

Dimensions (Thickness x Width)	0.90mm x 3.95mm
Springiness	3.1°
Resistivity at 20°C	≤ 0.01724 Ω.mm²/m

Table 5: Magnet Wire Insulation Properties of APTIV 1000-025 Film (25µm)

Property	Units	Test Method	APTIV 1000-025 Film
Film Thickness	µm	n/a	25
Number of Layers		n/a	4
Overlap	%	n/a	50
Measured Insulation Thickness	mm	n/a	0.23
Breakdown Voltage Straight Minimum Average	kV	IEC 851-5	 11.5 12
Bend Test Breakdown Voltage Edgewise 4xWidth Minimum Average	kV	IEC 851-3	 9.9 10.5
Bend Test Breakdown Voltage Flatwise 4xThickness Minimum Average	kV	IEC 851-3	 10.2 11.8
Bend Test After Thermal Shock (30 minutes at 240°C) Breakdown Voltage Edgewise 4xWidth Minimum Average	kV	IEC 851-6	 10.1 12.2
Bend Test After Thermal Shock (30 minutes at 240°C) Breakdown Voltage Flatwise 4xThickness Minimum Average	kV	IEC 851-6	 9.3 9.9

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Environmental

Moisture Uptake

APTIV film shows low moisture absorption and as a consequence stable dielectric properties under general atmospheric conditions of 50% RH. Equilibrium moisture content is low at only 0.5% by weight.

Hydrolysis Resistance

Even in a high temperature and high humidity environment, APTIV film demonstrates exceptional stability in properties, resulting in excellent retention and minimal variability in the performance of finished products.

Chemical Resistance

APTIV film has excellent resistance to a wide range of chemical environments including oils, grease, common solvents and reagents, even at elevated temperatures.

APTIV film is compatible with common and high temperature impregnation resins and varnishes according to supplier laboratory tests conducted in accordance with UL1446 after ageing at 265°C for 336 hours. Similar testing with silicone oils confirms compatibility with these substances also.

Packaging and Customizing



All products are packaged using a robust and purpose designed packaging, and are fully labeled to comply with national and international standards. Labels indicating grade, unique batch number, roll length, roll width, product thickness, and net weight will be affixed to the outer packaging and the core.

APTIV film can be custom slit to specific width requirements for wire wrapping and can be folded, precision die cut, laser marked, printed onto, laminated, adhesively bonded, laser and ultrasonically welded. As a thermoplastic polymer, APTIV film can also be hot wrapped without the need for heat sealing layers.

* Kapton is a registered trademark of E. I. duPont de Nemours and Company

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