

Section 8 Product Properties

The following numbers are typical values for properties of Pyralux flexible composites. They should not be considered as numbers for setting specifications. Contact your DuPont Technical Representative for a copy of release specifications.

Unless otherwise noted, the typical value(s) represents all products (coverlay, bond ply, sheet adhesive, and clads) after cure. The clads have copper removed unless required for the test. Most properties are tested at ambient conditions. Individual IPC test methods are given except where noted. All IPC methods may be found in IPC-TM-650.

Electrical Properties

Property	Typical Values	Test Condition	Test Method
Dielectric Constant Adhesive/Kapton [®] Composites LF Adhesive FR Adhesive Kapton [®] HN, 1 mil	3.6-3.8 3.8 3.2 4.0 3.3 3.4	1 MHz 1 MHz 1 GHz 1 MHz 1 GHz 1 MHz	IPC-2.5.5.3
Dissipation Factor Adhesive/Kapton [®] Composites LF Adhesive FR Adhesive Kapton [®] HN, 1 mil	0.02-0.03 0.030 0.028 0.036 0.026 0.020	1 MHz 1 MHz 1 GHz 1 MHz 1 GHz 1 MHz	IPC-2.5.5.3
Dielectric Strength, volts/mil (kV/mm) Adhesive only Coverlay, bond ply and clads Kapton [®] HN 1 mil (25 μm) 2 mil (50 μm) 3 mil (75 μm) 5 mil (125 μm)	2000-3000 (180-120) 4000-5000 (160-195) 7700 (303) 6100 (240) 5200 (205) 3900 (154)	60 Hz ¼" electrodes 500 V/sec rise	ASTM D-149
Insulation Resistance, megohm	10 ⁵		IPC 2.6.3.2 Method A
Moisture and Insulation Resistance, megohm	10 ² 10 ⁵	at 95±4°F (35±2°C), 90-95% RH, for 4 days after recovery	IPC-2.6.3.2 Method B

Volume Resistivity, megohm-cm Coverlay, bond ply and clads: at ambient 170°F (75°C) 212°F (100°C) 300°F (150°C) damp	10 ⁸ 10 ⁷ 10 ⁷ 10 ⁵ 10 ⁶	damp at 95±4°F (35±2°C), 90-95% RH, for 4 days	ASTM D-257 IPC-2.5.17
Kapton® HN, 1 mil 1 mil (25 µm) 2 mil (50 µm) 3 mil (75 µm) 5 mil (125 µm)	1.5 x 10 ¹¹ 1.5 x 10 ¹¹ 1.4 x 10 ¹¹ 1.0 x 10 ¹¹		ASTM D-257-91
Surface Resistivity, megohm Coverlay, bond ply and clads: at ambient 170°F (75°C) 212°F (100°C) 300°F (150°C) damp	10 ⁷ 10 ⁷ 10 ⁶ 10 ⁵ 10 ⁶	damp at 95±4°F (35±2°C), 90-95% RH, for 4 days	ASTM D-257 IPC-2.5.17
Arc Resistance, seconds	90		ASTM D-495
Corona Pulse Detection, volts Inception voltage Extinction voltage	600 500		ASTM D-1868

Physical and Thermal Properties

Property	Typical Value	Test Method
Flow, mils/mil of adhesive Adhesive, coverlay and bond ply (B staged products)	2-4 depending on adhesive thickness, lamination temperature and pressure and press pad system used	IPC 2.3.17.1
Density, g/cm ³ Adhesive only Coverlay, bond ply and clad Kapton® HN	1.1 1.3 – 1.4 1.42	ASTM D-1505

Specific Heat, Btu/lb°F or cal/g°C Adhesive only 20°C (68°F) 220°C (428°F) Kapton® HN	0.46 0.50 0.26	DSC
Refractive Index, Sodium D Line Adhesive only Kapton® HN	1.50 1.70	ASTM D-542-90
Fungus Resistance, Pyralux® composites Kapton® HN	non-nutrient non-nutrient	IPC-2.6.1
Flammability, % (Limited oxygen index) LF Adhesive only Kapton® HN, V-0 Pyralux® FR, VTM-0	15-18% 37% na	IPC-2.3.8
Glass Transition Temperature, °C (°F) Adhesive only Kapton® HN	40° (104°) 360°-410° (680° – 770°)	TMA
Moisture Absorption, % Pyralux® Composites Kapton® HN, 50% RH, 23°C Kapton® HN, immersion, 23°C	1-2.8 1.8 2.8	IPC-2.6.2

Physical and Thermal Properties

Property	Typical Value		Test Method
Dimensional Stability, %	MD = Machine Direction TD = Transverse Direction		
Coverlay and bond ply, % change Kapton® film thickness, 1 mil (25 µm) LF0110 LF0210 LF0111	MD -0.03 -0.04 +0.01	TD +0.00 +0.00 +0.00	IPC 2.2.4 Method A
Clads, % change (copper removed) Kapton® thickness, 1 mil (25 µm) LF9110 LF9111	-0.09 -0.05	-0.07 -0.05	IPC 2.2.4 Method B
Clads, % change (after thermal exposure) Kapton® thickness, 1 mil (25 µm) LF9110 LF9111	-0.10 -0.05	-0.08 -0.05	IPC 2.2.4 Method C
Rated Service Temperature	-60°C to 125°C		

Thermal Coefficient of Expansion, ppm/deg°C (in/in•deg°C) Adhesive only (Z axis) Below Tg (40°C, 104°F) Above Tg Kapton HN (X, Y, Z axes)	100 (10x10 ⁻⁵) 400 (40x10 ⁻⁵) 20 (2x10 ⁻⁵)	TMA
Coefficient of Thermal Conductivity, W/m•°K (cal/cm•sec•°C) Adhesive only Kapton® HN	0.23 (5.5x10 ⁻⁴) 0.12 (2.87x10 ⁻⁴)	TC-1000 Thermal Comparator
Solder Resistance (dip) 10 min. at 500°F (260°C) 5 min at 550°F (288°C) 30 sec. at 600°F (316°C)	no blistering, delam no blistering, delam no blistering, delam	IPC 2.4.13
Outgassing, Pyralux® LF and AP composites NASA specification SP-R-0022	Meets criteria: ≤ 1.0% TML (total mass loss) ≤ 0.10% CVCM (collected volatile condensable material)	ASTM E 595-77 SP-R-0022

Mechanical Properties

Property	Typical Value	Test Method
Initiation Tear Strength, g/mil (N/mm) Coverlay, bond ply and clad Construction dependent Kapton® HN, 1 mil	500-900 (193-347) 746 (288)	IPC 2.4.16
Propagating Tear Strength, g/mil (N/μm) Coverlay, bond ply and clad Construction dependent Kapton® HN, 1 mil	6-11 (2.31-4.25) 7.25 (2.8)	IPC 2.4.17.1
Ultimate Elongation, percent Adhesive only Coverlay, bond ply and clad Kapton® HN, 1 mil @23°C	200-300 70 72	ASTM D-882
Ultimate Tensile Strength, psi (MPa) Adhesive only Coverlay, bond ply and laminate Construction dependent Kapton® HN, 1 mil	3500 (24.1) 10,000 – 20,000 (69-138) 33,500 (231)	ASTM D-882

Tensile Modulus (Young's Modulus) psi (MPa) Cured adhesive only Coverlay, bond ply and clad Kapton® HN, 1 mil	85,000 (586) 150,000 – 300,000 (1,035 – 2,070) 370,000 (2,550)	ASTM D-882
Low Temperature Flexibility, cycles Coverlay, bond ply and clad	>10	IPC-2.6.18
Peel Strength, lb/in (N/mm) Coverlay, bond ply and clad (1 oz/ft ² [35 µm] treated copper bonded to 1, 2, 3 and 5 mil (25, 50, 75, and 125 µm)	9-12 (1.6 – 2.1)	IPC-2.4.9
Poisson's Ratio Kapton® HN	0.34	Avg. three samples elongated 5%, 7%, 10%

Chemical Resistance

Pyralex® flexible composites have withstood the following chemicals at the conditions listed, with no blistering, delamination, loss of adhesion, or swelling:

Chemical	Temp °F	Temp °C	Time
20% ammonium persulfate	140	60	10 min.
10% nitric acid	73	23	10 min.
30% nitric acid	73	23	10 min.
30% nitric acid	122	50	10 min.
30% sulfuric acid	73	23	15 min.
50% acetic acid	73	23	10 min.
10% acetic acid	73	23	10 min.
2N sodium hydroxide	73	23	10 min.
30% hydrazine	73	23	15 min.
trichloroethylene	73	23	10 min.
toluene	73	23	10 min.
methylethyl ketone	73	23	10 min.
methylene chloride*	73	23	10 min.
methylene chloride/trichloroethylene (50/50)*	73	23	10 min.
methanol*	73	23	10 min.
isopropyl alcohol	73	23	10 min.
dimethyl formamide	73	23	10 min.
hydraulic fluid	122	50	24 hr.
lubricating oil	122	50	24 hr.
aviation fuel	73	23	24 hr.
2N hydrochloric acid	73	23	10 min.

Sequential Exposure:			
1) methylene chloride	73	23	10 min
2) 2N sodium hydroxide	73	23	10 min.
3) 2N sulfuric acid	73	23	10 min.

*Recovers after conditioning – 24 hours at room temperature