

DuPont™ Nomex® 414

Technical data sheet

Nomex® 414 is an aramid paper that meets or exceeds requirements of IEC 60819-3-3 for Type 2 papers. It is designed for applications requiring a strong, yet flexible and conformable sheet. Over and above the fact that it is electrically and thermally similar to Nomex® 410, Nomex® 414 provides unique properties due to being manufactured using different conditions.

Nomex® 414 paper is produced in four thicknesses (0.18-0.25-0.30-0.38 mm) (7-10-12-15 mils), with density from 0.92 to 0.94 g/cm³. It was originally designed for use as slot insulation in hand-wound motors, but it is also used in other applications where its specific characteristics are desirable, such as folded or punched parts. Another example is its improved impregnability versus Nomex® 410. While being a paper of relatively high density, Nomex® 414 paper shows impregnability equivalent to medium density papers with more open structures.

Electrical properties

The typical electrical property values in air for Nomex® 414 paper are shown in Table I. The AC Rapid Rise dielectric strength data of Table I, represent voltage stress levels, withstood 10 to 20 seconds at a frequency of 60 Hz. These values differ from long-term strength potential. DuPont recommends that continuous stresses in transformers not exceed 1.6 kV/mm (40 V/mil) to minimize the risk of partial discharges (corona). This recommendation is based on dielectric strength of the air and is only valid for dry type applications.

The Full Wave Impulse dielectric strength data shown in Table I are based on multiple sheets. These values are appropriate for applications that employ these materials in such configurations. Data based on single sheets of material are available upon request. The dielectric strength data are typical values and not recommended for design purposes. Design values can be supplied upon request.

Please note:

The properties in this data sheet are typical, or average values and should not be used as specification limits. Unless otherwise noted, all properties were measured in air under “standard” conditions (in equilibrium at 23 °C, 50% relative humidity). Note that, like other products of papermaking technology, Nomex® papers have somewhat different properties in the papermaking machine direction (MD) compared to the cross direction (XD). In some applications it may be necessary to orient the paper in the optimum direction to obtain its maximum potential performance.

Table I – Typical electrical properties

Nominal thickness (mil) (mm)	7 0.18	10 0.25	12 0.30	15 0.38	Test method
Dielectric strength - AC rapid rise ⁽¹⁾ (V/mil) (kV/mm)	785 31	760 30	745 29	750 30	ASTM D149
Dielectric strength - Full wave impulse ⁽²⁾ (V/mil) (kV/mm)	1300 51	1300 51	1300 51	1200 47	ASTM D3426
Dielectric constant at 60 Hz at 1 kHz	2.5 2.5	2.7 2.7	2.8 2.8	2.9 2.9	ASTM D150
Dissipation factor at 60 Hz (x10 ⁻³)	8	8	8	9	ASTM D150

⁽¹⁾ ASTM D149 using 50 mm (2 inches) electrodes, rapid rise; corresponds with IEC 60243-1 subclause 9.1, except for electrode set-up of 50mm (2 inches)

⁽²⁾ ASTM D3426 using 50 mm (2 inches) electrodes

The effects of temperature on dielectric strength and dielectric constant are shown for Nomex® 410 paper in Figure 1 of the Nomex® 410 technical data sheet. Since Nomex® 414 paper is chemically identical to Nomex® 410 (differing only in structure), its electrical properties will react similarly to temperature changes up to and including 220°C. Variations in frequency up to 10⁴ Hz have essentially no effect on the dielectric constant of Nomex® 414 paper, and dissipation factors remain below 0.015 up to these frequencies.

Mechanical properties

The typical mechanical property values for Nomex® 414 paper are shown in Table III. The effects of temperature on tensile strength and elongation are illustrated for Nomex® 410 paper in Figure 5 of the Nomex® 410 data sheet. These effects will be similar for Nomex® 414 paper. The flexibility of Nomex® 414 paper is shown by the good fold endurance values in Table III. These values are at least double the values for the same thickness of Nomex® 410.

Figure 1 – EFFECT OF HUMIDITY ON ELECTRICAL PROPERTIES

Nomex® 414 – 0.25 mm (10 mil)

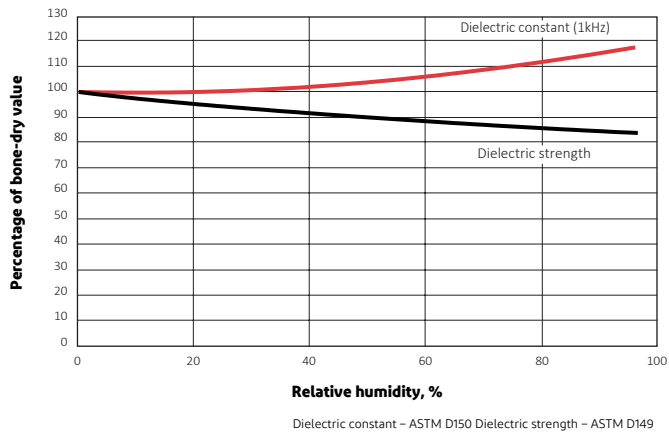


Table II – Humidity effects on electrical properties

Nomex® 414 – 0.25 mm (10 mil)

Relative humidity (%)	Oven dry	50	96
Dissipation factor ⁽¹⁾ at 1 Hz (x 10 ⁻³)	10	11	26
Volume resistivity ⁽²⁾ (ohm.cm)	10 ¹⁶	10 ¹⁵	10 ¹⁴

⁽¹⁾ASTM D150
⁽²⁾ASTM D257

Table III – Typical mechanical properties

Nominal thickness	(mil)		7	10	12	15	Test method
	(mm)		0.18	0.25	0.30	0.38	
Typical thickness ⁽¹⁾	(mil)		7.6	10.2	12.8	16.1	ASTM D374
	(mm)		0.19	0.26	0.32	0.41	
Basis weight	(g/m ²)		180	244	299	380	ASTM D646
Density	(g/cc)		0.93	0.94	0.92	0.93	
Tensile strength	(N/cm)	MD	183	217	275	334	ASTM D828
	(N/cm)	XD	100	131	162	208	
Elongation	(%)	MD	15.4	14.8	16.9	14.9	ASTM D828
	(%)	XD	16.0	16.4	18.1	15.8	
Initial tear strength ⁽²⁾	(N)	MD	48	65	82	100	ASTM D1004
	(N)	XD	28	39	49	65	
Fold endurance	(cycles)	MD	7300	7400	7800	8200	ASTM D2176

⁽¹⁾ Method D; 17 N/cm²

⁽²⁾ Data presented for Initial Tear Strength is listed in the direction of the sample per ASTM D1004. The tear is 90 degrees to sample direction — hence for papers with a higher reported MD ITR, the paper will be tougher to tear in the cross direction.

MD = machine direction of paper
XD = cross direction of paper

- Water is a mild plasticizer for Nomex® papers. The effects of 7 days' exposure at various relative humidities on the tensile strength and elongation of Nomex® 414 – 0.25 mm (10 mil) paper are shown in Table IV. Like elongation, the tear strength and toughness of the paper are also increased at higher moisture contents.
- The dimensions of bone-dry Nomex® 414 paper exposed to 95% R.H. conditions will increase, at most, 1% in the machine direction and 2% in the cross direction (due to moisture absorption). This swelling is largely reversible when the paper is redried. The rate of change in dimensions will depend, of course, on paper thickness and configuration (for example, individual sheets versus tightly wound rolls). Variations in environmental humidity will usually produce dimensional changes which will be less than 1%. However, even small dimensional changes, especially if they are non-uniform, can cause or accentuate non-flatness and other problems in critical operations. Therefore, Nomex® intended for such applications should be kept sealed in its protective polyethylene wrapper, to maintain uniform moisture content, until just before use.

Thermal properties

Arrhenius plots of thermal aging behavior for Nomex® are exemplified by Figures 7 and 8 of the Nomex® 410 technical data sheet. Similar aging of Nomex® 414 paper at elevated temperatures has resulted in its recognition as a 220°C insulating material. Table V shows all of the UL yellow card information for Nomex® 414 including this 220°C thermal rating.

Chemical stability

The compatibility of Nomex® paper and pressboard with virtually all classes of electrical varnishes and adhesives (polyimides, silicones, epoxies, polyesters, acrylics, phenolics, synthetic rubbers), as well as other components of electrical equipment, is demonstrated by the many UL-recognized systems comprising Nomex® as well as longstanding commercial experience. Nomex® papers are also fully compatible (and in commercial use) with transformer liquids (mineral and silicone oils as well as natural and synthetic esters) and with lubricating oils and refrigerants used in hermetic systems. Nomex® papers also have recently been demonstrated as being the material of choice for insulating motors for electric vehicles, in large part due to demonstrated compatibility with fluids used in automotive applications such as automatic transmission fluids. Common industrial solvents (alcohols, ketones, acetone, toluene, xylene) have a slight softening and swelling effect on Nomex® 414 paper, similar to that of water. These effects are largely reversible when the solvent is removed.

Table IV – Humidity effects on mechanical properties

Nomex® 414 – 0.25 mm (10 mil)

Relative humidity (%)		Oven dry	50	96	Test method
Tensile strength (n/cm)	MD	248	217	203	ASTM D828
	XD	150	131	122	
Elongation (%)	MD	12.5	14.8	17.9	ASTM D828
	XD	15.6	16.4	20.9	

Table V - UL Ratings

ASTM D374	ASTM D374	UL 94	UL746A	UL746A	UL746B	UL746B	UL746A	UL746A
Thickness (mils)	Thickness (mm)	Flame Class	HWI Rating	HAI Rating	RTI Elec. Rating	RTI Mech. Rating	HVTR Rating	CTI Rating
7	0.18	V-0	0	0	220	220	3	3
10	0.25	V-0	0	0	220	220	3	3
12	0.30	V-0	0	0	220	220	3	3
15	0.38	V-0	0	0	220	220	3	3

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