DuPont™ Nomex® 818

Technical Data Sheet

Nomex® 818 is designed for high-voltage applications, including motor conductor and coil wrap, transformer ground and layer insulation. It is a calendered product with high inherent dielectric strength (700 V/mil to 1,000 V/mil [30 kV/mm to 40 kV/mm]), which can be readily impregnated with varnishes where this is desirable. Nomex® 818 is available in five thicknesses, ranging from 0.08 mm to 0.25 mm (3 mil to 10 mil). This calendered blend of aramid and mica offers increased voltage endurance compared to Nomex® 410 when subjected to corona attack.

Periodically, DuPont upgrades the branding of its materials to reflect a more consistent family of products for similar applications. Customers of materials previously designated as Nomex® 418 should know that these are the identical materials to those now designated as Nomex® 818. Materials formerly designated as Nomex® 419 are no longer sold commercially. The 800 Series of mica-containing products includes new materials designated as Nomex® 864. These materials are sold only for laminating with other sheets or films, and the properties of the laminated sheets are dependent on the final combinations of sheet materials. Therefore, the individual mechanical and electrical properties for Nomex® 864 products are not listed here.

Electrical Properties

The typical electrical property values for Nomex® 818 papers are shown in Table I.

The AC Rapid Rise dielectric strength data in Table I represent voltage stress levels withstood for 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 designed with Nomex® 818 not exceed 80 V/mil (3.2 kV/mm) to minimize the risk of partial discharges. The full wave impulse dielectric strength data in Table I were generated on flat sheets, such as in layer and barrier applications. The geometry of the system has an effect on the actual impulse strength values of the material.

The dielectric strength data are typical values and not recommended for design purposes. Design values can be supplied upon request.

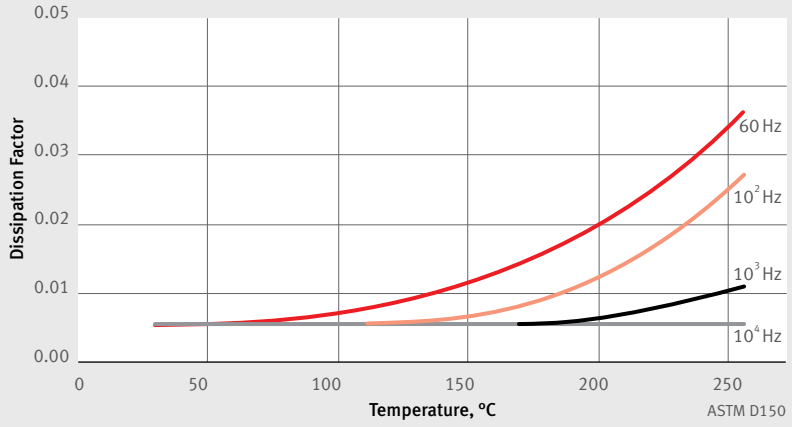
Table I. Typical Electrical Properties of DuPont™ Nomex® 818

Property	Nominal Thickness, mm (mil)					Test Method
	0.08 (3)	0.13 (5)	0.15 (6)	0.20 (8)	0.25 (10)	
Dielectric Strength AC Rapid Rise, V/mil kV/mm	710 28.1	890 35.0	990 39.0	1000 39.3	990 39.0	ASTM D149[1]
Full Wave Impulse, V/mil kV/mm	1600 63	1600 63	1600 63	1600 63	1700 67	ASTM D3426
Dielectric Constant at 60 Hz 50% RH Dry[2]	2.9 2.3	3.6 2.5	5.0 3.0	4.0 2.5	4.1 2.5	ASTM D150
Dissipation Factor at 60 Hz ($x10^{-3}$) 50% RH Dry[2]	130 6	120 6	180 5	140 6	140 6	ASTM D150
Volume Resistivity, ohm.cm 50% RH Dry[2]	10^{13} 10^{16}	10^{13} 10^{16}	10^{13} 10^{15}	10^{13} 10^{16}	10^{13} 10^{16}	ASTM D257
Surface Resistivity, ohm/square 50% RH Dry[2]	10^{11} 10^{14}	10^{12} 10^{15}	10^{12} 10^{14}	10^{12} 10^{15}	10^{12} 10^{15}	ASTM D257

1. Using 50-mm (2-in.) electrodes, rapid rise; corresponds with IEC 243-1 subclause 9.1, except for electrodes set-up of 50 mm (2 in.).
2. Values measured at 23°C after one hour drying at 120°C.

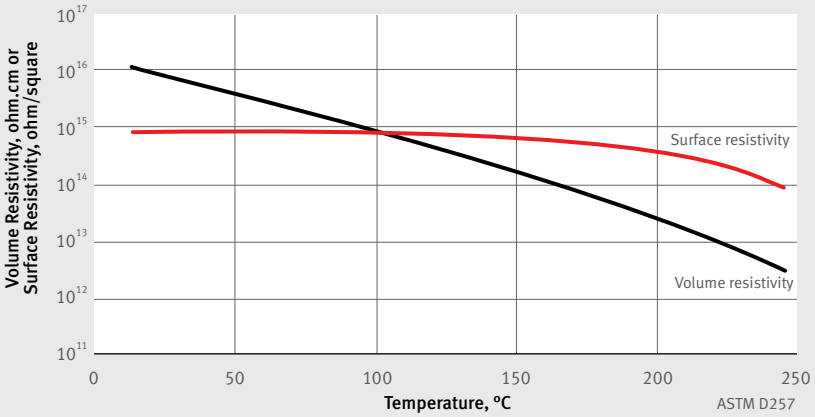
The effects of temperature on dielectric strength and dielectric constant are shown for Nomex® 410 paper in Figure 1 of the Nomex® 410 technical data sheet. Because Nomex® 818 is composed 50% of inorganic mica, its properties are even more stable with temperature. Dielectric constants of Nomex® 818 papers are essentially unchanged over the range of 23°C to 250°C. The effects of temperature and frequency on the dissipation factor of dry Nomex® 818—0.13 mm (5 mil) paper are shown in Figure 1.

Figure 1. Dissipation Factor versus Temperature and Frequency of DuPont™ Nomex® 818 — 0.13 mm (5 mil)



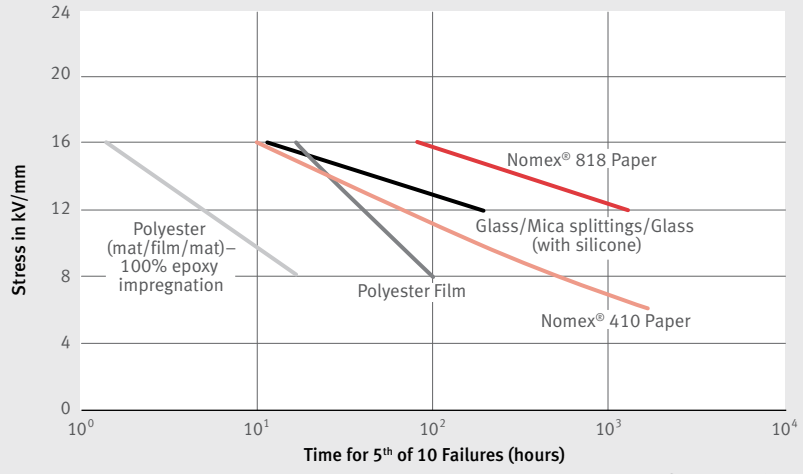
Surface and volume resistivities of dry Nomex® 818—0.13 mm (5 mil) paper are shown in Figure 2 as functions of temperature. Corresponding values for other thicknesses are very similar.

Figure 2. Resistivity versus Temperature of DuPont™ Nomex® 818 — 0.13 mm (5 mil)



Like other organic insulating materials, Nomex® paper is gradually eroded under attack by corona discharges. However, Nomex® 818 is specifically designed to provide voltage endurance (long times to failure under corona attack) at least equivalent to the best inorganic insulations, and greatly superior to other organic materials, as shown in Figure 3. These data were obtained at 360 Hz frequency; times to failure at 50-60 Hz are approximately 6 to 7 times as long as those indicated. Due to its superior corona resistance, Nomex® 818 paper has been used commercially for many years to insulate stator coils in AC motors up to 13.6 kV class.

Figure 3. Voltage Endurance of Various Insulating Materials — Single-Layer 0.25 mm (10 mil)



This data is provided for comparative purposes only and should not be used as design values.

Mechanical Properties

The typical mechanical property values for Nomex® 818 papers are shown in Table II. Nomex® 818 paper retains at least 50% of its room-temperature tensile strength and elongation at temperatures up to 250°C, as shown in Figure 4.

Water is a plasticizing agent for Nomex® 818 paper. Dipping or soaking Nomex® 818 papers in water reduces their tensile strengths to 30% to 50% of the typical values shown in Table II, but also increases break elongation by about 3 times and makes the paper softer and more conformable. This effect can be used to advantage in some applications (similar to the common practice of dipping mica composite tapes in mixtures of water and alcohol to improve their handling characteristics during wrapping of motor coils). Due to the permeable nature of Nomex® 818 paper, absorbed water can be readily removed during normal drying or baking procedures. This restores the paper properties to their normal values.

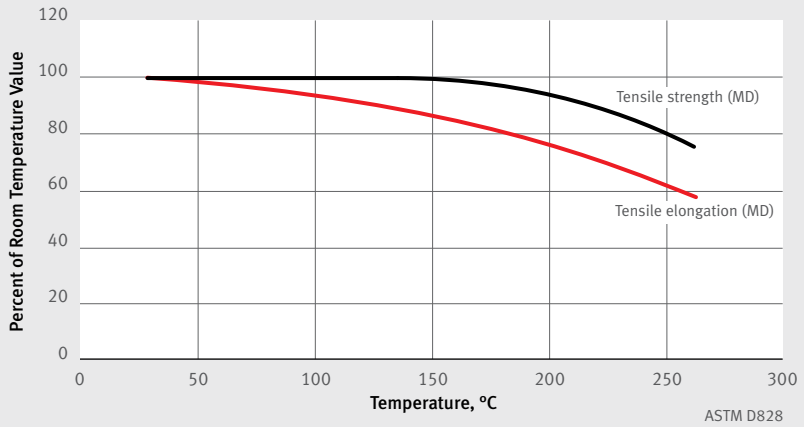
Table II. Typical Mechanical Properties of DuPont™ Nomex® 818

Property	Nominal Thickness, mm (mil)					Test Method
	0.08 (3)	0.13 (5)	0.15 (6)	0.20 (8)	0.25 (10)	
Typical Thickness, mm mil	 0.08 3.1	 0.13 5.2	 0.15 6.0	 0.21 8.3	 0.27 10.6	ASTM D374[1]
Basis Weight, g/m²	89.2	148.4	179.5	240	298	ASTM D646
Density, g/cc	1.13	1.13	1.18	1.15	1.12	
Tensile Strength, N/cm MD XD	 31 22	 52 38	 67 48	 91 65	 111 78	ASTM D828
Elongation, % MD XD	 2.9 3.0	 3.0 3.4	 3.6 3.7	 3.7 3.7	 3.8 3.8	ASTM D828
Elmendorf Tear, N MD XD	 1.1 1.6	 2.0 2.9	 2.6 3.9	 3.6 5.2	 4.9 6.7	TAPPI 414
Initial Tear Strength, N MD XD	 9 6	 16 10	 20 14	 28 19	 34 24	ASTM D1004[2]
Shrinkage at 300°C, % MD XD	 0.1 0.0	 0.1 0.0	 0.0 0.0	 0.0 0.0	 0.0 0.0	

MD = Machine Direction; XD = Cross Direction

1. Method D, using 17 N/cm² for Nomex® 818.
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 machine direction initial tear strength, the paper will be tougher to tear in the cross direction.

Figure 4. Temperature Effects on Mechanical Properties of DuPont™ Nomex® 818 — 0.13 mm (5 mil)



Thermal Properties

Arrhenius plots of thermal aging behavior for Nomex® are exemplified by Figures 7 and 8 in the Nomex® 410 technical data sheet. Similar aging of Nomex® 818 papers at elevated temperatures has resulted in their recognition as 220°C insulating materials.

The thermal conductivity of Nomex® 818—0.25 mm (10 mil) paper is shown in Figure 5 as a function of temperature. The total system construction may affect the overall thermal conductivity; therefore, care should be taken in applying individual sheet data to actual situations. For example, two sheet insulations with identical thermal conductivities may have quite different effects on heat transfer from a coil due to differences in stiffness or winding tension (which affect the spacing between the insulation layers) or differences in the absorption of impregnating varnishes.

Chemical Stability

The compatibility of Nomex® papers and pressboards with virtually all classes of electrical varnishes and adhesives (polyimides, silicones, epoxies, polyesters, acrylics, phenolics, synthetic rubbers, etc.), as well as with other components of electrical equipment, is demonstrated by the many UL-recognized systems comprising Nomex®, as well as long-standing commercial experience. Nomex® 818 papers are specifically included in these systems. These papers are also fully compatible with transformer fluids (mineral and silicone oils and other synthetics) and with lubricating oils and refrigerants used in hermetic systems.

The Limiting Oxygen Index (LOI) of Nomex® 818—0.13 mm (5 mil) paper at room temperature is 63%, declining to 52% at 220°C. Thicker grades should have slightly higher LOI. Materials with LOI above 20.8% will not support combustion in air. As is shown in Figure 6, Nomex® 818 must be heated to more than 700°C before its LOI declines below the flammability threshold.

Figure 5. Thermal Conductivity versus Temperature for DuPont™ Nomex® 818 – 0.25 mm (10 mil)

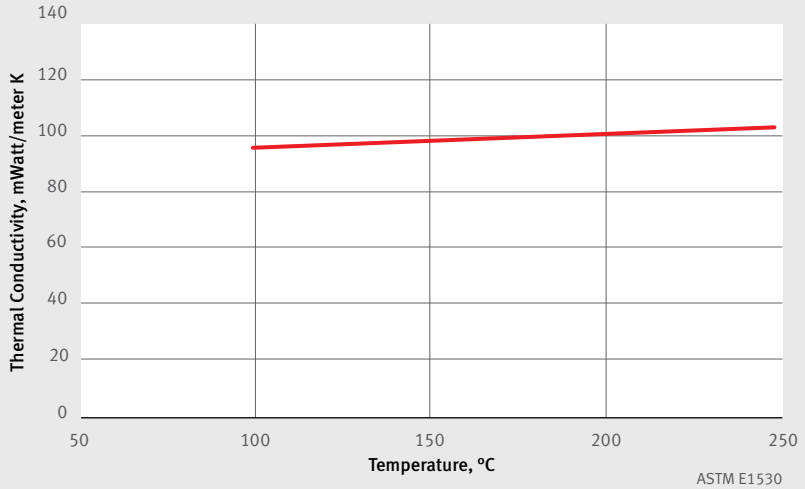
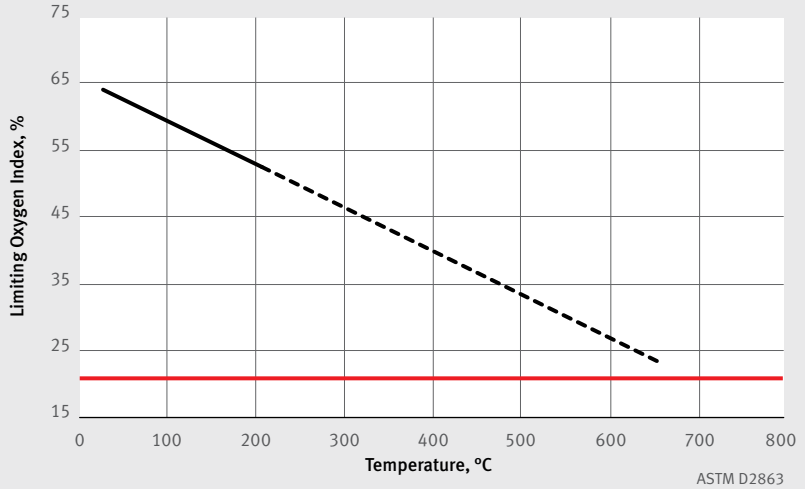


Figure 6. Limiting Oxygen Index (LOI) of DuPont™ Nomex® 818 – 0.13 mm (5 mil)



Radiation Resistance

The effect of 64 Mgy (6400 megarads) of 2 MeV beta radiation on the mechanical and electrical properties of Nomex® 818 is shown in Table III. (By comparison, a laminate of polyester film and polyester mat of the same thickness, 100% epoxy-impregnated, crumbles after 8 Mgy [800 megarads]). Similar results were obtained on exposure to gamma radiation. This outstanding radiation resistance is another indication of the basic chemical stability of Nomex® paper.

Table III. Radiation Resistance of DuPont™ Nomex® 818—0.25 mm (10 mil) to 2 MeV Electrons (Beta Rays)

Property	Dose, Mgy								Test Method
	0	1	2	4	8	16	32	64	
Tensile Strength, % of original									
MD	100	96	100	100	100	100	87	88	ASTM D828
XD	100	99	100	91	93	90	96	78	
Elongation, % of original									
MD	100	100	100	91	64	46	46	27	ASTM D828
XD	100	86	93	79	64	43	50	21	
Dielectric Strength,									
V/mil	1370	1370	1400	1370	1220	1350	1420	1320	ASTM D149[1]
kV/mm	54	54	55	54	48	53	56	52	
Dielectric Constant									
at 60 Hz	3.9	3.6	3.8	3.9	3.5	3.4	2.5	2.9	ASTM D150
at 1 Hz	3.3	3.0	3.3	3.4	3.1	3.0	2.3	2.7	
at 10 Hz	2.9	2.7	2.9	3.0	2.7	2.7	2.1	2.6	
Dissipation Factor (x 10^{-3})									
at 60 Hz	103	94	79	93	87	95	67	48	ASTM D150
at 1 Hz	96	93	82	91	82	83	53	40	
at 10 Hz	76	81	75	85	76	73	40	31	

MD = Machine Direction; XD = Cross Direction
1. With a 6.4-mm (1.4-in.) electrode.

UL Ratings

Table IV shows the UL ratings for Nomex® 818 and Nomex® 864 papers. Descriptions of the numerical values for each of the UL ratings are detailed in the UL website on Component Materials, which can be accessed at **iq.ul.com/ul/cert.aspx?ULID=230941**

TABLE IV. UL Ratings for DuPont™ Nomex® 818 and Nomex® 864

ASTM D374 Thickness, mm	ASTM D374 Thickness, mil	UL 94 Flame Class	UL 746A HWI Rating	UL 746A HAI Rating	UL 746B RTI Electrical Rating	UL 746B RTI Mechanical Rating	UL 746A HVTR Rating	UL 746A CTI Rating
0.08	3	V-0	4	4	220	220	3	3
0.13	5	V-0	4	4	220	220	3	3
0.14	6	V-0	4	4	220	220	3	3
0.20	8	V-0	4	4	220	220	3	3
0.25	10	V-0	4	4	220	220	3	3

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