Information about the product Nomex® Type 418 and 419

Dear Sir / Madam,

Information is provided in the Appendix about the product Nomex® Type 418 and 419.

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NOMEX®

DUPONT®

NOMEX® TYPE 418 AND 419

TECHNICAL DATA SHEET

NOMEX® Type 418 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 (30 to 40 kV/mm), which can be readily impregnated with varnishes where this is desirable. NOMEX® Type 418 is available in 5 thicknesses, from 0.08 to 0.36 mm (3 to 14 mil). This calendered blend of aramid and mica offers increased voltage endurance over NOMEX® Type 410 when subjected to corona attack.

NOMEX® Type 419 is the uncalendered precursor of NOMEX® Type 418, and is available in two thicknesses, 0.18 and 0.33 mm (7 and 13 mil). NOMEX® Type 419 is used in applications which take advantage of the lower density (0.5) which allows improved conformability and saturability.

Electrical properties

The typical electrical property values for NOMEX® Type 418 and NOMEX® Type 419 papers are shown in Table I. The AC Rapid Rise dielectric strength data of Table I, representing 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 3.2 kV/mm (80 V/mil) to minimize the risk of partial discharges (corona). The Full Wave Impulse dielectric strength data of 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.

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**

Type		418					419	
Nominal thickness (mil)		3	5	8	10	14	7	13
(mm)		0.08	0.13	0.20	0.25	0.36	0.18	0.33
Dielectric Strength								
AC rapid rise[1]								
(V/mil)		770	890	1020	965	920	395	370
(kV/mm)		30.3	35.0	40.2	38.0	36.2	15.6	14.6
Full wave impulse[2]								
(V/mil)		1600	1600	1600	1700	1500	650	650
(kV/mm)		63	63	63	67	59	26	26
Dielectric constant[3]	50% RH	2.9	3.6	4.0	4.1	3,4	2.0	2.0
at 60 Hz	Dry[4]	2.3	2.5	2.5	2.5	2.1	1.4	1.5
Dissipation factor[3]	50% RH	130	120	140	140	150	140	130
at 60 Hz (x10^{-3})	Dry[4]	6	6	6	6	5	11	14
Volume resistivity[5]	50% RH	$(10)^{13}$	$(10)^{13}$	$(10)^{13}$	$(10)^{13}$	$(10)^{14}$	$(10)^{13}$	$(10)^{13}$
(ohm.cm)	Dry[4]	$(10)^{16}$	$(10)^{16}$	$(10)^{16}$	$(10)^{16}$	$(10)^{15}$	$(10)^{16}$	$(10)^{16}$
Surface resistivity[5]	50% RH	$(10)^{11}$	$(10)^{12}$	$(10)^{12}$	$(10)^{12}$	$(10)^{13}$	$(10)^{13}$	$(10)^{13}$
(ohm/square)	Dry[4]	$(10)^{14}$	$(10)^{15}$	$(10)^{15}$	$(10)^{15}$	$(10)^{15}$	$(10)^{15}$	$(10)^{16}$

[1] ASTM D-149 using 50mm (2 inches) electrodes, rapid rise; corresponds with IEC 243-1 subclause 9.1, except for electrodes set-up of 50mm (2 inches)

[2] ASTM D-3426

[3] ASTM D-150

[4] Values measured at 23°C after one hour drying at 120°C

[5] ASTM D-257

The effects of temperature on dielectric strength and dielectric constant are shown for NOMEX® Type 410 paper in Figure 1 of the NOMEX® Type 410 data sheet. Since NOMEX® Type 418 is composed 50% of inorganic mica, its properties are even more stable with temperature. Dielectric constants of NOMEX® Type 418 and NOMEX® Type 419 papers are essentially unchanged over the range from 23 to 250°C. The effects of temperature and frequency on the dissipation factor of dry NOMEX® Type 418 – 0.13 mm (5 mil) paper are shown in Figure 1. Surface and Volume Resistivities of dry NOMEX® Type 418 – 0.13 mm (5 mil) paper are shown in Figure 2 as functions of temperature. Corresponding values for other thicknesses are very similar.

Like other organic insulating materials, NOMEX® paper is gradually eroded under attack by corona discharges. However, NOMEX® Type 418 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 6-7 times as long as those indicated. Due to its superior corona resistance, NOMEX® Type 418 paper has been used commercially for many years to insulate stator coils in AC motors up to 13.6 kV class.

Mechanical properties

The typical mechanical property values for NOMEX® Type 418 and NOMEX® Type 419 papers are shown in Table II. NOMEX® Type 418 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® Type 418 paper. Dipping or soaking NOMEX® Type 418 papers in water reduces their tensile strengths to 30-50% of the typical values shown in Table III, 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® Type 418 paper, absorbed water can be readily removed during normal drying or baking procedures. This restores the paper properties to their normal values.

Figure 1 - **DISSIPATION FACTOR VS. TEMPERATURE AND FREQUENCY NOMEX® TYPE 418 – 0.13 MM (5 MIL)**

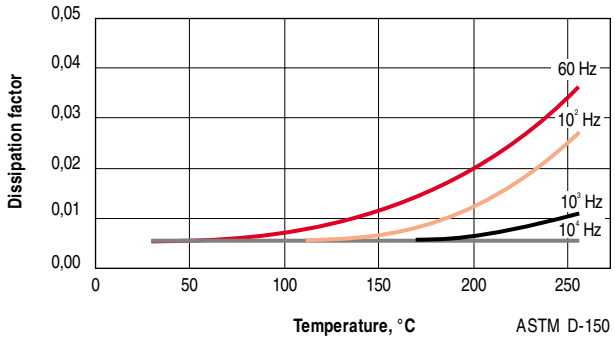


Figure 2 - **RESISTIVITY VS. TEMPERATURE NOMEX® TYPE 418 – 0.13 MM (5 MIL)**

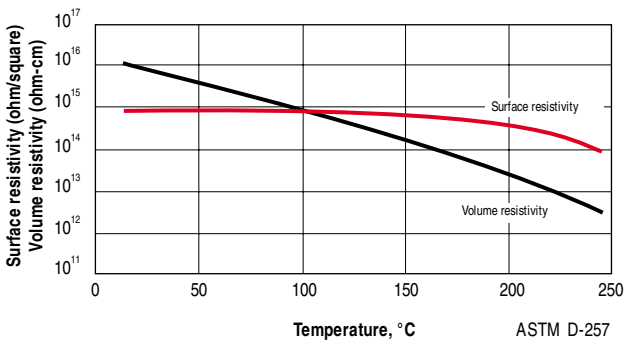


Figure 3 - **VOLTAGE ENDURANCE OF VARIOUS INSULATING MATERIALS SINGLE LAYER 0.25 MM (10 MIL)**

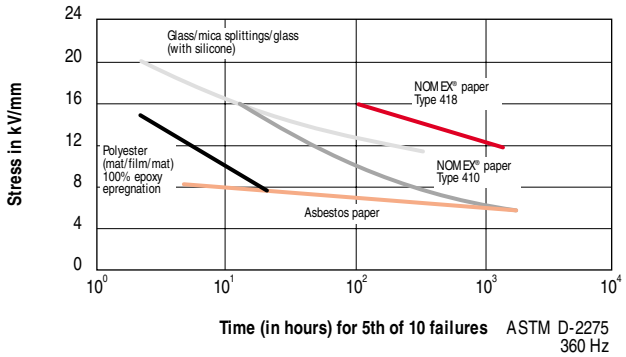
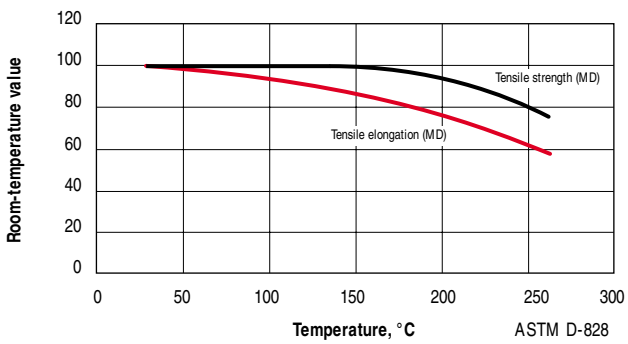


Figure 4 - **TEMPERATURE EFFECTS ON MECHANICAL PROPERTIES NOMEX® TYPE 418 – 0.13 MM (5 MIL)**



Thermal properties

Arrhenius plots of thermal aging behavior for NOMEX® are exemplified by Figures 7, 8 and 9 of the NOMEX® Type 410 data sheet. Similar aging of NOMEX® Type 418 and NOMEX® Type 419 papers at elevated temperatures has resulted in their recognition as 220°C insulating materials.

The thermal conductivity of NOMEX® Type 418 – 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® paper and pressboard with virtually all classes of electrical varnishes and adhesives (polyimides, silicones, epoxies, polyesters, acrylics, phenolics, synthetic rubbers, etc.), 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® Type 418 and Type 419 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.

Table II – TYPICAL MECHANICAL PROPERTIES

Type		418					419	
Nominal thickness (mil)		3	5	8	10	14	7	13
(mm)		0.08	0.13	0.20	0.25	0.36	0.18	0.33
Typical thickness[1] (mil)		3.1	5.2	8.1	10.6	14	8.1	13.8
(mm)		0.08	0.13	0.21	0.27	0.36	0.20	0.35
Basis weight[2] (g/m²)		89.2	148.4	236.8	301.3	396.7	91.5	152.3
Density (g/cc)		1.13	1.13	1.15	1.12	1.12	0.45	0.44
Tensile strength[3] (N/cm)	MD	29	52	87	111	149	18	30
	XD	19	35	60	78	102	12	20
Elongation[3] (%)	MD	2.4	2.9	3.7	3.8	3.0	1.83	1.99
	XD	2.8	3.2	3.7	3.8	3.5	2.09	2.40
Elmendorf tear[4] (N)	MD	1.1	2.2	3.6	4.9	5.9	0.8	1.4
	XD	1.6	2.9	4.8	6.3	7.8	1.0	1.8
Initial tear strength[5] (N)	MD	8	16	26	34	38	5	8
	XD	5	10	18	24	21	3	6
Shrinkage at 300°C (%)	MD	0.3	0.1	0.1	0.1	0.3		
	XD	0.0	0.0	0.0	0.0	0.2		
Shrinkage at 240°C (%)	MD						0.1	0.1
	XD						0.0	0.0

[1] ASTM D 374, method D, using 17 N/cm² for NOMEX® Type 418 and TAPPI 411, using 5 N/cm² for NOMEX® Type 419

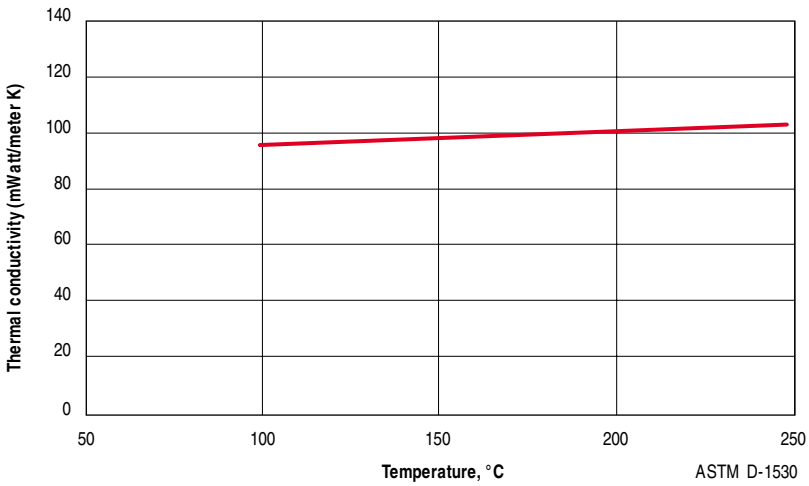
[2] ASTM D-646

[3] ASTM D-828

[4] TAPPI 414

[5] ASTM D-1004. Data presented for Initial Tear Strength is listed in the direction of the sample per ASTM D-1004. 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.

Figure 5 – THERMAL CONDUCTIVITY VS. TEMPERATURE NOMEX® TYPE 418 – 0.25 MM (10 MIL)



The Limiting Oxygen Index (LOI) of NOMEX® Type 418 – 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® Type 418 must be heated to more than 700°C before its LOI declines below the flammability threshold.

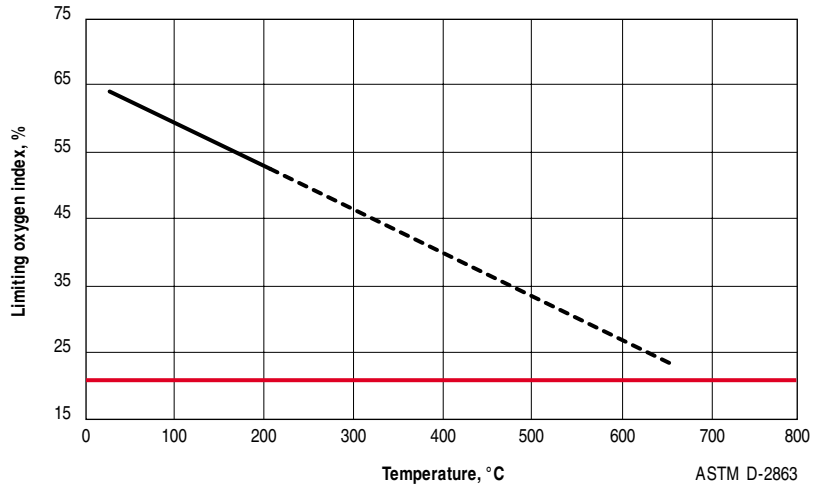
The effect of 64 Mgy (6400 megarads) of 2 MeV beta radiation on the mechanical and electrical properties of NOMEX® paper Type 418 is shown in Table III. (By comparison, a laminate of polyester film and polyester mat of the same thickness, 100% epoxy-impregnated, crumble after 8 Mgy (800 megarads). Similar 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 TO 2 MEV ELECTRONS (BETA RAYS) NOMEX® TYPE 418 – 0.25 MM (10 MIL)

(Mgy) Dose		0	1	2	4	8	16	32	64
Tensile strength[1] (% of original)	MD	100	96	100	100	100	100	87	88
	XD	100	99	100	91	93	90	96	78
Elongation[1] (% of original)	MD	100	100	100	91	64	46	46	27
	XD	100	86	93	79	64	43	50	21
Dielectric strength[2] (kV/mm)		54	54	55	54	48	53	56	52
Dielectric constant[3]	60Hz	3.9	3.6	3.8	3.9	3.5	3.4	2.5	2.9
	1Hz	3.3	3.0	3.3	3.4	3.1	3.0	2.3	2.7
	10Hz	2.9	2.7	2.9	3.0	2.7	2.7	2.1	2.6
Dielectric Factor[3] ($\times 10^{-3}$)	60Hz	103	94	79	93	87	95	67	48
	1Hz	96	93	82	91	82	83	53	40
	10Hz	76	81	75	85	76	73	40	31

[1] ASTM D-828 [2] ASTM D-149 with a 6,4 mm (1.4 inches) electrode [3] ASTM D-150

Figure 6 – LIMITING OXYGEN INDEX (LOI) NOMEX® TYPE 418 – 0.13 MM (5 MIL)



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