



MANUFACTURERS OF
ELECTRICAL INSULATION MATERIALS

INSULATING COMPONENTS FOR
POWER SYSTEMS EQUIPMENT

The Gund Company, Inc
St. Louis, Missouri – USA

TEL - 314.423.5200
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MATERIAL DATA SHEET

Item: Nomex™ Aramid Paper Type 410

Description: Nomex™ paper is produced from short length fibers called *floc* and small binder particles called *fibrids* of high temperature resistant aramid polymer. These constituents, *floc*, and *fibrids* are formed into a sheet structure on a Fourdrinier paper machine without the use of additional binders, fillers, or sizers. The products is then calendered with heat and pressure to densify it to a bulk specific gravity of 0.7 to 1.2 (depending on its thickness). The paper is available in rolls and sheets of various widths and in thickness of 2 to 30 mils (0.05 to 0.76 millimeters).

Type 410 paper also retains good electrical properties at high relative humidity as shown in Table II (page 2 of 3). The dielectric strength is essentially the same for Type 410 paper conditioned at 0 and 95% relative humidity. The dielectric constant dissipation, and volume resistivity are affected only slightly over the same range.

Nomex™ paper is fully suitable for continuous operation at 220°C (430°F). More than ten years of commercial experience with Nomex™ paper in a broad variety of high temperature electrical applications have verified these extrapolations. Measurements show, for example, that Nomex™ Type 410 Paper will maintain 300 volts/mil (12kV/mm) dielectric strength for several hours at 400°C (750°F), which is the performance predicted by extrapolating the Arrhenius curve. This means that Nomex™ paper offers outstanding protection against short-term high-temperature excursions caused by stalled rotors or other overload conditions.

The molecular structure responsible for the excellent thermal stability of Nomex™ Type 410 Aramid Paper also results in outstanding chemical stability and resistance to most common acids and alkalines. Nomex™ Type 410 paper is fully compatible and used commercially with transformer oils, silicones, and refrigerants. Nomex™ paper is also compatible with common classes of electrical varnishes and adhesives as well as other components of electrical equipment.

Performance in Oils:

The impulse dielectric strength of Nomex™ Type 410 paper impregnated with mineral oil is significantly better than that of impregnated kraft paper of the same thickness when tested with 125kV impulse generator.

Physical Properties:

Typically, physical properties of Nomex™ Type 410 paper at room temperature and 50% relative humidity, in both the machine direction (MD) and cross-machine direction (CMD), are listed in Table II (page 2 of 3).

The high temperature properties and thermal stability of Nomex™ paper are outstanding. With increasing temperature, there is a gradual decrease in tensile strength, such that at 225°C (435°F) it retains about two-thirds of its room temperature value. Break elongation remains relatively constant up to 200°C (390°F).

Nomex™ paper also retains good physical properties at very low temperatures. For example, at the temperature of liquid nitrogen, -196°C (-320°F), the tensile strength of 10 mil (0.25 millimeters) of Nomex™ Type 410 increases 30-60% over room temperature, while elongation to break exceeds 3% (better than most inorganic materials at room temperature). (Continued)



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(Continued from page 1) Water acts much like a plasticizer on Nomex™ paper. The rate of moisture pick-up of Nomex™ Type 410 paper at a given relative humidity and temperature varies inversely with the paper's thickness, density, and basis weight. At equilibrium, the percentage of moisture absorbed by Nomex™ paper is approximately one-tenth the relative humidity. The effect of relative humidity on the dimensions of Nomex™ paper is indicated in Table IV (page 3 of 3).

The optimum balance of properties of Nomex™ Type 410 paper is obtained at 3 – 5% moisture content which corresponds to equilibrium at 30 – 50% RH. Increasing the moisture content to 7% (based on dry weight) generally improves the paper's mechanical properties to the following extent: significant increases in elongation, toughness, fold endurance, and Finch and impact tear strength.

**Table I:
Electrical Properties of Nomex™ Aramid Paper Type 410**

Key Characteristics	Test Method	Units	Typical Values, Mils (Inches)					
			2 (0.05)	3 (0.08)	4 (0.10)	5 (0.13)	7 (0.18)	10 (0.25)
Dielectric Strength, AC Rapid Rise	ASTM D-149	V/mil	530	590	630	690	830	850
		kV/mm	21	23	25	27	33	34
Dielectric Constant	ASTM D-150	1000 Hz	2.0	2.1	2.2	2.3	2.5	2.6
Dissipation Factor	ASTM D-150	1000 Hz	0.007	0.008	0.009	0.010	0.012	0.014

Key Characteristics	Test Method	Units	Typical Values, Mils (Inches)					
			12 (0.30)	15 (0.38)	20 (0.51)	24 (0.61)	29 (0.74)	30 (0.76)
Dielectric Strength, AC Rapid Rise	ASTM D-149	V/mil	860	860	770	750	730	700
		kV/mm	34	34	30	30	29	28
Dielectric Constant	ASTM D-150	1000 Hz	2.8	3.0	3.3	3.3	3.3	3.4
Dissipation Factor	ASTM D-150	1000 Hz	0.015	0.016	0.018	0.018	0.019	0.020

**Table II:
Electrical Properties vs. Relative Humidity for Nomex™ Aramid Paper Type 410
(10 mil, 0.25 mm)**

Relative Humidity	Dielectric Strength		Dielectric Constant	Dissipation Factor	Volume Resistivity
%	V/mil	kV/mm	1000 Hz	1000 Hz	Ohm-cm
Dry Oven	960	38	2.3	0.013	6 x 10 ¹⁶
50	920	36	2.6	0.014	2 x 10 ¹⁶
95	880	35	3.1	0.025	2 x 10 ¹⁴

All of the information, suggestions, and recommendations pertaining to the properties and uses of the products herein are based upon tests and data believed to be accurate; however, the final determination regarding the suitability of any material described herein for the use contemplated, the manner of such use, and whether the use infringes any patents is the sole responsibility of the user. There is no warranty, expressed or implied, including, without limitation warranty of merchantability or fitness for a particular purpose. Under no circumstances shall we be liable for incidental or consequential loss or damage.



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**Table III:
Typical Properties of Nomex™ Type 410 Aramid Paper**

Electrical Properties	Test Method	Units	0.005"	0.010"	0.020"	0.030"
Dielectric Strength, AC Rapid Rise Full Wave Impulse 1250	ASTM D-149	V/mil	635	810	790	695
	ASTM D-3426		--	1,400	1,600	1,400
Dielectric Constant	ASTM D-150	--	2.4	2.7	3.4	3.7
Dissipation Factor	ASTM D-150	--	0.006	0.006	0.007	0.007
Mechanical Properties	Test Method	Units	0.005"	0.010"	0.020"	0.030"
Basis Weight	ASTM D-646	Oz./yd. ²	3.4	7.3	16.1	24.8
Specific Gravity	--	--	0.87	0.96	1.05	1.08
Tensile Strength MD CMD	ASTM D-828	lb./in.	80	175	375	520
			40	85	215	350
Tear Resistance MD CMD	ASTM D-1004	lb.	7.3	16.0	36.4	54.1
			3.6	9.2	24.1	43.0
Elmendorf Tear MD CMD	TAPPI-414	gm.	240	525	1173	n/a
			520	1010	2000	n/a
Shrinkage, 300°C (570°F)	--	%	0.7	0.5	0.3	0.3

**Table IV:
Effect of Relative Humidity on the Dimensions
of Nomex™ Aramid Paper Type 410**

Relative Humidity	% Increase Over Oven Dry Conditions			
	Dielectric Strength		Dielectric Constant	
%	MD	CMD	MD	CMD
50	0.4	0.9	0.4	0.9
65	0.6	1.2	0.6	1.4
95	0.9	1.7	1.1	2.1

MD = Machine Direction
CMD = Cross-Machine Direction

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