



DuPont™ Nomex® 356

Technical Data Sheet

Introduction to the Nomex® 300 Series

The Nomex® 300 Series is a family of insulation products for less-demanding electrical applications where the total capabilities of Nomex® 410 are not required. Designed specifically to address the less-demanding requirements and increased cost constraints of electrical applications, the Nomex® 300 Series provides good value-in-use. 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 E-56 or E-56A should know that these are the identical materials to those now designated as Nomex® 356.

The Nomex® 300 Series is based on the same technologies as Nomex® 410, offering outstanding performance and reliability while featuring less mechanical and electrical

strength compared to Nomex® 410. So, when you need a cost-effective solution for your less-demanding electrical applications and you want the proven performance and long-term reliability of Nomex® brand electrical insulation, choose the Nomex® 300 Series.

Nomex® 356

Nomex® 356 is a medium-density paper that exhibits properties that are midway between high-density Nomex® 410 paper and low-density Nomex® 411 paper. Nomex® 356 is designed for use as layer insulation within transformers and as phase insulation in hand-wound motors, with layer insulation in liquid immersed transformers being one of the best applications. Nomex® 356 is produced in seven thicknesses ranging from 0.08 mm (3 mil) to 0.51 mm (20 mil), with densities ranging from 0.66 g/cc to 0.71 g/cc.

Electrical Properties in Air

The electrical property values for Nomex® 356 paper are shown in Table I. The AC Rapid Rise dielectric strength data of 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 dry type applications not exceed 1.6 kV/mm (40 V/mil) to minimize the risk of partial discharges (corona). Because the major difference between Nomex® 356 papers and Nomex® 410 papers is the density, its electrical properties in air are expected to react similarly to temperature changes up to and including 220°C. See Figure 1 of the Nomex® 410 Technical Data Sheet for reference. Variations in frequency up to 10⁴ Hz should also have no effect on the dielectric constant of Nomex® 356 paper, and dissipation factors are expected to remain below 15 x 10⁻³ up to these frequencies.

Table I. Typical Electrical Properties of DuPont™ Nomex® 356 Paper in Air

Property	Product Thickness, mm (mil)							Test Method
	0.08 (3)	0.13 (5)	0.18 (7)	0.25 (10)	0.30 (12)	0.38 (15)	0.51 (20)	
AC Rapid Rise Breakdown, V/mil kV/mm	440 17	445 18	490 19	490 19	510 20	530 21	520 21	ASTM D149 ¹
Full Wave Impulse Breakdown, V/mil kV/mm	825 32	825 32	850 33	900 35	825 32	825 32	825 33	ASTM D3426 ²
Dielectric Constant at 60 Hz	1.8	2.0	2.1	2.2	2.1	2.2	2.4	ASTM D150
Dissipation Factor at 60 Hz	6	6	6	5	5	5	9	ASTM D150

1. 50-mm electrodes, rapid rise, corresponds with IEC 60243-1, except for electrode set-up of 50 mm.
2. Using 50-mm electrodes.

Electrical Properties in Fluids

Table II provides data comparing the thin grades of Nomex® 356 paper to Nomex® 410 paper after impregnation in mineral oil. Although the dielectric strength values of Nomex® 356 are lower than those for

Nomex® 410 when tested in air, the impregnated Nomex® 356 paper allows for higher dielectric strength than the equivalent thickness of Nomex® 410 paper. This characteristic has led to this material being widely adopted as

layer insulation in high-temperature liquid immersed transformers. Similar improvements would be expected with other dielectric fluids such as esters or silicone fluids.

Table II. Typical Electrical Properties of DuPont™ Nomex® 356 and Nomex® 410 in Mineral Oil*

Property	Product						Test Method
	Nomex® 356	Nomex® 410	Nomex® 356	Nomex® 410	Nomex® 356	Nomex® 410	
Nominal Thickness, mm mil	0.08 3	0.08 3	0.13 5	0.13 5	0.25 10	0.25 10	ASTM D374
AC Rapid Rise Breakdown, V/mil kV/mm	1880 74			2130 84	1700 67	1580 62	ASTM D149 ¹
Full Wave Impulse Breakdown, V/mil kV/mm	3600 141	3250 128	3950 156	3200 126	4100 161	3250 128	ASTM D3426 ²

*Values shown above were measured at 23°C after drying at 120°C until bone dry and impregnating in mineral oil.
1. 50-mm electrodes, rapid rise, corresponds with IEC 60243-1, except for electrode set-up of 50 mm.
2. Using 50-mm electrodes.

Mechanical Properties

The mechanical property values for Nomex® 356 paper are shown in Table III. The effects of temperature on tensile strength and elongation of Nomex® 356 paper should be similar to that of Nomex® 410 paper. For reference, see Figure 5 of the Nomex® 410 Technical Data Sheet.

The dimensions of bone-dry Nomex® 356 paper, when exposed to 95% relative humidity

(RH) conditions, will increase in size due to moisture absorption. This swelling is largely reversible when the paper is re-dried. The rate of change in dimensions will depend, of course, on paper thickness and configuration (e.g., individual sheets versus tightly wound rolls). Variations in environmental humidity will usually produce dimensional changes that should 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® paper intended for such applications should be kept sealed in its protective polyethylene wrapper to maintain uniform moisture content until just before use.

Table III. Typical Mechanical Properties of DuPont™ Nomex® 356 Paper

Property	Product Thickness, mm (mil)							Test Method
	0.08 (3)	0.13 (5)	0.18 (7)	0.25 (10)	0.30 (12)	0.38 (15)	0.51 (20)	
Typical Thickness, mm mil	0.09 3.35	0.13 5.1	0.18 7.0	0.25 9.8	0.29 11.4	0.36 14.1	0.48 19.0	ASTM D374 ¹
Basis Weight, g/m ²	56	86	119	164	194	254	334	ASTM D646
Density, g/cc	0.66	0.67	0.67	0.66	0.67	0.71	0.69	ASTM D646
Tensile Strength, N/cm MD XD	51 27	66 35	106 57	156 82	174 97	548 131	311 171	ASTM D882
Elongation, % MD XD	10.1 8.8	8.9 10.4	12.2 12.4	12.4 12.7	13.5 13.6	15.7 13.5	15.8 15.3	ASTM D882
Tear Strength, N MD XD	15 10	25 13	34 19	45 27	54 34	67 43	93 58	ASTM D1004 ²

MD = Machine Direction, XD = Cross Machine Direction

1. Method D, using 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 machine direction initial tear strength, the paper will be tougher to tear in the cross direction.

Thermal Properties

Arrhenius plots of thermal aging behavior for DuPont™ Nomex® brand papers are exemplified by Figures 7 and 8 of the Nomex® 410 Technical Data Sheet. Similar aging of Nomex® 356 paper at elevated temperatures has resulted in its recognition as a 220°C insulating material by the Underwriters Laboratory (UL). The thermal conductivity of Nomex® 356 — 0.25 mm (10 mil) paper is 83 milliWatts/meter K at 150°C. Because the density of all grades of Nomex® 356 are similar, the thermal conductivities are similar as well.

Chemical Stability

Nomex® papers are compatible 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. Because the major difference between Nomex® 356 papers and Nomex® 410 papers is the density, they too should be fully compatible with these compounds, as well as 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) (ASTM D2863) of Nomex® 356 — 0.13 mm (5 mil) paper at room temperature is 29%; at 220°C it is 24%. Materials with LOI above 20.8% (ambient air) will not support combustion. Nomex® 356 — 0.13 mm (5 mil) paper must be heated to above 320°C before its LOI declines below the flammability threshold.

Nomex® 356 paper is suitable for construction of electrical equipment having specific stringent requirements for fire safety. Nomex® aramid papers are widely used in applications for mining, oil & gas industry and railways. Nomex® 356 paper has been certified according to European Standard EN 45545-2 for “Fire protection of railway vehicles” and meets requirements for Hazard Level 1 and 2. If an insulation system of the electrical component is tested, such a system with Nomex® 356 paper can meet the highest classification of Hazard Level 3.

Nomex® 411 paper offers improved saturability of varnishes versus Nomex® 410 paper due to its more open structure. Because Nomex® 356 is a product whose density is between these two products, its saturability falls in between the two. While the exact amount of saturability difference depends on the specific varnish, application technique and product thickness, in one test using a silicone fluid, the saturability of Nomex® 356 was 3 times that of Nomex® 410 and 1/3 that of Nomex® 411.

UL Ratings

Table IV shows the UL ratings for Nomex® 356 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 <http://iq.ul.com/ul/cert.aspx?ULID=100119936>

Table IV. UL Yellow Card Information for DuPont™ Nomex® 356 Papers

Property	Product Thickness, mm (mil)							Test Method
	0.08 (3)	0.13 (5)	0.18 (7)	0.25 (10)	0.30 (12)	0.38 (15)	0.51 (20)	
Relative Temperature Index (RTI) Electrical	220	220	220	220	220	220	220	UL 746B
Relative Temperature Index (RTI) Mechanical	220	220	220	220	220	220	220	UL 746B
Flame Class	VTM-0	VTM-0	VTM-0	VTM-0	V-0	V-0	V-0	UL 746A
Hot Wire Ignition Rating (HWI)	0	0	0	0	0	0	0	UL 746A
High Current Arc Ignition Rating (HAI)	0	0	0	0	0	0	0	UL 746A
Comparative Tracking Index (CTI)	3	3	3	3	3	3	3	UL 746A
High-Voltage Arc Tracking Rate (HVTR)	3	3	3	3	3	3	3	UL 746A

For more information about DuPont™ Nomex® or for global product support, contact us in your region:

USA & Canada

1-800-931-3456
nomexpaper.dupont.com/contact

Latin America

01-800-849-7514
nomex.dupont.com.mx/contact

Brazil

+0800-17-17-15
nomex.dupont.com.br/contact

United Kingdom

es.nomex.co.uk/contact

Germany

es.nomex.de/kontakt

Japan

+81-3-5521-2801
dtpjc542.securesites.net/contact.php

Greater China

+86-400-8851-888
nomex.com/paper/cn/contact

India

+91 1800-419-0899
nomexpaper.dupont.co.in/contact

Korea

+82 2-2222-5220

Singapore

+65 6586-3688

Thailand

+662 659-4000

nomexpaper.dupont.com

The properties in this technical data sheet are 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.

Product safety information is available upon request. This information corresponds to our current knowledge on the subject. It is offered solely to provide possible suggestions for your own experimentations. It is not intended, however, to substitute for any testing you may need to conduct to determine for yourself the suitability of our products for your particular purposes. This information may be subject to revision as new knowledge and experience become available. Since we cannot anticipate all variations in actual end-use conditions, DUPONT MAKES NO WARRANTIES AND ASSUMES NO LIABILITY WHATSOEVER IN CONNECTION WITH ANY USE OF THIS INFORMATION. Nothing in this publication is to be considered as a license to operate under or a recommendation to infringe upon any trademark or patent right.

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