

NOMEX® TYPE E56

NOMEX® Type E56 is designed for cost-critical applications which require a moderate amount of mechanical and electrical strength. It is thermally similar to NOMEX® Type 410 (220°C UL component rated), but as a medium density paper, it exhibits properties that are midway between NOMEX® Type 410 and NOMEX® Type 411. NOMEX® Type E56 is currently offered in six thicknesses (0.13 to 0.51 mm) (5 to 20 mil), with a density from 0.66 to 0.68 g/cc. NOMEX® Type E56 is designed for use as layer insulation within transformers and as phase insulation in hand-wound motors. It can also be effectively used as electrical and thermal barriers in appliance and electronic equipment applications.

Electrical properties

The electrical property values for NOMEX® Type E56 paper 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 1.6 kV/mm (40 V/mil) to minimize the risk of partial discharges (corona).

The minor 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 E56 paper is chemically identical to NOMEX® Type 410 (differing only in density), its electrical properties are expected to react similarly to temperature changes up to and including 220°C. Variations in frequency up to 10⁴ Hz should also have no effect on the dielectric constant of NOMEX® Type E56 paper, and dissipation factors are expected to remain below 15 x 10⁻³ up to these frequencies.

The insensitivity of electrical performance to moisture (humidity) has already been shown for NOMEX® Type 410 paper in Table II of the NOMEX® Type 410 data sheet. Since NOMEX® Type E56 paper is chemically similar to NOMEX® Type 410, it too is expected to be similarly insensitive to moisture and humidity.

TECHNICAL DATA SHEET

Mechanical properties

The mechanical property values for NOMEX® Type E56 paper are shown in Table II. The effects of temperature on tensile strength and elongation are illustrated for NOMEX® Type 410 paper in Figure 5 of the NOMEX® Type 410 data sheet. These effects should be similar for NOMEX® Type E56 paper.

The dimensions of bone-dry NOMEX® Type E56 paper exposed to 95% R.H. 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 (for example, individual sheets versus tightly-wound rolls). Variations in environmental humidity will

Please note:

These properties are preliminary average values and cannot be used as specification limits. Unless otherwise noted, all properties were measured 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 is necessary to orient the paper in the optimum direction to obtain its maximum potential performance.

Table I — **TYPICAL ELECTRICAL PROPERTIES**

Nominal thickness (mil) (mm)	5 0.13	7 0.18	10 0.25	12 0.30	15 0.38	20 0.51
Dielectric strength						
- AC rapid rise ¹⁾ (V/mil) (kV/mm)	390 15	460 18	470 19	460 18	510 20	515 20
- Full wave impulse ²⁾ (V/mil) (kV/mm)	950 37.4	925 36.4	900 35.4	825 32.5	850 33.5	900 35.4
Dielectric constant ³⁾ at 60 kHz	1.7	2.1	2.2	2.1	2.2	2.4
Dissipation factor ³⁾ at 60 Hz (x10 ⁻³)	5	6	5	5	5	9

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

²⁾ ASTM D-3426

³⁾ ASTM D-150

usually produce dimensional changes which 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.

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 E56 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® Type E56 0.25mm (10 mil) paper is 83m Watt/meter K at 150°C. As the density of all grades NOMEX® Type E56 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

Table II – **TYPICAL MECHANICAL PROPERTIES**

Nominal thickness (mil) (mm)		5	7	10	12	15	20
		0.13	0.18	0.25	0.30	0.38	0.51
Typical thickness ¹⁾ (mil) (mm)		5.3	6.9	10.0	11.6	15.1	20.2
		0.13	0.18	0.25	0.29	0.38	0.51
Basis weight ²⁾ (g/m ²)		87	120	171	196	257	342
Density (g/cc)		0.66	0.68	0.67	0.67	0.67	0.67
Tensile strength (N/cm)	MD	65	112	152	165	224	299
	XD	31	49	77	93	116	163
Elongation ³⁾ (%)	MD	7.8	10.8	10.6	10.3	11.8	11.9
	XD	8.9	12.0	13.4	11.1	19.5	12.8
Initial tear strength ⁴⁾ (N)	MD	25	38	51	55	78	101
	XD	13	17	25	34	42	56

¹⁾ ASTM D-374, method D using 5 N/cm²

²⁾ ASTM D-646

³⁾ ASTM D-828

⁴⁾ 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.

electrical equipment. Since NOMEX® Type E56 papers are identical chemically to the rest of NOMEX® papers, they too should be fully compatible with these compounds as well as transformer fluids (mineral and silicone oils and other synthetics) and with lubricating oils and refrigerants used in hermetic systems. The Limiting Oxygen Index (ASTM D-2863) of E56/0.13 mm paper at room temperature is 29%, and is 24% at 220°C. Materials with LOI above 20.8% (ambient air) will not support combustion. NOMEX® Type E56/0.13 mm (5 mil) must be heated to above 320°C before its LOI declines below the flammability threshold.

NOMEX® Type 411 paper offers improved saturability of varnishes versus NOMEX® Type 410 paper due to its more open structure. Since NOMEX® Type E56 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 Type E56 was 3 times that of Type 410 and 1/3 that of Type 411.

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