

NOMEX® TYPE 994

Type 994 is a densified, rigid board which has a unique combination of superior resistance to compression, even at elevated temperatures, along with relatively high oil absorption characteristics. This combination results in a product which is especially useful as spacers or other structural components in liquid-filled systems. With a specific gravity ranging from 1.1 to 1.2, Type 994 pressboard is available in 14 thicknesses from 1.0 to 9.6 mm (40 to 380 mils), as is shown in Table I.

Electrical properties

The typical electrical property values for Type 994 pressboard in air and oil are shown in Tables II and III. The AC Rapid Rise dielectric strength data of Table III represent voltage stress levels withstood for 10 to 20 second time periods at a frequency of 60 Hz. These values differ from long-term strength potential. DuPont recommends that continuous stresses in dry-type transformers not exceed 1.6 kV/mm (40V/mil) to minimize the risk of partial discharges (corona). The Full Wave Impulse dielectric strength data of Table III 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.

The data in Tables II and III are representative of data for all thicknesses of Type 994. Type 994

pressboard will pick up 8 to 10% oil by weight, with the oil absorption being inversely related to density. This impregnability is rare among rigid insulating materials. As with Type 410 paper, the values for the properties listed will vary somewhat with changes in thickness and density. The effects of temperature on dielectric strength and dielectric constant are shown for Type 410 paper in Figure 1 of the Type 410 data sheet. Since Type 994 pressboard is chemically identical to Type 410 paper, its electrical properties will react similarly to temperature changes.

Table I – TYPICAL PROPERTIES

Nominal (mm)	1.0	1.5	2.0	2.5	3.0	3.2	4.0	4.8	5.0	6.0	6.4	7.0	8.0	9.6
Thickness (mil)	40	60	80	100	120	125	160	190	200	240	250	275	315	380
Typical ¹⁾ (mm)	1.00	1.49	2.00	2.50	3.01	3.18	4.01	4.78	5.01	6.00	6.34	7.01	8.02	9.62
Thickness (mil)	39	59	79	98	118	125	158	188	197	236	250	276	316	379
Basis														
Weight ²⁾ (kg/m ²)	1.15	1.71	2.31	2.88	3.45	3.66	4.55	5.48	5.69	6.77	7.15	8.04	9.07	11.07
Density ³⁾ (g/cc)	1.15	1.15	1.15	1.15	1.15	1.15	1.14	1.15	1.14	1.13	1.13	1.15	1.13	1.15

¹⁾ ASTM D-374; Method D, using 17 N/cm²

²⁾ ASTM D-3394

³⁾ Calculated using basis weight and thickness

Table II – TYPICAL ELECTRICAL PROPERTIES IN AIR

Nominal Thickness (mm)	3.2	6.4
Dielectric Constant ¹⁾ at 60 Hz	3.5	3.5
Dissipation Factor ¹⁾ at 60 Hz (x10 ⁻³)	7	10
Volume Resistivity ²⁾ (ohm-m)	10 ¹⁴	10 ¹⁴
Surface Resistivity ²⁾ (ohm/square)	10 ¹⁷	10 ¹⁷

Values shown above were measured at 23°C after drying at 120°C until bone dry

¹⁾ ASTM D-150

²⁾ ASTM D-257

TECHNICAL DATA SHEET

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 boardmaking technology, NOMEX® brand pressboards have somewhat different properties in the boardmaking machine direction (MD) compared to the cross direction (XD). In some applications it may be necessary to orient the board in the optimum direction to obtain its maximum potential performance.

Mechanical properties

The typical mechanical property values for Type 994 pressboard are shown in Table IV. These data are representative of data for all thicknesses of Type 994. As with Type 410 paper, the values for the properties listed will vary somewhat with changes in thickness and density. The effects of temperature on tensile strength and elongation are illustrated for Type 410 paper in Figure 5 of the Type 410 data sheet. The effects of exposure to high temperatures will be similar for Type 994 pressboard. As with Type 410 papers, the tensile strength of Type 994 pressboard at minus 196°C (77K) exceeds its room temperature value while elongation to break is still greater than 3%. This makes Type 994 an excellent candidate for cryogenic applications.

Table III – TYPICAL ELECTRICAL PROPERTIES IN OIL

Nominal Thickness (mm)	3.2	
Dielectric Strength - AC rapid rise ¹⁾ (kV/mm)	27	
Dielectric Strength - Full wave impulse ²⁾ (kV/mm)	70	
Dielectric Constant ³⁾ at 60 Hz	25°C – 4.0	125°C – 4.4
Dissipation Factor ³⁾ ($\times 10^{-3}$) at 60 Hz	25°C – 11	125°C – 16
Volume Resistivity ⁴⁾ (ohm-m)	25°C – 10^{15}	125°C – 10^{13}

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

²⁾ ASTM D-3426

³⁾ ASTM D-150

⁴⁾ ASTM D-257

Table IV – TYPICAL MECHANICAL PROPERTIES

Nominal Thickness (mm)		3.2	6.4
Tensile Strength ¹⁾ (kN/cm ²)	MD	10.7	11.0
	XD	9.3	7.2
Flex Modulus ²⁾ (kN/cm ²)	MD	360	415
	XD	255	365
Flexure Strength ²⁾ (kN/cm ²)	MD	9	9
	XD	8	8
Izod Impact ³⁾ (joules/m)	MD	545	355
	XD	375	285
Shear Strength ⁴⁾ (kN)		43	68
Hardness ⁵⁾ (shore D)		84	84
Elongation ¹⁾ (%)	MD	18	22
	XD	17	20
Shrinkage at 240°C ⁶⁾ (%)	MD	0.0	0.2
	XD	0.0	0.2
Compressibility ⁶⁾ (%)		1.1	1.2
Compression Set ⁶⁾ (%)		0.3	0.2

¹⁾ ASTM D-828

²⁾ ASTM D-790

³⁾ ASTM D-256

⁴⁾ ASTM D-732

⁵⁾ ASTM D-2240

⁶⁾ ASTM D-3392

Thermal properties

Arrhenius plots of thermal aging behavior for NOMEX® brand materials are exemplified by Figures 7, 8 and 9 of the Type 410 data sheet. Similar aging of Type 994 pressboard at elevated temperatures has resulted in its recognition as a 220°C insulating material.

The thermal conductivity of 3.2 mm (125 mil) Type 994 pressboard is shown in Figure 1 as a function of temperature. DuPont has also tested the thermal conductivity of this product impregnated with various types of transformer fluids. This data is available upon request.

Chemical stability

The compatibility of NOMEX® brand 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® papers and pressboards are also compatible with transformer fluids, including mineral and silicone oils, ester fluids, high temperature hydrocarbon fluids and other synthetic fluids.

The Limiting Oxygen Index (LOI) of 6.4 mm (250 mil) Type 994 pressboard at room temperature is 39%, declining to 29% at 220°C. Materials with LOI above 20.8% (ambient air) will not support combustion. 6.4 mm (250 mil) Type 994 pressboard must be heated to above 380°C before its LOI declines below the flammability threshold, as is shown in Figure 2.

Figure 1 – **THERMAL CONDUCTIVITY VS. TEMPERATURE** 3.2 mm (125 mil) Type 994

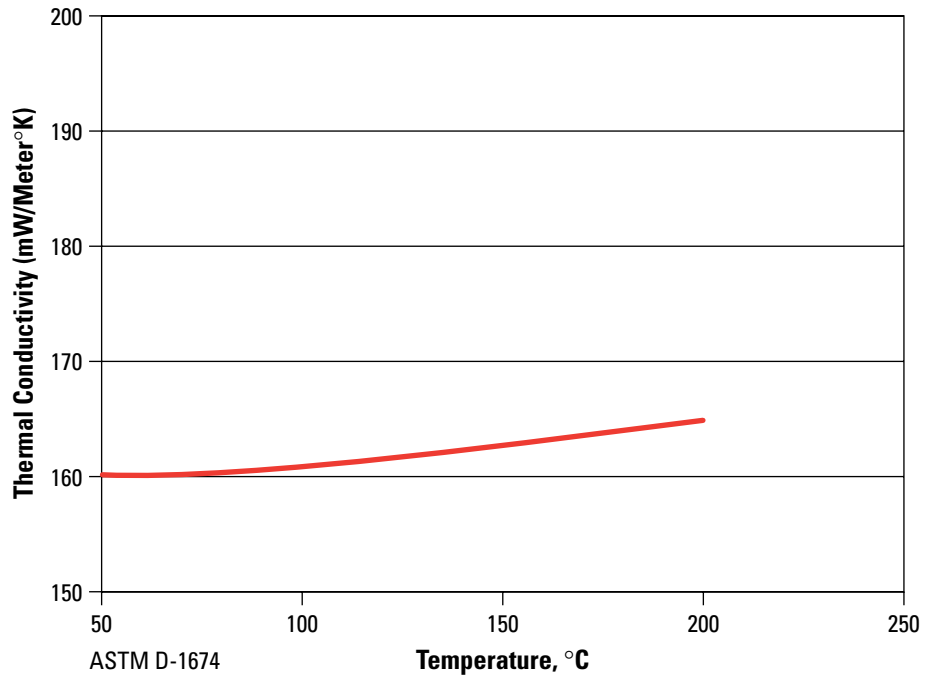
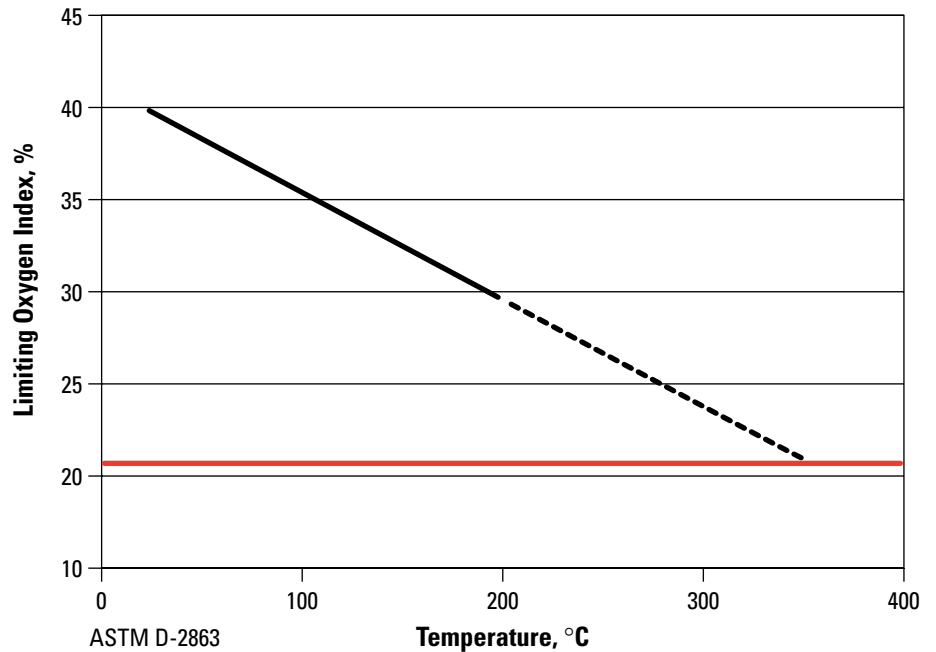


Figure 2 – **LIMITING OXYGEN INDEX (LOI)** 6.4 mm (250 mil) Type 994



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