

DuPont™ Nomex® Pressboard

Technical Data Sheet

Introduction

DuPont™ Nomex® pressboards are available in a range of densities to meet the specific needs of your application. Nomex® 992 PSB is the least dense product and is designed for applications requiring a combination of electrical, mechanical and forming characteristics, such as barrier, gap spacers, end fillers, core tubes and coil yokes. Non-electrical applications include thermal barriers and gaskets. Nomex® 992 PSB offers a balance of superior formability, outstanding saturability and strong thermal performance, along with good electrical properties. This cost-effective pressboard product should only be used where the superior electrical properties of Nomex® 993 PSB are not required. Nomex® 992 PSB is available in two thicknesses — 1.6 and 3.2 mm (63 and 125 mil).

Nomex® 993 PSB is a medium-density pressboard that offers a balance of rigidity and conformability along with outstanding saturability and excellent properties in air and oil. Typical applications include three-dimensional parts such as V-rings,

angle rings and spools, as well as barrier, gap spacers and core tubes. Nomex® 993 PSB is available in six thicknesses ranging from 1.0 to 4.0 mm (39 to 160 mils).

For the highest level of density, Nomex® 994 PSB is a densified, rigid board that 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 that is especially useful as spacers or other structural components in liquid-immersed systems. With a specific gravity ranging from 1.1 to 1.2, Nomex® 994 PSB is available in 11 thicknesses from 1.0 to 9.6 mm (39 to 380 mils).

Table I summarizes the various thickness ranges and sheet sizes available for each product.

Electrical Properties

The typical electrical property values for Nomex® pressboards are shown in Tables II and III. The AC Rapid Rise dielectric strength data 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 (40 V/mil) to minimize the risk of partial discharges (corona) in the air adjacent to the solid insulation. The Full Wave Impulse dielectric strength data of Tables II and 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 electrical properties are enhanced in liquids due to the excellent impregnability of Nomex® pressboards. Nomex® 992 PSB is highly impregnable and will pick up 100% to 110% mineral oil by weight. Nomex® 993 PSB will pick up 30% to 60% oil by weight as the oil absorption is inversely related to density, while Nomex® 994 PSB will pick up 8% to 10% mineral oil by weight. This level of impregnability is rare among rigid insulating materials.

Table I—DuPont™ Nomex® Pressboard Products and Typical Sheet Size Availability

Product	Thicknesses available (mm)	Thickness range (mils)	Sheet width range (mm)	Sheet length range (mm)	Sheet width range (in.)	Sheet length range (in.)
Nomex® 992 PSB	1.6, 3.2	63, 125	1067	1040 to 2100	42	41 to 83
Nomex® 993 PSB	1, 1.5, 2, 2.4, 3, 4	40, 60, 80, 95, 120, 160	1067 to 1600	1040 to 3150	42 to 63	41 to 124
Nomex® 994 PSB	1, 1.5, 2	40, 60, 80	700 to 720	2200	28	86.5
	2.5, 3, 4, 5, 6, 7, 8, 9.6	100, 120, 160, 200, 240, 275, 315, 380	355	1500	14	59

Table II—Typical Electrical Properties of DuPont™ Nomex® Pressboard in Air

	Nomex® 992 PSB		Nomex® 993 PSB						Nomex® 994 PSB		Test method
	1.6	3.2	1.0	1.5	2.0	2.4	3.0	4.0	3.0	6.0	
Nominal thickness (mm)	1.6	3.2	1.0	1.5	2.0	2.4	3.0	4.0	3.0	6.0	
Dielectric strength—AC rapid rise ¹ (kV/mm)	16	14	21	22	20	20	20	19			ASTM D149
Dielectric strength—full wave impulse (kV/mm)	27	32									ASTM D3426
Dielectric constant at 60 Hz	1.7	1.7							3.5	3.5	ASTM D150
Dissipation factor at 60 Hz (x10 ⁻³)	10	20							7	10	ASTM D150
Volume resistivity (ohm-m)									10 ¹⁴	10 ¹⁴	ASTM D257
Surface resistivity (ohm/square)									10 ¹⁷	10 ¹⁷	

¹ASTM D149, 50-mm electrodes, rapid rise; corresponds with IEC 60243-1, subclause 10.1, except for electrode setup of 50 mm.

Table III—Typical Electrical Properties of DuPont™ Nomex® Pressboard in Mineral Oil

	Nomex® 992 PSB		Nomex® 993 PSB			Nomex® 994 PSB			Test method
	1.6	3.2	1.5	3.0	4.0	1.0	2.0	3.0	
Nominal thickness (mm)	1.6	3.2	1.5	3.0	4.0	1.0	2.0	3.0	
Dielectric strength									
AC rapid rise ¹ (kV/mm)	31	26	34	30	27	68	68	27	ASTM D149
Full Wave Impulse (kV/mm)	71	63	73	62	60	105	110	70	ASTM D3426
Dielectric constant at 60 Hz									
20° C–25° C	2.8	3.0	3.2	3.5	3.6	3.4	3.3	4.0	ASTM D150
90° C	2.8	3.0	3.2	3.5	3.7				
125° C–130° C	2.8	3.0	3.3	3.7	3.8	3.7	3.2	4.4	
Dissipation factor (x10 ⁻³) at 60 Hz									
20° C–25° C	3	4	5	6	7	>10	>10	11	ASTM D150
90° C	3	3	5	5	5				
125° C–130° C	4	4	7	7	6	>10	>10	16	
Volume resistivity (ohm-m)									
20° C–25° C	10 ¹⁵	10 ¹⁵						10 ¹⁵	ASTM D257
90° C	10 ¹⁴	10 ¹⁴	10 ¹⁶	10 ¹⁶	10 ¹⁶				
125° C–130° C	10 ¹³	10 ¹³	10 ¹⁵	10 ¹⁵	10 ¹⁵			10 ¹³	

¹ASTM D149, 50-mm electrodes, rapid rise; corresponds with IEC 243-1, subclause 9.1, except for electrode setup of 50 mm.

Mechanical Properties

The typical mechanical property values for Nomex® pressboards are shown in Tables IV and V. It can be observed that as the density increases from Nomex® 992 PSB to Nomex® 993 PSB, to Nomex® 994 PSB, the tensile properties improve proportionately. The effects of temperature on tensile strength and elongation

are illustrated for Nomex® 410 paper in Figure 5 of the Nomex® 410 technical data sheet. The effects of short-term exposure to temperatures up to and including 220° C will be similar for Nomex® pressboard. In addition, however, the tensile strength of Nomex® 992 PSB and Nomex® 993 PSB can be significantly increased

through heat treatment under certain specific conditions. Contact DuPont for information regarding heat treatment or for the shaping of three-dimensional parts from these two products.

Table IV—Typical Mechanical Properties of DuPont™ Nomex® 992 PSB and Nomex® 993 PSB									
	Nomex® 992 PSB		Nomex® 993 PSB						Test method
Nominal thickness (mm)	1.6	3.2	1.0	1.5	2.0	2.4	3.0	4.0	
Typical thickness ¹									
(mm)	1.60	3.10	1.04	1.52	2.02	2.40	3.02	4.15	ASTM D374 ¹
(mils)	63	123	41	60	80	94	119	163	
Basic weight (g/m ²)	810	1630	735	1110	1590	1770	2202	3494	ASTM D646
Density ² (g/m ³)	0.52	0.53	0.71	0.74	0.79	0.77	0.75	0.87	ASTM D3394
Tensile strength (kN/cm ²)									
MD	2.2	2.4	3.2	3.8	4.4	4.4	4.0	4.9	ASTM D828
XD	1.8	1.9	2.8	3.3	3.8	3.7	3.4	4.1	
Elongation (%)									
MD	9	10	13	14	15	12	13	14	ASTM D828
XD	9	10	14	15	16	12	14	14	
Shrinkage at 105° C (%)									
MD	0.4	0.5	0.6	0.7	0.7	0.8	0.7	0.4	ASTM D3394/D644
XD	0.7	0.7	0.9	1.0	1.1	1.1	1.0	0.6	
Shrinkage at 240° C (%)									
MD	0.9	1.2	1.1	1.5	1.1	1.2	1.2	1.2	ASTM D3394/D644
XD	1.4	1.3	1.6	1.6	2.0	1.8	1.8	1.5	
Oil absorption ³ (%)	110	100	60					30	ASTM D3394

¹ ASTM D374, method D, using 17 N/cm².

² Calculated number using basis weight and thickness.

³ Type 2 mineral oil of ASTM D3487, as per D3394/Section 75.

Table V—Typical Mechanical Properties of DuPont™ Nomex® 994 PSB

	Nomex® 994 PSB											Test method
Nominal thickness (mm)	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0	7.0	8.0	9.6	
Typical thickness ¹												
(mm)	1.00	1.52	1.98	2.56	3.01	4.01	5.01	6.00	7.01	8.02	9.62	ASTM D374 ¹
(mils)	39	60	78	101	118	158	197	236	276	316	379	
Basic weight (kg/m ²)	1.16	1.8	2.32	2.94	3.45	4.55	5.69	6.77	8.04	9.07	11.07	ASTM D646
Density ² (g/cm ³)	1.17	1.17	1.17	1.15	1.15	1.14	1.14	1.13	1.15	1.13	1.15	ASTM D3394
Tensile strength (kN/cm ²)												
MD	14	12	12	11	11			11				ASTM D828
XD	9	10	10	9	9			7				
Elongation (%)												
MD	15	13	12	15	18			22				ASTM D828
XD	15	14	13	14	17			20				
Shrinkage at 240° C (%)												
MD					0			0.2				ASTM D3394/ D644
XD					0			0.2				
Oil absorption ³ (%)	10		10		8			8				ASTM D3394

¹ ASTM D374, method D, using 17 N/cm².

² Calculated number using basis weight and thickness.

³ Type 2 mineral oil of ASTM D3487, as per D3394/Section 75.

Because of the special applications for the very rigid and dense Nomex® 994 PSB, such as spacers, washers and other structural components, there is a need for special properties that characterize the performance of Nomex® 994 PSB in these kinds of applications. These are shown for three thicknesses in Table VI and would be typical of all grades of Nomex® 994 PSB.



Table VI—Typical Special Mechanical Properties of DuPont™ Nomex® 994 PSB				
Nominal thickness (mm)	1.0	3.0	6.0	Test method
Flex modulus (kN/cm ²)				
MD		360	415	ASTM D790
XD		255	365	
Flexure strength (kN/cm ²)				
MD		9	9	ASTM D790
XD		8	8	
Izod impact (joules/m)				
MD		545	355	ASTM D256
XD		375	285	
Shear strength (kN)	13	43	68	ASTM D732
Hardness (shore D)	84	84	84	ASTM D2240
Compressibility (%)	1.2	1.1	1.2	ASTM D3394 method A
Compression set (%)	0.1	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

Nomex® pressboards have thermal performance consistent with Nomex® 410 papers. As such, some of our pressboards have UL component recognition at 220° C. If you need information about which are covered, please contact UL.

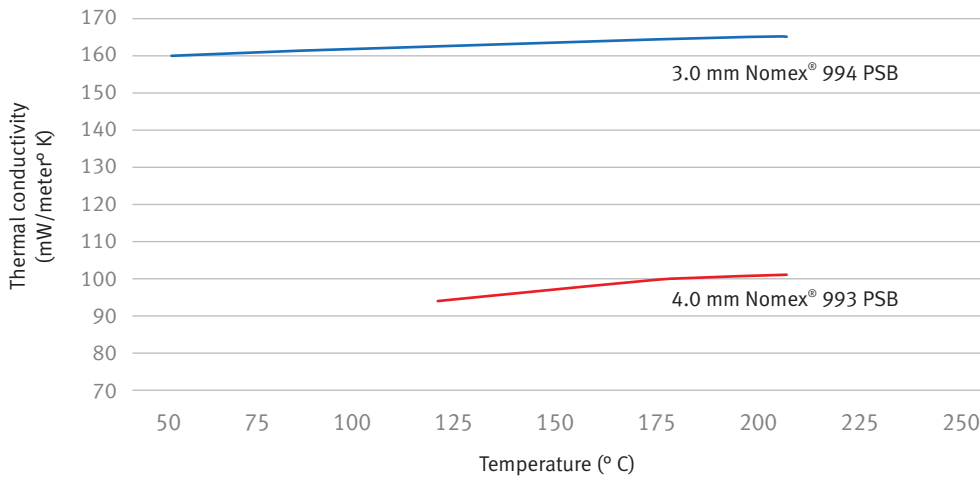
The effects of temperature on dielectric properties of Nomex® 993 PSB are shown in Table VII. The effects on dielectric strength are shown for Nomex® 410 paper in Figure 1 of the Nomex® 410 technical data sheet.

Because Nomex® pressboard is chemically essentially identical to Nomex® 410 paper (differing only in structure), its electrical properties will react similarly to temperature changes up to and including 220° C.

Table VII—Effect of Temperature on Electrical Properties of DuPont™ Nomex® 993 PSB — Nominal Thickness (mm) 3.0 mm (120 mil)					
Temperature (° C)	23	50	100	150	220
Dielectric constant ¹ at 60 Hz	2.6	2.6	2.7	2.8	2.9
Dissipation factor ¹ at 60 Hz (x10 ⁻³)	15	12	5	6	12
Volume resistivity ² (ohm-m)	10 ¹⁷	10 ¹⁶	10 ¹⁶	10 ¹⁵	10 ¹³
Surface resistivity ² (ohm/square)	10 ¹⁷	10 ¹⁷	10 ¹⁷	10 ¹⁶	10 ¹⁵

Values shown above were measured at 23° C after drying at 120° C until bone dry.
¹ ASTM D150.
² ASTM D257.

Figure 1—Thermal Conductivity vs. Temperature of DuPont™ Nomex® Pressboard—ASTM E1530-11



Thermal Conductivity

The thermal conductivities of all three pressboard materials in air are outlined below. DuPont has also tested the thermal conductivity of these products impregnated with various types of transformer insulating liquids. This data is available upon request.

Nomex® 992 PSB

The thermal conductivity of 3.2 mm (125 mil) Nomex® 992 PSB is 73 mW/meter° K at 150° C in air. For thermal barrier applications, trade-supplied metallized versions of Nomex® 992 PSB are available if appropriate for the design.

Nomex® 993 PSB

The thermal conductivity of 4.0 mm (160 mil) Nomex® 993 PSB in air is shown in Figure 1 as a function of temperature. The graph is similar to those for cellulosic boards and, as with most materials, is primarily affected by density. Thinner, less dense grades of Nomex® 993 PSB will have slightly lower conductivities, and thicker, denser grades will have higher conductivities.

Nomex® 994 PSB

The thermal conductivity of 3.0 mm (120 mil) Nomex® 994 PSB is shown in Figure 1 as a function of temperature.

Chemical Stability

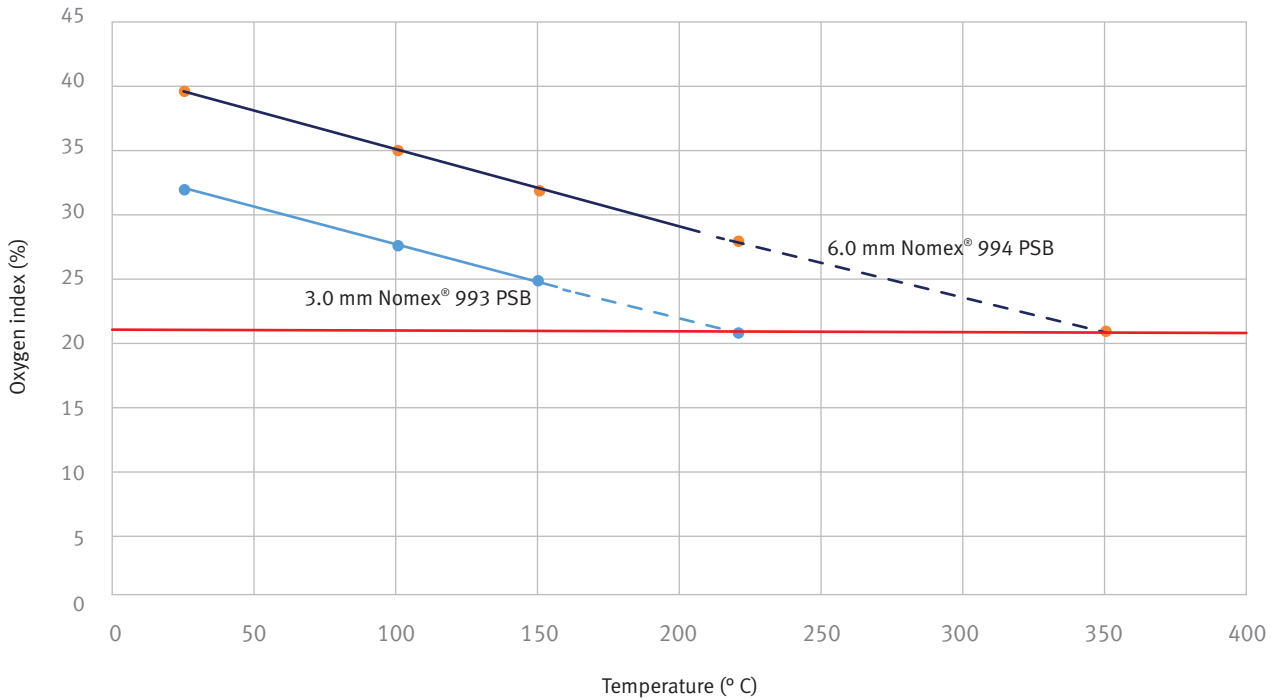
The compatibility of Nomex® brand paper and pressboard with virtually all classes of electrical varnishes and adhesives (polyimides, silicones, epoxies, polyesters, acrylics, phenolics, synthetic rubbers, etc.), as well as other components of electrical equipment, is demonstrated by the many UL-recognized systems that include Nomex® materials, as well as long-standing commercial experience. Nomex® papers and pressboards are also compatible with transformer insulating liquids, including mineral and silicone liquids, natural ester liquids and other synthetics.

The Limiting Oxygen Index (LOI) and Oxygen Index (OI)(ASTM D2863) are terms used interchangeably in general literature. The term LOI was used previously in our literature. For the sake of clarity and industry uniformity with ASTM, we will use OI in this document; however, the term LOI may still be referenced and is the same number. The OI of Nomex® pressboards varies with temperature, thickness and density. Materials, like Nomex® pressboard, with an OI above 20.9% (ambient air) will not support combustion in air. The OI of 3.2 mm (125 mil) Nomex® 992 PSB at room temperature is 29%. The room temperature OI of 1.6 mm (63 mil) Nomex® 992 PSB is 28%.

The OI of 3.0 mm (120 mil) Nomex® 993 PSB at room temperature is 32%, declining to 23% at 180° C, and it must be heated above 230° C before its OI declines below the flammability threshold, as shown in Figure 2.

The OI of 6.4 mm (250 mil) Nomex® 994 PSB at room temperature is 39%, declining to 29% at 220° C. And, 6.0 mm (240 mil) Nomex® 994 PSB must be heated to above 350° C before its OI declines below the flammability threshold, as shown in Figure 2.

Figure 2—Oxygen Index (OI) of DuPont™ Nomex® Pressboard—ASTM D2863



UL Ratings

Table VIII shows the UL ratings for Nomex® pressboard. 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 [iq.ul.com/ul/cert.aspx?ULID=230948, 230949, 230950](http://iq.ul.com/ul/cert.aspx?ULID=230948,230949,230950)

Table VIII—UL Ratings for DuPont™ Nomex® Pressboard									
Pressboard type	Nominal thickness (mm)	Nominal thickness (mil)	UL94 flame class	UL746A HWI rating	UL746A HAI rating	UL746B RTI electrical	UL746B RTI mechanical	UL746A HVTR rating	UL746A CTI rating
Nomex® 992 PSB	1.6	63	V-0	1	NT	220	220	3	3
	3.2	126	V-0	0	NT	220	220	3	3
Nomex® 993 PSB	1.0	40	V-0	3	NT	220	220	2	3
	3.0	120	V-0	0	NT	220	220	2	3
	4.0	160	V-0	0	NT	220	220	2	3
Nomex® 994 PSB	4.0	160	V-0	1	NT	220	220	2	3
	6.0	240	V-0	1	NT	220	220	2	3
	9.6	380	V-0	1	NT	220	220	2	3

NT = Not tested.

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

01800-849-7514
nomex.dupont.com.mx/contact

Brazil

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

EUROPE

United Kingdom

es.nomex.co.uk/contact

Germany

es.nomex.de/kontakt

Japan

+81-3-5521-2801
chihirio.kondo@jpn.dupont.com

ASIA PACIFIC

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

This document provides a summary of the typical properties for the various types of Nomex® pressboard available in today's marketplace. For more general information about the sheet size availability, typical applications for each product and the processing recommendations, refer to our brochure *Nomex® Setting the Standard in Electrical Insulation* for more detailed information.

The properties in these data sheets 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 board-making technology, Nomex® brand pressboards have somewhat different properties in the board-making 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. All properties are tested in air unless otherwise noted.

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.

Copyright © 2017 DuPont. All rights reserved. The DuPont Oval Logo, DuPont™ and Nomex® are trademarks or registered trademarks of E.I. du Pont de Nemours and Company or its affiliates. K-29471 (02/17)