

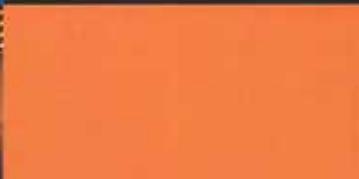
# Providing Strength From Within



Electrical Power Generation & Distribution



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Oil & Gas Exploration & Distribution



Aerospace

**NORPLEX  
MICARTA**

HIGH-PERFORMANCE COMPOSITES



## PRODUCTS AND SERVICES

Industrial Laminates/Norplex, Inc. manufactures "IL/Norplex" brand thermoset industrial laminate sheet composites from a wide variety of reinforcements and thermosetting resin systems. Like many of our customers, we have over forty-five years experience in manufacturing and working with these materials. Our expertise includes the engineering, development, manufacture and fabrication techniques required to maintain state-of-the-art composites for industrial use. We are constantly evaluating and developing new resin systems for new substrate types, and new manufacturing methods to maintain and develop our expertise.

Because of our experience, we are prepared to partner with you and your customers to make sure that you are satisfied with the product and its performance. The moment you receive an opportunity for a job, we can help you determine which material will work best, based on the specific performance requirements of the application. Or, because of our many years of experience, we can help when a design engineer has a need, but no specific idea as to the part design or material type required, or which material will meet a particular need or specification.

### ENGINEERED PRODUCTS

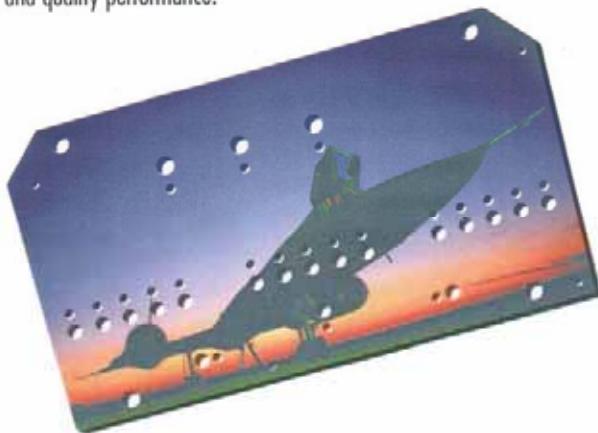
Beginning with the resin system and reinforcement that will offer the optimum match of compatibility and performance, we can engineer the Norplex composite laminate that best satisfies the primary requirement of performance while providing a balance of fabrication properties and cost efficiencies.

To help you make these decisions IL/Norplex can provide samples, along with a listing of the applications in which a particular material or Norplex grade has been used successfully. Our technical data bulletins give you information on specialized testing for a specific application.

### STREAMLINED PRODUCTION

Understanding that you must meet rigid production deadlines, we have geared our facility and production expertise from product development to shipping to help you meet your goals.

We evaluate new resins and reinforcement materials, then maintain control of approved materials by vendor certification, SPC reporting and incoming inspection as necessary. Our materials management team is constantly reviewing suppliers to determine the best cost and quality performance.



### SUPPORT AFTER DELIVERY

When our material arrives at your facility, it will meet your specifications and expectations. If you have concerns, we are prepared to help you with on-site assistance, fabrication techniques and/or a visit to your customer if necessary.

This Catalog provides basic information on the numerous IL/Norplex laminate grades produced by our facility in Postville, Iowa. For further information or test data on a particular grade, or on materials not listed in the catalog, contact our Customer Service Department at 800/350-9490 or 563/864-7321 or fax us at 800/350-9491 or 563/864-4231.

Norplex is a registered trademark of Industrial Laminates/Norplex, Inc.

### MATERIAL SELECTION

Physical strength, resiliency, ease and versatility of fabrication and excellent electrical properties combine to make IL/Norplex thermoset laminates useful as support components in a wide range of applications — both electrical and mechanical.

Because thermosetting laminates are excellent insulating materials and do not melt with heat, they are more functional than thermoplastics in primary or secondary electrical insulation and as thermal barriers. In applications that require dimensional stability, low creep and high flexural strength and modulus, laminates are the materials of choice. With resistance to wear, low noise in rotary operation against steel gears or cams, high heat resistance and low coefficient of friction, laminates are an excellent choice to replace metals in wear applications, including rotor and pump vanes, thrust washers, wear strips and surfaces, bearings, bushings, cams and gears.

For economy plus wide versatility in both fabrication techniques and end usage, phenolic resins are often the most attractive. Epoxy resins have excellent electrical properties over a wide range of humidity conditions and thermal variations. For arc resistance, melamine resin is superior and offers excellent heat and flammability resistance.

Paper-based phenolics are the most economical of laminates, yet provide significant electrical properties and good mechanical properties. For greater strength and machining versatility, cotton fabric phenolics are often the choice. Glass based grades have the best dimensional stability and mechanical strength, as well as low moisture absorption, but they are more difficult to machine when compared to the cotton fabric or paper based grades.



Some of the new substrates, aramide and carbon fiber fabrics offer impressive properties when combined with certain resin systems. They excel in heat resistance, mechanical strength, and, in the case of aramides, electrical properties, with especially low permittivity and dissipation factor.

Many of the above materials may be surfaced with rubber on one or both surfaces for special applications such as slinger washers, capacitor end caps and conformal gaskets. Vulcanized and other fiber type products, and thermoset and thermoplastic films are also used as surface plies for special applications.

## PAPER BASED LAMINATES

Paper based phenolics are the most economical of laminates; yet provide significant electrical properties and good mechanical properties.

### NP600

A special paper phenolic material designed for use as drill entry material for the manufacture of printed circuit boards. It has a hard flat surface for good drill starts and the strength to maintain hole position.

### NP602

An economy grade of laminate used in structural parts for various applications. Should not be used in applications requiring resistance to high humidity. Fair electrical properties when used in dry conditions.

### NP605

Drill backer material. Its hard flat surface and low sheet thickness variance gives superior drilling by helping to cool the bit and maintain its vertical axis.

### NP610 - NEMA GRADE X

Phenolic paper based NEMA Grade X, for mechanical applications. Good tensile, compressive and flexural strength. Primarily a machining material, but may be hot punched up to 0.093" thick.

### NP611 - NEMA GRADE XP

Hot punching general-purpose phenolic grade. Mechanical properties approach those of NP610 with improved electrical properties and punching characteristics.

### NP612 - NEMA GRADE XPC

Room temperature punching and shearing grade up to 0.125" thick. More flexible and lower mechanical properties than NP611. Intended for applications where electrical and moisture requirements are of secondary importance.

### NP613 - NEMA GRADE XX

A modified epoxy resin system combined with an electrical grade of kraft paper developed for the oil filled transformer industry.

### NP614

Our NP611 with vulcanized fiber covering plies. Designed for switch backs where arcing may be present during opening and closing of switch contacts.

### NP625 - NEMA GRADE XPC

Paper phenolic grade with better moisture resistance than NP612. Requires less heat to punch and shear than NP611.

### NP629 - NEMA GRADE XX

Formulated to make NEMA XX properties. Machining grade with lower electrical properties than NP630.

### NP630 - NEMA GRADE XXX

Machining grade with good electrical properties and moisture resistance. Low cold flow with good dimensional stability.

### NP639

Economical paper reinforced laminate developed with the capacity to withstand 150°C hot oil without blistering. High compressive strength and low moisture absorption. Must be post-baked to attain full heat resistance.

#### **NP660 - NEMA GRADE XP**

Economy version of NP611. This material is produced without the pigmented covers and is available in natural or black only.

#### **NP664 - NEMA GRADE XPC**

Economy version of NP612. Low cost room temperature punching and shearing grade with mechanical and electrical properties similar to NP612. It is made with kraft paper, so it is a little harder to punch, but has higher flexural strength. The UL recognized version comes with pigmented covers.

#### **NP680 - NEMA GRADE XP**

Hot punching grade with electrical properties between NP611 and NP631.

#### **NP691**

Flame resistant, room temperature punching grade. Very similar to NP612 in electrical properties and mechanical strength with improved moisture resistance. UL recognized.

#### **NP691K**

Flame resistant, room temperature punching grade like NP691, but with improved flexural, tensile and impact strengths. Designed for applications where higher mechanical properties are desired.

#### **NP842**

Paper reinforced phenolic resin grade with controlled conductivity. Mechanical strength similar to NP630.

#### **NP843**

Phenolic paper base laminate engineered for x-ray tabletop applications. Conductive NP842 surfaces on NEMA grade X core.

### **COTTON FABRIC BASE LAMINATES**

For greater strength and matching versatility, cotton fabric phenolics are often the choice. For specialized applications, the resin system can be easily modified to include solid lubricants and other additives.

#### **NP310 - NEMA GRADE C**

Canvas machining grade for structural and mechanical applications. Better impact strength than phenolic paper grades.

#### **NP310AG**

Cotton phenolic laminate similar to NEMA grade C, with non-afterglow properties similar to Grade CF, NEMA LI-1-1998.

#### **NP310E - NEMA GRADE CE**

Similar to NP310 with improved moisture resistance and electrical properties. Mechanical properties similar to NP310.

#### **NP310HT - NEMA GRADE C**

NP310HT is a heat treated version of NP310 engineered to pass General Electric's Heat Treated Specification.

#### **NP310LS**

NP310LS is composed of a woven cotton fabric and a specially engineered resin system designed to meet GE A50A341-58, for low shrink canvas materials. Shrinkage data is available on the Technical Data Bulletin.

#### **NP310U**

Economy grade of canvas combined with phenolic resin. Properties approach those of NEMA C and CE, but do not equal them.

#### **NP313**

Canvas phenolic material with molybdenum disulfide added as an internal lubricant. Mechanical properties slightly lower than NP310, especially the bond strength.

#### **NP315**

Canvas phenolic laminate with graphite added as a solid lubricant.

#### **NP318 - NEMA GRADE CF**

Post-forming canvas phenolic material. Mechanical and electrical properties similar to NP310E.

#### **NP319**

Bleached canvas combined with phenolic resin and graphite lubricant. Better moisture resistance and machining characteristics than NP315.

#### **NP320 - NEMA GRADE L**

Fine weave cotton fabric, commonly called linen, combined with phenolic resin to provide better machining than NP310. For smaller and more intricate shapes than NP310. Room temperature punching up to and including 0.062".

#### **NP320F - NEMA GRADE LE**

Similar to NP320 with improved moisture resistance. Suitable for electrical application in moderate humidity conditions.

#### **NP320U**

Economical version of NP320. Does not meet all of the properties of NEMA grade L or LE.

#### **NP321**

Linen phenolic laminate with excellent flatness characteristics. Self-lubrication properties provide improved wear resistance.

#### **NP322**

Linen phenolic laminate with molybdenum disulfide added. Provides the same lubricity as NP313, but has better machining qualities.

#### **NP325**

Linen phenolic laminate with graphite added as a solid lubricant. Linen substrate provides better machining than NP315.

#### **NP326**

Bleached fine weave (less than 4 ounce/square yard) cotton fabric commonly called linen, combined with modified phenolic resin to provide better machining than NP310LS while maintaining low shrink properties.

**NP329**

Bleached linen with melamine resin system. Provides better arc resistance than NP320E.

**NP342**

Fine weave canvas phenolic material with fabric weight between NP310 and NP320. Designed for better machining than NP310 and lower cost than NP320.

**NP344**

Same basic construction as NP342 with the exception that molybdenum disulfide is added to the resin system to reduce wear and friction in specific applications.

**NP347**

Bleached canvas with high temperature phenolic resin containing molybdenum disulfide as a solid lubricant. Capable of 150°C continuous operation.

**NP394**

Similar physical and electrical properties to NEMA grade LE. NP394 uses bleached linen and a proprietary resin system to provide better electrical properties and chemical resistance than standard grade NP320E.

**GLASS FABRIC BASE LAMINATES**

Glass based grades have the best dimensional stability and mechanical strength, as well as low moisture absorption, but they are more difficult to machine when compared to the cotton fabric or paper based grades.

**G-10 - NEMA G-10**

Glass fabric with non-brominated epoxy resin system. Combines excellent electrical characteristics with superior physical properties. Electrical properties maintained in high humidity conditions. Contains no bromine on the epoxy resin backbone. Not flame resistant.

**G-10A - NEMA G-10**

Woven glass fabric with easy machining, non-brominated epoxy resin. Engineered to provide NEMA Grade G10 properties with better machining attributes.

**NP130 - NEMA FR-4**

Woven glass fabric with epoxy resin system. Used primarily in the printed circuit board industry. Contains bromine on the epoxy resin backbone. Provides superior electrical and mechanical properties for most applications. Made to copper clad standards.

**NP130HF - NEMA FR-4**

Higher flexural, impact and tensile strengths with higher flexural modulus than standard FR-4 laminates.

**NP501 FR-4 HIGH TEMPERATURE**

Woven glass fiber with epoxy resin system. Engineered to provide improved properties over NEMA Grade FR-4 in applications involving thermal stress, such as reflow and solder pallets.

**NP504 - NEMA G-3**

Woven glass fabric with high temperature phenolic resin system. Excellent flexural compressive and impact strengths. Capable of continuous operation over 175°C.

**NP509 - NEMA G-5, G-9**

Woven glass fabric, melamine resin laminate. Very hard, flame resistant, machining grade with excellent electrical properties in high humidity conditions. High physical strength and excellent arc resistance.

**NP510A - NEMA FR-4**

Woven glass fabric epoxy laminate. Engineered to provide NEMA grade FR-4 properties. This material contains bromine on the epoxy resin backbone. UL-94 class V-O.

**NP511 - NEMA G-11**

High temperature, non-brominated epoxy resin system on glass fabric. Higher glass transition temperature than NEMA G-10.

**NP511EM - NEMA G-11**

Easier to machine than our standard G-11 with all of the NEMA G-11 properties.

**NP511ES**

Woven glass fabric with high temperature, static dissipative epoxy resin. Excellent mechanical strength and chemical resistance properties at elevated temperatures. Continuous operating temperature is 175°C, with excursion temperatures exceeding 300°C.

**NP511G**

A new introduction to the ILNorplex line of industrial laminates, NP511G features all the good properties of G-11, and exceeds most of NEMA g-11's mechanical properties. In addition, NP511G is easier to machine than our standard NP511; with less heat generated at the tool, and therefore less tool wear.

**NP511T**

Woven glass fabric with phenolic resin. Contains Kodite® for controlled conductivity. Acts as static electricity drain to protect electrical and electronic equipment.



## SYNTHETIC FABRIC BASE GRADES

Some of the new substrates, aramide and carbon fiber fabrics offer impressive properties when combined with certain resin systems. They excel in heat resistance, mechanical strength, and, in the case of aramides, electrical properties, with especially low permittivity and dissipation factor.

### NP101

Phenolic resin combined with spun nylon fabric. Good impact strength and excellent electrical properties under high humidity conditions. Meets applicable Boeing specification, but exempt from non-afterglow requirements.

### NP159

Woven aramide fiber fabric combined with high temperature phenolic resin. With a proper post baking procedure, NP159 will withstand continuous operation at 200°C.

### NP180

Aramid fabric material with a high performance epoxy resin matrix. Excellent electrical and mechanical properties at elevated temperatures and in adverse environments.

### NP190

Aramid fabric material with a high performance phenolic resin matrix. Excellent electrical and mechanical properties at elevated temperatures, and in adverse environments.

### NP192

8 oz. aramide and "soft glass" fibers are combined to make a fabric that is stronger than pure aramide and less abrasive than glass fabrics. This material is impregnated with a high temperature phenolic resin matrix, which produces a composite with excellent mechanical strength at elevated temperatures and adverse environments. Applications include wear plates for conveyor systems, and compressor and pump vanes.

### NP193E

17 oz. aramide and "soft glass" fibers are combined to make a fabric that is stronger than pure aramide and less abrasive than glass fabrics. This material is impregnated with a high temperature epoxy resin matrix, which produces a composite with excellent mechanical strength at elevated temperatures and adverse environments.

### NP193P

17 oz. aramide and "soft glass" fibers are combined to make a fabric that is stronger than pure aramide and less abrasive than glass fabrics. This material is impregnated with a high temperature phenolic resin matrix, which produces a composite with excellent mechanical strength at elevated temperatures and adverse environments.

### NP193M

17 oz. aramide and "soft glass" fibers are combined to make a fabric that is stronger than pure aramide and less abrasive than glass fabrics. This material is impregnated with a melamine resin matrix. Applications include compressor and pump vanes. Variations of this material may be developed for specific applications.

## CARBON FIBER FABRIC BASED LAMINATES

### NP545

NPS45 is composed of carbon fiber fabric and an epoxy resin system. It has excellent moisture resistance and physical properties.

### NP555

NP555 is composed of carbon fiber fabric and a phenolic resin system. It has excellent moisture resistance and physical properties.

## COMPOSITE MATERIALS

Composite laminate are combinations of two different types of materials, which combine the best properties of each type to produce a laminate with unique properties.

### NP185

NP190, aramide fiber fabric/phenolic surfaces (2 ply each side) on NP504 core material. Excellent mechanical properties at elevated temperatures and in adverse environments. Good wear resistance.

### NP424

Composite material composed of woven glass fabric surfaces and paper core combined with epoxy resin. Primarily used in the printed circuit board industry. Easy punching and excellent electrical properties and higher flexural strength than paper based grades.

### NP634

Worm punching, composite grade with woven glass covers for improved flexural, tensile and impact strength. Electrical properties comparable to NP611. Much stronger than most paper based grades.

### NP691K VO

Flame retardant kraft paper core primarily used in the telecommunications field for insulation and isolation of cabinets. The core is reinforced with skins of epoxy/glass fabric to improve both the moisture resistance and lower the moisture absorption. Provides excellent mechanical and electrical properties, and punches well up to .093".

## NOTES FOR INFORMATION CHARTS, PAGES 8-19

### COLORS:

NA = Natural; BK = Black; CH = Chocolate; WT = White; BL = Blue; and TN = Tan.

Other colors are available, but there is a minimum buy requirement. Contact Customer Service for details.

### MATERIAL WEIGHT:

To obtain weight in pounds per square foot, multiply the grade's Weight Factor by the thickness in inches. For example, NP612, 0.062 inches thick, weighs 0.44 pounds per square foot ( $7.1 \times 0.062 = 0.44$ )

### TEST CONDITIONS:

All tests are performed under ambient temperature and humidity conditions (Condition A) unless otherwise specified.

### CONDITIONING DESIGNATION:

Condition A: As received, no special conditioning.

Condition D: Immersion conditioning.

Condition D 1 : Immersion conditioning preceded by E-1/105.

Condition E: Temperature Conditioning.

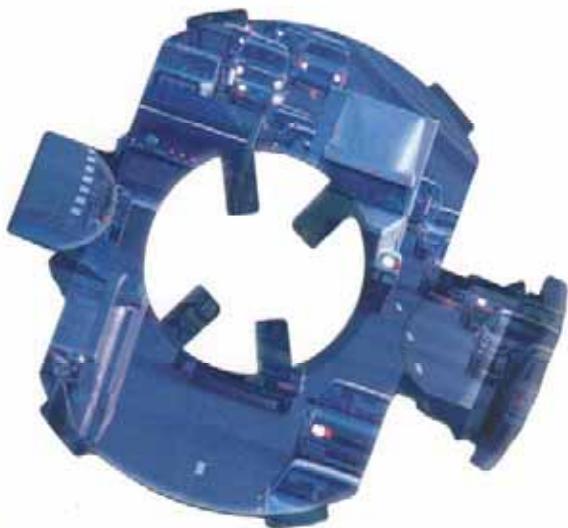
### FOOTNOTES:

<sup>1</sup> This temperature is recommendation only, based upon experience in various applications. The maximum operating temperature is dependent upon the application and should be investigated prior to use.

<sup>2</sup> A postbake procedure must be used for this material to attain this temperature resistance.

<sup>3</sup> All testing is performed on material which has not been post-formed.

 **NORPLEX  
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## COMPOSITE MATERIALS

NORPLEX GRADE	NP185	NP424	NP634	NP691K VO
NEMA Grade (Industry Designation)	—	CEM-1	—	
Military Specification (MIL-1-)	—	24768/29	—	
Military Type	—	187147	—	
UL File Number	—	—	—	
Colors	NA	TN	NA,BK	
Thickness Range	.125 - .500	.031 - .125	.031 - .093	
Weight Factor	—	—	—	
GENERAL PHYSICAL PROPERTIES*				
Specific Gravity	1.65 - 1.70	—	1.35 - 1.45	
Rockwell Hardness (M-Scale)	—	100 +/-10	95 +/- 10	
Moisture Absorption (%)	1.32	0.25	0.72	
Flexural Strength (psi)	—LW —CW	60,500 43,900	48,000 40,000	51,600 44,600
Modulus of Elasticity in Flexure (ksi)	—LW —CW	— —	2,500 2,100	1,800 1,500
Tensile Strength (psi)	—LW —CW	— —	44,900 34,100	23,900 20,100
Izod Impact Strength (ft/lb/in)	—LW Cond E-48/50	11.80 10.40	1.70 1.30	3.30 2.20
Compressive Strength (psi)	—	—	50,000	41,500
Bond Strength (lb)	—	—	1,400	1,500
Shear Strength (psi)	—	—	12,500	14,000
THERMAL AND ELECTRICAL PROPERTIES				
Maximum Operating Temperature <sup>†</sup> (C)	170	130	125	
Coefficient of Thermal Expansion x-axis (in/in/°C x 10 <sup>4</sup> )	— y-axis	13.0 16.0	15.0 13.0	
Flammability	HB	V-0	HB	
Breakdown Voltage (kV)	Cond A Cond D-48/50	— —	53.0 7.0	
Electric Strength (V/mil)	Cond A Cond D-48/50	— —	600 550	
Permittivity	Cond D-24/23	—	5.20	
Dissipation Factor	Cond D-24/23	—	0.037	
Arc Resistance (sec)	—	121	120	
Comparative Tracking Index (CTI)	—	300	200	
Gloss Transition Temperature Tg	—	—	—	

\*All testing performed Condition A on 0.062 inch thick laminate unless otherwise indicated on page 22.

See additional notes on page 7.

\*\*Preliminary test data.

The data supplied in this catalog, while believed to be accurate and based on reliable analytical methods, is for informational purposes only. Data supplied are "typical values"; not to be considered "specification values".

## CARBON FIBER GRADE

NORPLEX GRADE	NPS45	NPS55	
NEMA Grade (Industry Designation)	—	—	
Military Specification (MIL-1-)	—	—	
Military Type	—	—	
UL File Number	—	—	
Colors	BK	BK	
Thickness Range	.025 - 4.000	.025 - 4.000	
Weight Factor	8.80	8.30	
<b>GENERAL PHYSICAL PROPERTIES*</b>			
Specific Gravity	1.60 - 1.70	1.50 +/- 1.60	
Rockwell Hardness (M-Scale)	105 +/- 10	105 +/- 10	
Moisture Absorption (%)	0.10	0.10	
Flexural Strength (psi)	-LW -CW	98,500 98,000	55,200 46,800
Modulus of Elasticity in Flexure (ksi) -LW	6,000	1,300	
	-CW	5,300	1,200
Tensile Strength (psi)	-LW -CW	72,000 71,000	80,000 55,000
Izod Impact Strength (ft/lb/in)	-LW	—	40.00
Cond E-48/50	-CW	—	37.00
Compressive Strength (psi)	—	—	
Bond Strength (lb)	1,200	600	
Shear Strength (psi)	—	—	
<b>THERMAL AND ELECTRICAL PROPERTIES</b>			
Maximum Operating Temperature <sup>**</sup> (°C)	177	230	
Coefficient of Thermal Expansion (in/in/°C x 10 <sup>6</sup> )	x-axis y-axis	4.0 8.0	6.0 11.0
Flammability	HB	HB	
Breakdown Voltage (kV)	Cond A Cond D-48/5	— —	
Electric Strength (V/mil)	Cond A Cond D-48/50	— —	
Permittivity	Cond D-24/23	—	
Dissipation Factor	Cond D-24/23	—	
Arc Resistance (sec)	—	—	
Comparative Tracking Index (CTI)	—	—	
Glass Transition Temperature T <sub>g</sub>	125	—	

\*All testing performed Condition A on 0.062 inch thick laminate unless otherwise indicated on page 22.

See additional notes on page 7.

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## PAPER BASE GRADES

NORPLEX GRADE	NP600	NP602	NP605	NP610	
NEMA Grade (Industry Designation)	—	—	—	X	
Military Specification (MIL - I -)	—	—	—	24788/12	
Military Type	—	—	—	PBM	
UL File Number	—	—	—	E-187 147	
Colors	NA	NA,BK,CH	NA	NA,BK,CH	
Thickness Range	.010 - .032	.016 - 2.000	.026 - .250	.016 - 4.000	
Weight Factor	7.10	7.10	7.10	7.20	
GENERAL PHYSICAL PROPERTIES*					
Specific Gravity	1.30 - 1.35	1.30 - 1.35	1.30 - 1.35	1.35 - 1.45	
Rockwell Hardness (M-Scale)	90 +/- 10	90 +/- 10	90 +/- 10	105 +/- 10	
Moisture Absorption (%)	8.00	8.00	8.0	1.80	
Flexural Strength (psi)	-LW —CW	25,000 22,000	25,000 22,000	25,000 22,000	34,000 28,000
Modulus of Elasticity in Flexure (ksi) —LW	—	—	—	1,900	
	—CW	—	—	1,400	
Tensile Strength (psi)	-LW —CW	17,000 13,000	17,000 13,000	17,000 13,000	20,000 16,000
Izod Impact Strength (ft/lb/in)	-LW Cond E-48/50	0.55 0.50	0.55 0.50	—	0.82 0.76
Compressive Strength (psi)	—	35,000	35,000	35,000	
Bond Strength (lb)	—	—	—	—	1,000
Shear Strength (psi)	—	—	—	—	15,000
THERMAL AND ELECTRICAL PROPERTIES					
Maximum Operating Temperature (C)	—	150	—	130	
Coefficient of Thermal Expansion x-axis (in/in/°C x 10-6)	— y-axis	— —	— —	— 17.0	13.0
Flammability	HB	HB	HB	HB	
Breakdown Voltage (kV)	Cond A Cond D-48/50	60.0 3.0	60.0 3.0	60.0 —	40.0 —
Electric Strength (V/mil)	Cond A Cond D-48/50	— —	— —	— —	600
Permittivity	Cond D-24/23	—	—	—	—
Dissipation Factor	Cond D-24/23	—	—	—	—
Arc Resistance (sec)	—	—	—	—	90
Comparative Tracking Index (CTI)	—	—	—	—	—
Glass Transition Temperature Tg	—	—	—	—	—

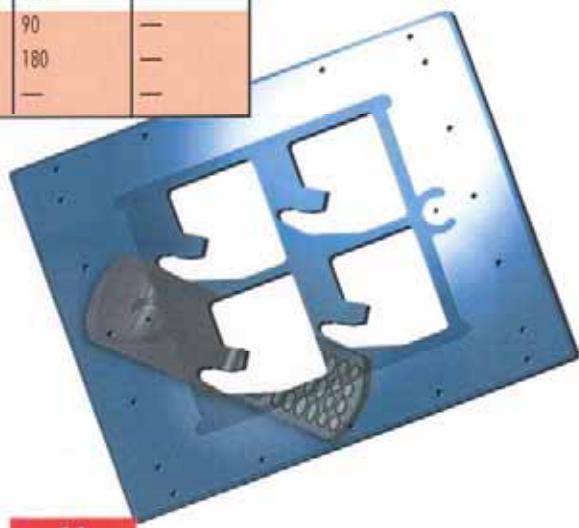
\*All testing performed Condition A on 0.062 inch thick laminate unless otherwise indicated on page 22.

See additional notes on page 7.

\*\*Preliminary test data.

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	NP611	NP612	NP613	NP615	NP625	NP629
XP	XPC	XX	XPC	XPC	XX	
24768/19	24768/20	24768/11	—	24768/20	24768/11	
PBM-P	PBM-PC	—	—	PBM-PC	P86	
E-187147	E-187147	—	E-187147	—	—	
NA,BK,CH	NA,BK	NA	NA	NA,BK,CH	NA,BK	
.016-.2000	.010-.500	.125-.4,000	.032-.093	.016-.500	.010-.4,000	
7.20	7.10	7.10	—	7.10	7.00	
1.32-1.38	1.35-1.40	1.30-1.35	1.35-1.45	1.35-1.45	1.30-1.40	
100 +/- 10	75 +/- 10	120 +/- 10	90 +/- 10	75 +/- 10	95 +/- 10	
2.20	3.20	2.00	3.00	2.30	2.00	
29,000	19,000	34,000	20,000	19,000	22,000	
22,000	17,600	28,000	14,000	17,000	17,000	
1,200	1,000	—	1,200	1,000	—	
900	850	—	1,000	850	—	
18,000	12,500	25,500	12,500	12,400	13,500	
13,500	8,400	19,000	8,400	10,400	11,500	
0.70	0.76	0.80	0.59	0.75	0.50	
0.60	0.66	0.60	0.57	0.70	0.40	
45,000	27,000	40,000	18,000	29,500	25,000	
1,100	1,400	1,500	1,400	1,100	900	
12,200	9,500	—	11,800	10,500	11,500	
130	130	140	120	130	—	
13.0	19.0	—	—	19.0	—	
17.0	15.0	—	—	15.0	—	
HB	HB	HB	HB	HB	HB	
50.0	55.0	>75	55.0	50.0	40.0	
—	—	8.0	—	—	5.0	
600	700	530	700	700	—	
—	—	140	—	—	—	
—	5.50	4.77	6.49	6.05	6.20	
—	0.06	0.46	0.096	0.06	0.052	
75	110	65	110	90	—	
180	500	—	—	180	—	
—	—	—	—	—	—	



## PAPER BASE GRADES

NORPLEX GRADE	NP630	NP639	NP660	NP664	
NEMA Grade (Industry Designation)	XXX	—	XP	XPC	
Military Specification (MIL - I -)	24768/10	—	24768/19	24768/20	
Military Type	PBE	—	PBM-P	PBM-PC	
UL File Number	E-187147	—	E-187147	E-187147	
Colors	NA,BK	NA	NA/BK	NA/BK	
Thickness Range	.010 - .4000	.025 - .250	.020 - 1.125	.031 - .500	
Weight Factor	7.00	7.10	7.10	7.10	
GENERAL PHYSICAL PROPERTIES*					
Specific Gravity	1.35 - 1.45	1.35 - 1.45	1.30 - 1.40	1.30 - 1.40	
Rockwell Hardness (M-Scale)	100 +/- 10	105 +/- 10	100 +/- 10	90 +/- 10	
Moisture Absorption (%)	1.30	1.00	3.50	5.50	
Flexural Strength (psi)	-LW -CW	20,000 15,000	25,000 20,000	29,000 22,000	26,000 24,000
Modulus of Elasticity in Flexure (ksi)	-LW -CW	1,300 1,050	1,500 1,300	1,900 1,400	1,200 1,000
Tensile Strength (psi)	-IW -CW	14,000 12,000	17,000 16,500	20,000 16,000	22,500 12,500
Izod Impact Strength (ft/lb/in)	-LW Cond E-48/50	0.55 0.45	0.65 0.50	0.75 0.70	0.67 0.62
Compressive Strength (psi)		30,00	40,000	49,000	30,000
Bond Strength (lb)		1,000	1,600	1,100	1,100
Shear Strength (psi)		12,800	13,000	14,000	11,000
THERMAL AND ELECTRICAL PROPERTIES					
Maximum Operating Temperature (C)	130	150	130	130	
Coefficient of Thermal Expansion x-axis (in/in/°C x 10 <sup>6</sup> )	19.0 y-axis 15.0	25.0 22.0	17.0 13.0	20.0 18.0	
Flammability	HB	HB	HB	HB	
Breakdown Voltage (kV)	Cond A Cond D-48/50	40.0 10.0	50.0 —	47.0 10.0	60.0 10.0
Electric Strength (V/mil)	Cond A Cond D-48/50	700 600	700 —	500 300	500 300
Permittivity	Cond D-24/23	6.10	—	5.45	—
Dissipation Factor	Cond D-24/23	0.05	—	0.45	—
Arc Resistance (sec)		110	—	60	110
Comparative Tracking Index (CTI)		200	—	150	180
Glass Transition Temperature Tg		—	—	—	—

\*All testing performed Condition A on 0.062 inch thick laminate unless otherwise indicated on page 22.

See additional notes on page 7.

\*\*Preliminary test data.

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	NP680	NP691	NP691K	NP842	NP843
XP	FR-1	FR-1	—	—	—
24/68/19	24/68/24	—	—	—	—
PBM-P	PBM-PF	—	—	—	—
—	E-187147	—	—	—	—
NA/BK	NA/BK	NA	BK	BK	
.010 - 1.125	.031 - 1.000	.062 - .250	.031 - .500	.125 - .500	
7.00	7.10	7.10	7.20	7.20	
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1.25 - 1.35	1.30 - 1.35	1.30 - 1.35	1.35 - 1.40	1.35 - 1.45	
95 +/- 10	85 +/- 10	95 +/- 10	100 +/- 10	100 +/- 10	
1.50	1.20	3.60	1.00	2.30	
26,400	16,000	26,000	21,000	25,000	
21,600	13,000	22,000	15,000	21,000	
1,000	1,000	—	1,000	2,100	
900	900	—	900	1,450	
17,000	12,000	16,000	20,000	22,000	
13,500	9,000	11,000	16,000	15,000	
0.56	0.70	0.70	0.55	0.70	
0.49	0.60	0.60	0.45	0.50	
38,000	25,000	29,000	32,000	44,000	
1,300	1,200	900	1,200	1,000	
11,000	12,000	12,000	11,200	11,500	
<hr/>					
130	105	105	130	125	
20.0	16.0	—	10.0	10.0	
16.0	20.0	—	12.0	12.0	
HB	V-1	V-1	HB	HB	
55.0	55.0	60.0	—	—	
10.0	5.0	2.0	—	—	
750	500	700	—	—	
300	300	20	—	—	
5.00	5.20	4.60	—	—	
0.04	0.065	0.04	—	—	
100	100	—	—	—	
180	240	—	—	—	
—	—	—	—	—	

## COTTON FABRIC LAMINATES

NORPLEX GRADE	NP310	NP31045	NP310E	NP310HT	NP310LS**	NP310U	NP313	
NEMA Grade (Industry Designation)	C	C	CE	C	C	—	(CMD)	
Military Specification (MIL - I -)	24768/16	—	24768/14	24768/16	—	—	—	
Military Type	FBM	—	FBG	FBM	—	—	—	
UL File Number	E-187147	—	—	—	—	—	—	
Colors	NA,BK	NA	NA,BK	NA/BK	NA	NA,BK	NA,BK	
Thickness Range	.031 - 4.000	.062 - .500	.031 - 4.000	.062-.500	.062 - .500	.062 - 4.000	.031 - 4.000	
Weight Factor	7.20	7.20	7.20	7.20	7.20	7.20	7.75	
GENERAL PHYSICAL PROPERTIES*								
Specific Gravity	1.35 - 1.40	1.35 - 1.40	1.35 - 1.40	1.35 - 1.40	1.35 - 1.40	1.30 - 1.40	1.35 - 1.45	
Rockwell Hardness (M-Scale)	100 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10	
Moisture Absorption (%)	3.50	1.07	2.00	3.40	0.68	2.00	1.95	
Flexural Strength (psi)	-LW -CW	18,000 17,000	23,000 17,500	17,500 15,000	18,000 18,000	18,500 17,500	23,000 13,500	19,000 17,000
Modulus of Elasticity in Flexure (ksi)	-LW -CW	1,600 1,500	— —	1,600 1,500	2,500 2,400	— —	900 1,000	1,200 1,000
Tensile Strength (psi)	-LW -CW	12,000 9,700	— —	11,000 9,000	— —	— —	7,500 6,000	11,000 9,000
Izod Impact Strength (ft/lb/in)	-LW -CW	1.95 1.75	2.80 2.56	1.70 1.50	2.35 2.02	2.30 1.90	1.50 1.00	1.70 1.40
Compressive Strength (psi)		34,000	—	34,000	—	—	28,000	36,000
Bond Strength (lb)		2,400	2,200	1,700	2,700	2,500	1,900	1,900
Shear Strength (psi)		14,000	—	14,000	—	—	13,000	13,500
THERMAL AND ELECTRICAL PROPERTIES								
Maximum Operating Temperature (°C)		125	—	125	125	—	125	145
Coefficient of Thermal Expansion (in/in/°C x 10-6)	xaxis <sup>3</sup> yaxis	20.0 22.0	— —	20.0 22.0	— —	— —	20.0 22.0	18.0 24.0
Flammability		HB	—	HB	HB	—	HB	HB
Breakdown Voltage (kV)	Cond A Cond D-48/50	20.0 2.0	37.0 3.0	40.0 —	55.0 —	— —	50.0 —	— —
Electric Strength (V/mil)	Cond A Cond D-48/50	400 150	— —	550 300	527 —	— —	550 —	— —
Permittivity	Cond D-24/23	—	—	—	—	—	—	—
Dissipation Factor	Cond D-24/23	—	—	—	—	—	—	—
Arc Resistance (sec)		15	—	15	—	—	15	—
Comparative Tracking Index (CTI)		155	—	—	—	—	150	—
Gloss Transition Temperature Tg		—	—	—	—	—	—	—

\*All testing performed Condition A on 0.062 inch thick laminate unless otherwise indicated on page 22.

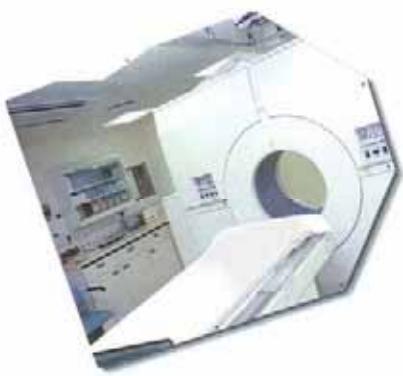
See additional notes on page 7.

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## Cotton Fabric & Synthetic Laminates

	NP315 (CYB)	NP318 <sup>a</sup> CF	NP319 —	NP320 24768/15	NP320E 24768/13	NP320U —	NP321 —	NP322 (LYB)	NP325 (LMD)
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
BK	NA/BK	BK	NA/BK	NA/BK	NA	NA	NA	NA,BK	BK
.047 - 4.000	.031 - .312	.062 - 4.000	.010 - 4.000	.010 - 4.000	.031 - 4.000	.125 - 1.000	.015 - 4.000	.015 - 4.000	.015 - 4.000
7.75	7.20	7.75	7.20	7.20	7.20	8.25	7.75	7.75	7.75
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1.35 - 1.45	1.30 - 1.40	1.35 - 1.45	1.30 - 1.40	1.30 - 1.40	1.30 - 1.40	1.30 - 1.40	1.35 - 1.45	1.35 - 1.45	1.35 - 1.45
90 +/- 10	90 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10	95 +/- 10	90 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10
2.20	2.00	2.50	2.30	1.90	3.00	1.90	2.40	1.50	1.50
19,000	17,000	20,000	24,500	22,000	19,000	25,700	23,800	20,100	20,100
15,000	14,000	18,000	18,500	16,000	13,500	21,300	18,000	19,200	19,200
1,200	1,100	1,300	1,700	1,600	1,500	1,000	1,500	1,500	1,500
1,000	900	1,000	1,300	1,200	1,100	800	1,100	1,100	1,100
10,000	10,000	11,000	14,000	13,000	13,000	18,500	14,000	13,500	13,500
7,000	6,000	9,000	10,000	9,000	9,000	12,500	9,700	9,500	9,500
1.70	2.50	2.00	1.70	1.35	1.10	2.60	1.60	1.42	1.42
1.40	2.00	1.85	1.35	1.10	0.86	2.20	1.30	1.35	1.35
38,000	25,000	36,000	38,000	36,000	30,000	34,000	39,000	35,000	35,000
1,800	1,800	1,700	2,000	1,900	1,700	1,600	1,900	1,900	1,900
13,000	12,000	13,000	13,500	13,500	12,000	12,000	14,500	14,500	14,500
<hr/>									
145	125	150	125	125	125	150	130	125	125
18.0	—	18.0	18.0	18.0	—	14.0	10.0	10.0	10.0
24.0	—	22.0	19.0	19.0	—	19.0	12.0	12.0	12.0
HB	HB	HB	HB	HB	HB	HB	HB	HB	HB
—	65.0	—	30.0	50.0	50.0	51.0	30.0	—	—
—	4.0	—	—	4.0	—	20.0	5.0	—	—
—	480	—	575	625	625	460	—	—	—
—	350	—	450	500	500	170	—	—	—
—	—	—	—	5.50	6.60	6.00	—	—	—
—	—	—	—	0.065	0.054	0.05	—	—	—
—	10	—	15	15	15	133	—	—	—
—	150	—	170	170	170	—	—	—	—
—	—	—	—	—	—	—	—	—	—



## COTTON FABRIC LAMINATES

NORPLEX GRADE	NP326**	NP 329	NP342	NP344	NP345	NP347	NP349*
NEMA Grade (Industry Designation)	L	(MLE)	(CFW)	—	CE	—	—
Military Specification (MIL-I-)	—	—	—	—	—	—	—
Military Type	—	—	—	—	—	—	—
UL File Number	—	—	—	—	—	N	N
Colors	NA	NA	NA	NA	NA	NA	NA
Thickness Range	.062 - 2.000	.015 - 4.00	.031 - 4.000	.125 - 4.000	.062 - 4.000	.125 - 4.000	.125 - 4.000
Weight Factor	7.20	8.25	7.20	7.50	7.25	7.75	7.50
GENERAL PHYSICAL PROPERTIES*							
Specific Gravity	1.35 - 1.45	1.45 - 1.50	1.30 - 1.40	1.35 - 1.45	1.30 - 1.40	1.35 - 1.45	1.30 - 1.40
Rockwell Hardness (M-Scale)	100 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10
Moisture Absorption (%)	1.05	1.80	3.20	2.00	2.00	1.60	0.80
Flexural Strength (psi)	-IW —CW	30,000 23,000	29,000 26,000	23,000 20,700	23,000 19,000	22,200 16,100	21,000 16,000
Modulus of Elasticity in Flexure (ksi)	-IW —CW	2,300 1,600	1,800 1,400	1,700 1,300	1,500 1,100	1,600 1,200	1,500 1,000
Tensile Strength (psi)	-IW —CW	25,000 16,000	16,000 9,700	12,700 10,900	12,500 9,500	11,000 6,000	12,000 7,000
Izod Impact Strength (ft/lb/in)	-IW —CW	2.10 1.50	1.90 1.75	1.90 1.70	1.70 1.50	1.90 1.40	2.40 1.80
Cond E-48/50	—CW	1.50	1.75	1.70	1.50	1.40	1.10
Compressive Strength (psi)	—	51,000	34,000	35,000	35,000	37,000	36,000
Bond Strength (lb)	—	2,000	1,900	1,900	1,900	2,200	2,200
Shear Strength (psi)	—	13,500	13,000	14,000	14,000	13,500	9,800
THERMAL AND ELECTRICAL PROPERTIES							
Maximum Operating Temperature (C)	—	130	125	130	130	150	125
Coefficient of Thermal Expansion (in/in/°C x 10 <sup>6</sup> )	x-axis y-axis	30.0 12.0	18.0 19.0	20.0 22.0	10.0 12.0	20.0 22.0	14.0 16.0
Flammability	HB	V-0	HB	HB	HB	HB	HB
Breakdown Voltage (kV)	Cond A Cond D-48/50	66.0 2.0	20.0 5.0	40.0 —	— —	55.0 5.0	80.0 75.0
Electric Strength (V/mil)	Cond A Cond D-48/50	— —	500 300	550 300	— —	600 350	— —
Permittivity	Cond D-24/23	—	7.00	—	—	15.00	—
Dissipation Factor	Cond D-24/23	—	0.05	—	—	—	0.047
Arc Resistance (sec)	—	120	—	—	150.0	—	124
Comparative Tracking Index (CTI)	—	200	—	—	—	—	—
Glass Transition Temperature T <sub>g</sub>	—	—	—	—	—	—	—

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See additional notes on page 7.

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## SYNTHETIC FABRIC LAMINATES

NORPLEX GRADE	NP101	NP159	NP180	NP190	NP192**	NP193C**	NP193P**	NP193M**
NEMA Grade (Industry Designation)	N-1	—	—	—	—	—	—	—
Military Specification (MIL-1-1)	24768/9	—	—	—	—	—	—	—
Military Type	NPG	—	—	—	—	—	—	—
UL File Number	—	—	—	—	—	—	—	—
Colors	NA	NA	NA	NA	NA	NA	NA	NA
Thickness Range	.031-.4000	.062-.500	.062-.500	.062-.500	.062-.500	.062-.500	.062-.500	.062-.500
Weight Factor	6.50	6.75	6.25	6.25	6.75	6.75	6.75	6.85
<b>GENERAL PHYSICAL PROPERTIES*</b>								
Specific Gravity	1.20-1.30	1.25-1.35	1.35-1.45	1.30-1.40	1.40-1.50	—	—	—
Rockwell Hardness (M-Scale)	90 +/- 10	120 +/- 10	90 +/- 10	100 +/- 10	100 +/- 10	—	—	—
Moisture Absorption (%)	0.30	1.30	0.30	2.60	2.86	0.50	3.69	5.70
Flexural Strength (psi)	-LW —CW	14,000 11,000	29,000 1,900	56,000 56,000	66,800 49,500	29,100 23,200	47,000 20,000	33,000 15,000
Modulus of Elasticity in Flexure (ksi)	-LW —CW	700 550	900 600	— —	— —	— —	1,800 1,700	1,200 1,200
Tensile Strength (psi)	-LW —CW	8,000 8,000	11,000 9,300	62,000 58,000	— —	— —	29,000 26,000	23,000 19,000
Izod Impact Strength (ft/lb/in)	-LW —CW	3.40 2.70	6.20 5.30	10.90 8.00	20.00 18.50	8.50 6.50	15.00 4.00	24.00 7.00
Compressive Strength (psi)	—	25,000	45,000	79,000	75,000	—	32,000	39,000
Bond Strength (lb)	—	1,800	2,400	—	1,800	—	2,400	2,400
Shear Strength (psi)	—	14,000	14,500	—	26,000	—	—	—
<b>THERMAL AND ELECTRICAL PROPERTIES</b>								
Maximum Operating Temperature (°C)	105	160 <sup>1</sup>	160 <sup>1</sup>	200	200	—	—	—
Coefficient of Thermal Expansion (in/in/°C x 10-6)	x axis y axis	95.0 120.0	40.0 45.0	— —	— —	44.4 26.0	21.0 30.8	18.0 11.0
Flammability	HB	HB	HB	V-0	HB	HB	HB	—
Breakdown Voltage (kV)	Cond A Cond D-48/50	65.0 45.0	65.0 35.0	47.0 54.0	75.0 9.0	61.0 2.5	46.0 45.0	53.0 11.0
Electric Strength (V/mil)	Cond A Cond D-48/50	650 500	700 550	650 500	540 242	— —	— —	— —
Permittivity	Cond D-24/23	3.75	3.80	3.91	5.91	—	4.30	5.00
Dissipation Factor	Cond D-24/23	0.035	0.035	0.0275	0.0461	—	0.021	0.03
Arc Resistance (sec)	—	17	200	121	182	—	—	—
Comparative Tracking Index (CTI)	—	150	—	145	—	—	—	—
Glass Transition Temperature Tg	—	—	—	—	—	—	—	—

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## GLASS FABRIC LAMINATES

NORPLEX GRADE	G-10	G-10A	NP130	NP130HF	NP501**	NP504	
NEMA Grade (Industry Designation)	G-10	G-10	FR-4	FR-4	FR-4	G-3	
Military Specification (MIL - 1 -)	24768/2	24768/2	24768/27	24768/27	24768/27	24768/18	
Military Type	GEE	GEE	GEE-F	GEE-F	GEE-F	GPG	
UL File Number	E-187147	—	E-187147	E-187147	—	E-187147	
Colors	NA	NA	NA,BK	NA	NA	NA	
Thickness Range	.012-.4000	.010-.4000	.007-.4000	.007-.4000	.007-.4000	.015-.4000	
Weight Factor	9.40	10.00	10.00	10.50	10.50	10.00	
GENERAL PHYSICAL PROPERTIES*							
Specific Gravity	1.75 - 1.85	1.75 - 1.85	1.75 - 1.85	1.90 - 2.00	1.90 - 2.00	1.75 - 1.85	
Rockwell Hardness (M-Scale)	110 +/- 10	100 +/- 10	100 +/- 10	100 +/- 10	115 +/- 10	110 +/- 10	
Moisture Absorption (%)	0.11	0.12	0.15	0.13	0.15	2.00	
Flexural Strength (psi)	-LW -CW	75,000 65,000	66,000 60,000	70,000 60,000	85,000 70,000	74,000 65,000	40,500 34,000
Modulus of Elasticity in Flexure (ksi)	-LW -CW	2,700 2,400	3,400 3,300	2,700 2,400	3,700 3,000	3,200 2,800	1,800 1,400
Tensile Strength (psi)	-LW -CW	45,000 38,000	43,000 39,000	45,000 38,000	65,000 53,000	40,000 32,000	42,000 34,000
Izod Impact Strength (ft/lb/in)	-LW -CW	14.00 12.00	9.50 7.50	14.00 12.00	13.00 9.00	7.90 7.30	12.00 11.00
Cond E-48/50							
Compressive Strength (psi)		65,000	44,000	55,000	72,000	66,000	76,000
Bond Strength (lb)		2,200	2,500	2,200	2,500	2,100	1,600
Shear Strength (psi)		22.00	19,000	22,000	2,500	21,500	18,000
THERMAL AND ELECTRICAL PROPERTIES							
Maximum Operating Temperature (°C)	140	130	140	130	145	175	
Coefficient of Thermal Expansion (in/in/°C x 10 <sup>6</sup> )	x-axis y-axis	10.0 12.0	12.1 9.6	10.0 12.0	14.7 13.7	10.0 13.0	15.0 18.0
Flammability		HB	HB	V-0	V-0	V-0	HB
Breakdown Voltage (kV)	Cond A Cond D-48/50	60.0 50.0	48.0 49.0	65.0 54.0	63.0 60.0	66.0 65.0	50.0 15.0
Electric Strength (V/mil)	Cond A Cond D-48/50	800 750	960 1000	800 750	900 700	— —	375 200
Permittivity	Cond D-24/23	4.80	4.80	4.80	4.80	4.50	—
Dissipation Factor	Cond D-24/23	0.025	0.02	0.025	0.022	0.02	—
Arc Resistance (sec)		100	175	100	75	120	100
Comparative Tracking Index (CTI)		150	150	150	—	—	150
Glass Transition Temperature Tg		115	128	127	130	140	—

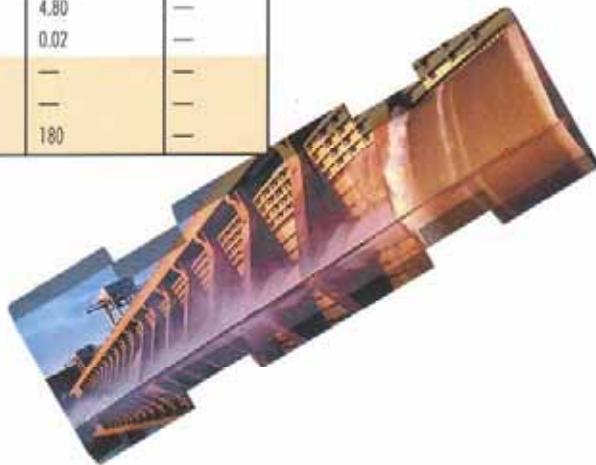
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	NP509	NP510A	NP511	NP511B	NP511ES	NP5116**	NP841
G5/G9	FR4	G11	G11	G11 Type	G11	G11	—
24768/1	24768/27	24768/3	24768/3	—	—	24768/3	—
GME	GEE-F	GEB	GEB	—	—	GEB	—
E-18147	E-18147	E-18147	—	—	—	—	—
NA	NA/BK	NA	NA	BK	NA	BK	—
.008-.4.000	.010-.4.000	.007-.4.000	.125-.4.000	.125-.2.000	.012-.4.000	.010-.2.000	—
10.25	10.00	10.00	10.25	10.25	10.0	10.00	—
1.80-1.90	1.80-1.90	1.80-1.90	1.75-1.85	1.85-1.95	1.75-1.85	1.80-1.90	—
115 +/-10	115 +/-10	110 +/-10	110 +/-10	110 +/-10	110 +/-10	110 +/-10	—
0.60	0.10	0.20	0.12	0.22	—	0.40	—
61,600	65,000	80,000	80,000	83,000	80,000	5,000	—
51,100	52,000	70,000	65,000	70,000	70,000	40,000	—
2,000	2,900	3,000	4,200	4,780	3,500	1,600	—
1,700	2,600	2,700	4,000	4,310	3,200	1,400	—
61,600	40,000	43,000	61,000	60,200	43,000	42,000	—
51,100	32,000	37,000	53,000	48,000	37,000	34,000	—
12.50	7.90	12.00	12.00	13.00	15.00	11.00	—
8.50	7.30	9.00	9.00	9.00	11.00	8.00	—
70,000	66,000	63,000	91,000	85,000	63,000	60,000	—
1,900	2,300	2,200	2,200	1,800	1,700	1,600	—
18,000	21,500	22,000	26,000	26,000	22,000	19,000	—
140	140	185	165	180	185	175	—
15.0	10.0	13.0	16.2	9.7	13.0	15.0	—
18.0	13.0	15.0	12.7	17.7	15.0	18.0	—
V-0	V-0	HB	HB	HB	HB	HB	—
65.0	66.0	60.0	50.0	—	70.0	—	—
55.0	65.0	55.0	57.0	—	60.0	—	—
450	800	900	860	—	—	—	—
400	750	800	450	—	—	—	—
7.03	4.80	4.38	5.00	—	4.80	—	—
0.15	0.032	0.02	0.02	—	0.02	—	—
	130	120	148	—	—	—	—
	300	150	600	—	—	—	—
	130	165	157	180	180	—	—



## UNDERWRITERS LABORATORIES LISTED PRODUCTS UL FILE E-187147

Material Designation	ANSI Type	Color	Minimum Thickness		UL94 Flame Class	TI		H	H	H	C	Meets UL746E DSR
			IN	(mm)		Elec	Mech	W	A	V	T	
NP130	FR-4	NC	0.008	(0.02)	94V-0	120	130	3	0	—	—	—
			0.015	(0.38)	94V-0	130	130	0	4	4	—	Yes
			0.025	(0.63)	94V-0	130	140	0	4	4	—	Yes
			0.055	(1.40)	94V-0	130	140	0	4	4	3	Yes
NP130P	FR-4	All	0.025	(0.63)	94V-0	130	140	0	3	4	—	Yes
			0.055	(1.40)	94V-0	130	140	0	2	4	3	Yes
NP130C	—	NC	0.025	(0.63)	94V-0	120	130	0	1	—	—	Yes
			0.055	(1.40)	94V-0	120	130	0	0	2	3	Yes
NP502	FR-4	NC,GN	0.008	(0.20)	94V-0	120	120	3	0	—	—	—
			0.015	(0.38)	94V-0	130	130	0	4	4	—	—
			0.025	(0.63)	94V-0	130	140	0	4	4	—	Yes
			0.057	(1.45)	94V-0	130	140	0	4	4	3	Yes
NP509	G-9	NC	0.025	(0.63)	94V-0	50	140	3	1	0	—	—
			0.057	(1.45)	94V-0	50	140	3	1	0	1	—
G10	G-10	NC	0.002	(0.05)	—	105	105	5	8	4	—	—
			0.008	(0.20)	—	105	105	5	14	3	—	—
			0.025	(0.63)	—	130	140	7	33	0	—	—
			0.057	(1.45)	—	130	140	—	—	—	—	—
NP511	G-11	NC	0.025	(0.63)	94HB	140	160	4	4	4	—	—
			0.055	(1.40)	94HB	170	180	3	4	4	—	—
NP510A	FR-4	NC	0.002	(0.05)	94V-0	105	105	0	0	3	—	—
			0.008	(0.20)	94V-0	130	140	0	0	4	—	—
			0.025	(0.63)	94V-0	130	140	3	2	0	—	—
			0.057	(1.45)	94V-0	130	140	0	0	1	3	—
NP510A+	FR-4	NC,TN	0.030	(0.76)	94V-0	13	140	0	0	—	—	Yes
			0.060	(1.5)	94V-0	130	140	0	0	0	1	Yes
NP610	X	NC,BK	0.028	(0.71)	94HB	130	130	4	3	4	—	—
			0.058	(1.07)	94HB	130	130	4	3	4	—	—
NP611	XP	NC,DK,BK	0.028	(0.71)	94HB	130	130	5	4	4	—	—
			0.057	(1.45)	94HB	130	130	5	3	4	3	—
NP660	XP	NC	0.028	(0.71)	94HB	130	130	5	4	4	—	—
			0.057	(1.45)	94HB	130	130	5	3	4	—	—
NP697	XP	NC	0.033	(0.84)	94HB	130	130	4	4	4	—	—
			0.057	(1.45)	94HB	130	130	4	3	4	—	—
NP612	XPC	NC,BK	0.028	(0.71)	94HB	130	130	4	3	4	—	—
			0.057	(1.45)	94HB	130	130	4	2	4	—	—
NP664	XPC	NC	0.028	(0.71)	94HB	130	130	4	4	4	—	—
			0.057	(1.45)	94HB	130	130	4	3	4	—	—
NP630	XXX	NC,BK	0.028	(0.71)	94HB	130	130	4	2	4	—	—
			0.057	(1.45)	94HB	130	130	4	2	4	—	—
NP631	XXXXP	NC,BK	0.028	(0.71)	94HB	125	125	5	3	4	—	—
			0.057	(1.45)	94HB	125	125	4	3	4	—	—
NP691	—	NC,BK	0.028	(0.71)	94V-0	130	130	4	4	4	—	—
			0.057	(1.45)	94V-0	130	130	4	3	4	3	—
NP310	C	NC,BK	0.028	(0.71)	94HB	85	85	4	2	4	—	—
			0.057	(1.45)	94HB	115	125	4	2	1	4	—
NP424	CEM-1	TN,BK,BL	0.25	(0.63)	94V-0	130	140	0	0	4	—	Yes
			0.55	(1.4)	94V-0	130	140	0	0	4	2	Yes
NP614	—	NC	0.113	(2.87)	94V-0	130	140	—	—	4	—	—
			0.058	(0.71)	94HB	115	110	—	—	4	—	—
P95	GPY	NC	0.025	(0.63)	94HB	140	160	0	0	0	—	—
			0.055	(1.40)	94HB	170	180	0	0	0	2	—

## TOLERANCES OF IL/NORPLEX INDUSTRIAL LAMINATES

### SHEET THICKNESS TOLERANCES

At least 90% of the area of the sheet shall be within the tolerances given, and at no point shall the thickness vary from the nominal by a value greater than 125% of this specified tolerance. For nominal thickness' not listed, the tolerance shall be the same for the next greater thickness. For nominal thickness' greater than 2.0, inches, please contact the Customer Service Department.

### TOLERANCES IN THICKNESS, INCHES

Nominal Thickness	Paper Based Grades	Cotton Fabric Based Grades				Gloss Based Grades	Aramid & Nylon Grades
		NP600 Series	NP310	NP320	NP310E	NP320E	
(Inches)	(+ or -)	(+ or -)	(+ or -)	(+ or -)	(+ or -)	(+ or -)	(+ or -)
0.010	0.0002	—	0.003	—	—	0.002	0.003
0.015	0.0025	—	0.0035	—	0.0035	0.003	0.0035
0.020	0.003	—	0.004	—	0.004	0.004	0.004
0.025	0.0035	—	0.0045	0.005	0.0045	0.005	0.0045
0.031	0.0035	0.0065	0.005	0.0065	0.0055	0.0065	0.0065
0.047	0.0045	0.0075	0.0055	0.0075	0.0055	0.0075	0.0075
0.062	0.005	0.0075	0.006	0.0075	0.006	0.0075	0.0075
0.094	0.007	0.009	0.007	0.009	0.007	0.009	0.009
0.125	0.008	0.010	0.008	0.010	0.008	0.012	0.010
0.156	0.009	0.011	0.009	0.011	0.009	0.015	0.011
0.188	0.010	0.0125	0.010	0.0125	0.010	0.019	0.0125
0.219	0.011	0.014	0.011	0.014	0.011	0.021	0.014
		(+ only)	(+ only)				
0.250	0.012	0.030	0.024	0.015	0.012	0.022	0.015
0.312	0.014	0.035	0.029	0.017	0.0145	0.026	0.024
0.375	0.017	0.040	0.034	0.020	0.017	0.030	0.032
0.438	0.019	0.044	0.038	0.022	0.019	0.033	0.040
0.500	0.021	0.048	0.042	0.024	0.021	0.036	0.048
0.625	0.024	0.053	0.048	0.027	0.024	0.040	0.054
0.750	0.027	0.058	0.054	0.029	0.027	0.043	0.058
0.875	0.030	0.062	0.060	0.031	0.030	0.046	0.062
1.000	0.033	0.065	0.065	0.033	0.033	0.049	0.066
1.125	0.035	0.069	0.069	0.035	0.035	0.053	—
1.250	0.037	0.073	0.073	0.037	0.037	0.055	—
1.375	0.039	0.077	0.077	0.039	0.039	0.058	—
1.500	0.041	0.081	0.081	0.041	0.041	0.061	—
1.625	0.043	0.085	0.085	0.043	0.043	0.064	—
1.750	0.045	0.089	0.089	0.045	0.045	0.067	—
1.875	0.047	0.093	0.093	0.047	0.047	0.070	—
2.000	0.049	0.097	0.097	0.049	0.049	0.073	—

\* For paper based grades NP600, NP602 and NP605, use glass tolerances for thicknesses over 0.125".

### SHEET BOW OR TWIST TOLERANCE

All Grades Thickness, Inches	Max. Bow or Twist *Percent
0.031 (.061)	5.00
0.062 (.124)	2.50
0.125 (.249)	1.00
0.250 (.750)	0.50
0.751 and over	0.025

\*Percentage of bow is stated in terms of the length or width dimensions;  
percentage of twist is stated in terms to the dimensions from one corner to the diagonally opposite corner.

### LENGTH AND WIDTH TOLERANCES

All sheet sizes: the tolerance in length and width shall be plus or minus 1.0 inch from the nominal trimmed dimensions.

Panels or strips: the tolerance of cut pieces is entirely dependent upon the cutting equipment.

Shearing, sawing, and rotary cutting operations achieve different tolerances. Therefore, the tolerances pertaining to an order will depend upon the cutting operation required. Close tolerances may be possible, but require special attention and equipment.



### TEST METHODS USED FOR NORPLEX® INDUSTRIAL LAMINATES

Test	Specimen Thickness	Test Method
Specific Gravity	0.062"	ASTM D792
Rockwell Hardness	0.062"	ASTM D785
Moisture Absorption	0.062"	ASTM D229
Flexural Strength	0.062"	ASTM D790
Modulus of Elasticity in Flexure	0.062"	ASTM D229
Tensile Strength	0.062"	ASTM D638
Compressive Strength	0.500"	ASTM D695
Izod Impact Strength	0.500"	ASTM D256
Bond Strength	0.500"	ASTM D229
Shear Strength	0.062"	ASTM D732
Coefficient of Thermal Expansion	0.062"	IPC-TM-650-2.4.24
Flammability	0.062"	UL Bulletin 94
Breakdown Voltage	0.062"	ASTM D229 S/S
Electric Strength	0.062"	ASTM D229 S.T.
Permittivity	0.062"	ASTM D150
Dissipation Factor	0.062"	ASTM D150
Arc Resistance	0.125"	ASTM D495
Comparative Tracking Index	0.125"	ASTM D3638
Tracking Index, Cu electrodes	0.125"	ASTM D5288

### SPECIFICATIONS AND DESIGNATIONS

Material	ANSI/ASTM ASTM D709	NEMA DT-1998	U/Norplex Grade
MS-24768 - Type			
/12 - PBM	X	X	NP610
/19 - PBM-P	XP	XP	NP611, NP660, NP680
/20 - PBM-PC	XPC	XPC	NP612, NP625, NP664
/11 - PBG	XX	XX	NP603, NP629
/10 - PBE	XXX	XXX	NP630
/16 - FBM	C	C	NP310
/14 - FBG	CE	CE	NP310E
	CF	CF	NP318
/15 - FBI	L	L	NP320
/13 - FBE	LE	LE	NP320E
/18 - GPG	G-3	G-3	NP504
/8 - GMG	G-5	G-5	NP509
/1 - GME	G-9	G-9	NP509
/2 - GEE	G-10	G-10	G10
/27 - GEE-F	FR-4	FR-4	NP130, NP130HE, NP501, NP510A
/3 - GEB	G-11	G-11	NP511, NP511EM, NP511G
/29 - CEM-1	CEM-1	CEM-1	NP424
/9 - NPG	N-1	N-1	NP101

## HISTORY OF ILNORPLEX®, INC.

Industrial Laminates/Norplex, Inc. was founded in 1945 in La Crosse, Wisconsin under the name Northern Plastics. The company originally manufactured plastic rowboats, bread trays, and toilet seats. In 1949, our product line changed to industrial laminated plastics. The company expanded in the late fifties, adding a plant in Black River Falls, Wisconsin and expanding in La Crosse, Wisconsin. During this time, the company shortened its name to Norplex.

In 1965, Universal Oil Products (UOP) Company acquired Norplex. UOP had diversified interest from RD&E services to operations in plastics, chemicals, construction, transportation, steel fabrication and nuclear and aircraft parts. The Universal Oil Products name was changed in 1975 to UOP, Inc.

1969 to 1974 saw expansion into West Germany, Franklin, Indiana, and Postville, Iowa. Signal purchased UOP, becoming the sole owner in 1978. Internally, Norplex expanded in the Pacific region, adding sales offices in Hong Kong. UOP changed its corporate name to Signal Chemicals Group in 1985. Signal Companies then merged with Allied Corporation to form Allied-Signal. Under this new reorganization, Norplex was assigned to Allied Signal's Engineered Products Sector.

Norplex purchased a laminating plant in Singapore in 1986, and acquired Oak Materials Group Inc. The purchase of Oak led Norplex to change its name to Norplex/Oak. By purchasing Oak, Norplex/Oak assumed control of plants in New York, India, and Taiwan.

The late eighties saw further expansion into Taiwan, and Thailand, as well as acquisitions of laminate technology rights from Mica Corp, and the copper clad Division of Westinghouse including Fortin Industries.

On August 15, 1996, the Postville, Iowa, facility and the Industrial laminates business was sold, and IL/Norplex was incorporated in the state of Iowa as a private company.





HIGH-PERFORMANCE COMPOSITES

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