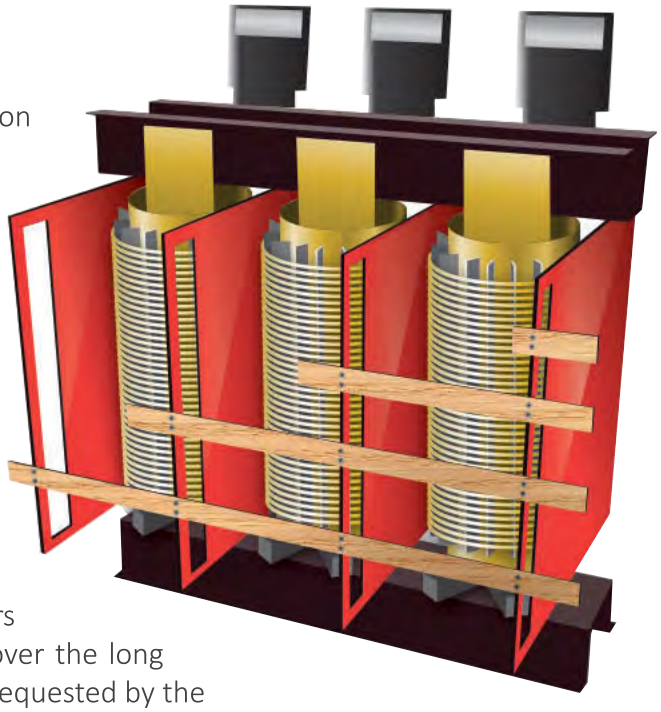
THE GUND COMPANY
MANUFACTURERS & FABRICATORS OF ENGINEERED MATERIAL SOLUTIONS
Los Angeles Milwaukee Dallas St. Louis Cedar Lake Canada Mexico China

Nomex® Paper



The Gund Company custom fabricates a wide range of insulation materials based on the unique requirements of our customers. Our wide range of materials and fabrication capabilities offer numerous material options to our customers. Our approach to material selection starts by evaluating the customer's application and specifying the material that suits their mechanical and electrical specifications. To help our customers learn more about aramid paper insulation materials like Nomex®, we have prepared this technical white paper.

Nomex® is just one material option for insulation applications. For example, in the dry type transformers (pictured at right), Nomex® is commonly used as layer insulation in the coils and as the conductor wrap insulation in the coils. Some manufacturers may chose alternate materials, but Nomex® has been proven over the long term to offer excellent performance. Regardless of the material requested by the customer, The Gund Company can support all of our customer's material needs.

Composite materials often consist of substrates or base materials manufactured using a paper making process. Many types of organic fibers can be made into a paper substrate. An example of an organic fiber would be cellulose produced from trees. Another example would be the synthetic aramid fiber pioneered by DuPont®- Nomex®. Other naturally occurring materials such as mica can also be made into a paper substrate.

These papers can be manufactured into insulating materials, either individually, or when combined with other materials to form a composite insulation material commonly referred to as a flexible laminate.

The table below includes common industrial fibers:

Natural - Animal Based	Alpaca, Angora, Camel Hair, Cashmere, Catgut, Chiengora, Llama, Mohair, Silk, Sinew, Spider Silk, Wool
Natural - Vegetable Based	Bamboo, Coir, Cotton, Flax, Hemp, Jute, Kenaf, Abaca, Pina, Faffia, Ramie, Sisal
Natural - Mineral Based	Asbestos, Basalt, Mineral Wool, Glass Wool, Mica
Synthetic	Acrylic, Aramid, Carbon, Nylon, Olefin, Polyester, Polyethylene, Zylon

THE GUND COMPANY

MANUFACTURERS & FABRICATORS OF ENGINEERED MATERIAL SOLUTIONS

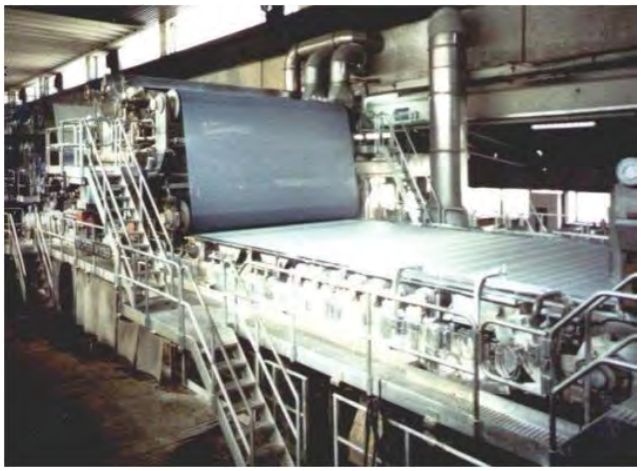
Los Angeles Milwaukee Dallas St. Louis Cedar Lake Canada Mexico China

Nomex® is a synthetic aromatic polyamide polymer that offers high levels of electrical, chemical and mechanical integrity, when converted into its various sheet forms. Generally, the term "paper" applies to thin sheets (i.e. < .062"), and "pressboard" to thick sheets. In the case of Nomex®, it can be made in the form of paper or pressboard depending on the application requirements.

The photo at right shows two dry type transformer coils. The coils use .030" thick Nomex® 410 paper as layer insulation. The winding combs are standing on edge resting on the Nomex® layer insulation. The conductors passing through the slots of the winding combs are insulated with .003" thick Nomex® paper used as conductor wrap insulation.

Nomex® is produced from a polyamide polymer (the same basic polymer as the familiar nylon, but quite different in terms of thermal characteristics). The polyamide molecule that produces the aramid Nomex® fiber is a laboratory created fiber as opposed to a kraft paper or rag paper fiber, which comes from trees and cotton plants respectively.

It can be considered an aromatic nylon, the meta variant of the para-aramid Kevlar®. It is sold in both fiber and sheet forms and is used as a fabric wherever resistance from heat and flame is required. Nomex® sheet is actually a calendered paper and made in a similar fashion. Nomex® Type 410 paper is the original, and one of the larger grade types made; It is mostly need for electrical insulation purposes. The Spruance plant, in Richmond, VA, is the sole North American paper production site. The paper is used in electrical laminates such as circuit boards, transformer cores, as well as fireproof honeycomb structures where it is saturated with a phenolic resin. Honeycomb structures such as these, as well as Mylar®- Nomex® laminates are used extensively in aircraft construction. Both the firefighting and vehicle racing industries use Nomex® to create clothing and equipment that can withstand intense heat. All aramids are heat and flame resistant but Kevlar,® having a para orientation, can be molecularly aligned and gives high strength. Meta aramid cannot align during filament formation and has poor strength. Nomex® fiber is made in the USA and in Spain (Asturias).



Unlike the polyamide in the familiar nylon, the high temperature material used for Nomex® will neither melt nor support combustion (flame retardant). At 250 °C, the melting point of normal Nylon 6-6, Nomex® retains 60% of its room-temperature strength. In essence, Nomex® acts like the thermoset version of the thermoplastic Nylon.

Nomex® paper is made on conventional paper making equipment, such as the example in the photo (left). Two types of fibers are used: flock fibers, which are relatively short, and fibrids, which are small fibrous binder particles. Mixed in the necessary proportion, these fibers are made into a paper that is furnished, when the process includes calendaring (as with Nomex® 410), in thickness of 2, 3, 5, 7, 10, 15, 20, and 30 mils. No materials other than the polymer fibers are used to make the paper.

THE GUND COMPANY

MANUFACTURERS & FABRICATORS OF ENGINEERED MATERIAL SOLUTIONS

Los Angeles | Milwaukee | Dallas | St. Louis | Cedar Lake | Canada | Mexico | China

Nomex® 411 is uncalendared and available from 6 to 42 mm. It has lower density (because it is not calendared) and is relatively porous allowing for much better impregnation and compression. Pressboard is made by laminating 410 and 411 together without adhesives, using the application of heat and pressure. Lamination requires temperatures up to 280 °C and pressures starting from 200 psi increasing to 2,000 psi.

Depending on the customer's application, The Gund Company can fabricate a wide range of parts:

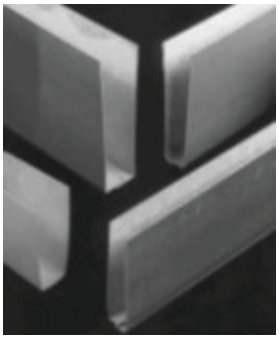
Electric Motor Applications

» J- Strips
» Slot Liners
» Phase Insulation
» Pole Turn Insulation

Electronic Transformer Applications

» Bobbin Insulation
» Layer Insulation

Generator Applications

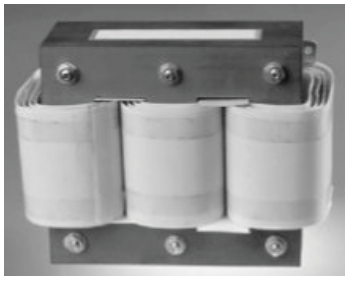


» Slot cells
» Slot Covers
» Turn Insulation
*Ask us about our Rotoguard protection package

Electricronic Equipment

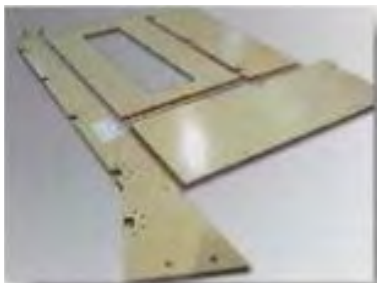
» Capacitor Insulation
» Chassis Liners
» PCB Insulation
» Transformer Insulation
» Air Baffles

Dry-Type Transformer Applications



» Layer Insualtion
» Crossover Pads
» Slit Conductor Wrap

Aerospace Applications



» Machined Aramid Fibre
» Honeycomb Panels

THE GUND COMPANY

MANUFACTURERS & FABRICATORS OF ENGINEERED MATERIAL SOLUTIONS

Los Angeles | Milwaukee | Dallas | St. Louis | Cedar Lake | Canada | Mexico | China

Of course, material selection depends on the application requirements. The various physical, mechanical, electrical, and chemical property requirements of the application must be considered with the benefits of each material option being reviewed.

For example, one manufacturer of power supplies asked The Gund Company to review several different legacy materials as well as modern material options for cost reduction opportunities. Because many power supply manufacturers were familiar with Nomex® due to its use in their dry type transformers, it is common for them to use Nomex® for any and all insulation material applications in their equipment from fuse clip insulation to print circuit board insulation to chassis insulation. The customer determined their most critical property requirements for their design and we produced a comparative property chart for several material options as you can see below.

	PolyPro® FR	Formex®	Vulcanized Fibre	Duroid® D-100 FR	Mylar®	Nomex®	Valox®
Flammability	UL 94 V-0	UL 94 V-0	UL 94 HB	UL 94 V-0	UL 94 HB	UL 94 V-0	UL 94 V-0
Dielectric Strength	1,000 VPM	500 VPM	215 VPM	200 VPM	1,400 VPM	700 VPM	400 VPM
Tensile Strength	4,300 psi	4,800 psi	14,000 psi	12,000 psi	25,600 psi	N/A	7,500 psi
Temperature Index	110 °C	110 °C	110 °C	90 °C	130 °C	220 °C	140 °C
Water Absorption	0.01%	0.01%	66%	40%	0.01%	20%	0.04%
Relative Cost	$2.00	$2.50	$2.20	$2.10	$2.00	$10.00	$3.50

This chart helps the customers streamline their material specification and selection criteria for several applications in their equipment. For applications in the dry type transformer or near the heat generated by the transformer, the customer specified Nomex® 410. Because The Gund Company has maintained a well planned inventory of Nomex®, we could guarantee supply despite the historical Nomex® supply chain issues that started in 2006 saving the customer from having to qualify newer, less proven material options that had not yet been added to their insulation system. For applications that did not require the 220 °C temperature resistance of Nomex®, the customer specified PolyPro® FR to replace Nomex® and then standardized on PolyPro® FR to replace Formex®, Vulcanized Fibre, and Voltoid® materials in legacy designs.

By understanding customer applications, The Gund Company's application engineering services can provide our customer's with options for their selection of the optimal material from a cost and performance perspective.

Dedicated inventory, complete fabrication facilities, and extremely short lead-times insures The Gund Company's ability to provide electrical insulating materials for the manufacture, and repair of electrical power systems equipment. The Gund Company is up to the challenge to engineer lower cost alternatives. Contact us today to learn more about material selection: *materials@thegundcompany.com*