

**NOMEX<sup>®</sup>**



**UL-Recognized 600 Volt Class Electrical Insulation  
Systems Based On NOMEX<sup>®</sup>**

# NOMEX®



## UL-Recognized 600 Volt Class Electrical Insulation Systems Based On NOMEX®

**U. L. File Number E57692 (OBJS2)**

### Overview

To make safe and reliable electrical equipment, manufacturers must use an insulation system which lasts throughout the useful life of the equipment while protecting the lives and property of the users. Underwriters Laboratories Inc. (UL), an internationally respected safety agency, develops, publishes, and enforces safety standards for insulation systems and equipment, and since 1894, users have relied on the UL "Listed" or "Recognized" marks to confirm that rigorous safety standards and procedures have been used in producing equipment they purchase.

More than thirty years ago, DuPont was the first insulation manufacturer to obtain UL Recognition on electrical insulation systems for our customers. Ever since, we have provided systems based on NOMEX® brand papers and pressboards. Durability, an important consideration in these systems, has been proven by successful use of NOMEX® in thousands of different model motors and transformers. NOMEX® is well known as a key material in safe, reliable, high-quality electrical equipment.

This brochure describes the insulation systems DuPont currently offers for use in the 600 Volt primary winding voltage class.

1. Call UL to obtain more information about those systems.
2. If you find that any of our systems meet your needs, contact us.

We will provide our systems without a license fee and we will notify UL to release the necessary data to you. Of course, we will be glad to assist you in applying these systems for your equipment. Call us at the telephone numbers listed at the end of this brochure. We also offer other systems for use in dry-type distribution transformers up to 35 kV, which are published in a separate piece of literature.

### Advantages of these Systems

Use of DuPont systems saves manufacturers time (often up 18 months or more) and substantial costs involved in insulation system testing needed to obtain UL Recognition. Also, as mentioned previously, DuPont does not charge a fee to use these systems. In addition to the systems we offer based on our tests, many modifications to our systems have been UL-Recognized for other material suppliers, giving the user a wide variety of choices.

Other DuPont groups also offer insulation systems for use by customers. As an important example, DuPont Engineering Polymers offers many systems based on molding plastics, and those systems include NOMEX® brand paper where appropriate. Contact us for further information, or obtain the brochure "Thermoplastics for UL/IEC Electrical Insulation Systems: Transformers, Motors, Coils, Relays, and Encapsulation" by contacting the Engineering Polymers office listed at the end of this brochure.

## **System Voltage Ratings**

While this information sheet deals mostly with electrical equipment which has a primary winding voltage up to 600 Volts, UL may allow these systems to be used at higher voltages. The required ground and interwinding insulation thicknesses described in the UL report must be increased proportionately, so that the volt per mil stresses represented by the original test voltage are not exceeded. If a thinner thickness or higher volt/mil stress is desired, an aging test will be required.

## **Component Recognition vs. Insulation System Recognition**

NOMEX® brand paper Types 410, 411, 414, 418, 419, and E56, plus pressboard types 992, 993, and 994, are UL Component-Recognized (UL File E-34739) per UL 746 with a Relative Thermal Index (RTI) of 220°C for both mechanical and electrical properties. Most thicknesses (of all types) are also rated 94V-0 by UL. NOMEX® insulation therefore makes a reliable product for top-quality insulation systems. Type N196 is UL Component-Recognized with a RTI of 220°C for mechanical properties. For further information and specific property data for any of these products, contact DuPont at the offices given at the end of this brochure.

Component Recognition is granted to a material based on its inherent properties, regardless of how or where it is to be used, and the material is tested alone or with a control. Component Recognition may involve ratings for only one or for many different electrical, mechanical, and flammability properties, although such a test program is likely to be time-consuming and complex, DuPont has already done this work for our materials. Insulation System Recognition, by comparison, is limited to one specific kind of use, with materials being tested in a model. DuPont conducts all tests in accordance with UL Standards, which you may purchase from UL or their agents.

## **Insulation System Testing**

UL Standard 1446 prescribes procedures to determine the RTI for an insulation system. An insulation system is defined by IEC as “one or more electrical insulating materials together with associated conducting parts employed in an electrotechnical device”. When an

application for an insulation system is received, UL assigns a project engineer, and this person is available to assist in planning the necessary test program. The following is a brief outline of the work required for a system aging test program.

Generally, a model, usually a standard form called a motorette, is used to test all insulation parts together. Other types of models or actual production units may be used if UL and the manufacturer or client agree. To account for variations in test conditions, an accepted “control” insulation system with a proven history is tested along with the proposed new system. Test units are heat-aged at three or more elevated temperatures, normally at 20°C intervals. The lowest temperature is selected to bring about end-of-life in a minimum of 5,000 hours, and the highest temperature should bring about end-of-life in at least 100 hours. The models are tested through repeated cycles of oven aging followed by environmental testing, which includes vibration, cold shock, and high humidity. While saturated with moisture, the insulation is proof tested at elevated voltages to prove the integrity of the insulation system.

When the proposed and control systems have reached their end-of-life, the data are processed as described in the Standard to create a life line or curve for the system over the test temperature range, and this is extrapolated to operating temperature ranges. The lifetime of the control system at its class temperature (usually about 20,000 hours, though it can vary) sets the lifetime requirement of the proposed system, and the temperature yielding that lifetime is the RTI of the new system. The RTI will be given as a temperature, not necessarily matching one of the common “letter” insulation classes. The insulation system, when Recognized by UL, is published with an assigned temperature class equal to the next lowest temperature from the RTI that is numerically equal to a class rating.

When a system has been Recognized through an aging test program, substitutions and additions to the system may be made in accordance with UL Standard 1446. Normally, a sealed-tube or one-temperature-point test is sufficient provided the new material meets certain UL criteria. Exact procedures are given in the Standard.

### **Test Lifetimes Compared to Actual Lifetimes**

It should be understood that the “lifetimes” projected from these tests are not necessarily as long as the actual service lifetimes which users expect. Equipment insulated with the “control” insulation systems have an “accepted” life in normal use, usually many years, depending on the end use. The tests expose every part of the insulation system to the design “hot spot” (or “hottest spot”) temperature of the unit for the entire period of aging. In actual use, the maximum hottest-spot temperature is seldom reached, and even then only a small part of the insulation system is exposed to that temperature. The test “lifetimes” are simply a way to compare the control and proposed systems.

### **Design Temperature Classes**

Insulation systems based on NOMEX® brand paper are available for all common UL temperature classes from 130(B) through 220(R). Since most NOMEX® paper is UL-Recognized as a 220°C component, designing with NOMEX® to a temperature class of 180(H) or 220(R) instead of 130(B) may involve little additional cost, since the materials are largely the same. Of course, any system may be used at a lower temperature. For example, System 16(Class 180 or H) may be used as a Class 155(F) system, with very long life and outstanding reliability.

### **Design Voltage Stress**

DuPont recommends continuous voltage stresses not exceed 40 V/mil (1.6 kV/mm) r.m.s. for most equipment, or less if the input or output power waveforms may be distorted by harmonics. For transformers above 600 Volts, design stresses under 30 V/mil (1.2 kV/mm) are often preferred to assure long life and freedom from partial discharge (corona). For more information on higher voltage equipment, refer to our bulletin on medium voltage systems.

### **Ground and Interwinding Insulation (Major Insulation)**

Ground and interwinding insulations are essential to the safe operation of the unit since failures, even if not noticeably affecting operation, could create a shock or fire hazard. They are consequently called “major” insulation. The superior thermal, electrical and mechanical properties of NOMEX®, plus its outstanding flame resistance, make it the material of choice for these critical uses. Also, laminates of NOMEX® with either polyester or polyimide film may be used where high tear strength is required, provided a sufficient thickness of NOMEX® is used. A sealed tube test may be required to qualify laminates because of different films, adhesives, manufacturers, etc.

### **Magnet Wire or Conductor Insulation**

This is also major insulation and must be fully tested. Any type of NOMEX® listed in the table is permitted, along with many well-known ANSI/NEMA MW1000 enamels, and substitutions may be made with UL agreement. Generally, UL allows substitution from different suppliers within groups of similar enamel coatings. For general reference, see Part 2 of the NEMA MW1000 guide, which lists all of the currently available magnet wires by thermal class.

### **Minor Insulation**

Much of the insulation in a piece of equipment is essential to manufacturing and/or operation, but a failure in many cases does not create a hazard as failure of ground insulation might. Examples are tapes, sleeveings, and certain kinds of layer insulation. These are commonly called “minor” insulation, and are subject to less severe standards. They may be added to an insulation system as needed with UL agreement, generally involving short-term compatibility testing.

## **Baking Varnishes**

Due to the superior inherent properties of NOMEX® brand paper, DuPont was able to obtain UL Recognition on most insulation systems without varnish, and these systems are designated as “Varnish Optional”. These systems were developed to allow easy addition of many varnishes, but DuPont does not recommend manufacturing equipment without varnish, except in special cases as noted below. In these systems, the varnish is considered a minor insulation material, and users may add a varnish of choice by running a sealed-tube test in accordance with UL Standard 1446. This is relatively brief and inexpensive. The varnish selected must be UL Component-Recognized in combination with the magnet wire selected, with a thermal index not more than one temperature class below the UL-Recognized class of the unvarnished wire. Varnishes listed by name and type in this brochure have been previously qualified and may be used without testing, and varnish suppliers have qualified many others and can provide specific information.

DuPont recommends using a varnish in nearly all types of equipment. A good varnish increases mechanical strength, improves cooling, reduces noise, protects against dirt and contaminants, and helps in cleaning the coils. In some cases, a varnish may not be necessary, such as in low power equipment having enclosed coils.

## **Other Electrical Insulation Materials Provided by DuPont**

As mentioned earlier, DuPont manufactures a wide range of insulating materials. Many of these are engineering plastics which have been tested and are

discussed in UL-Recognized insulation systems by DuPont Engineering Polymers (File No. E69939), and NOMEX® brand paper is included in these systems. The systems are based on:

- DuPont Moldable Composite Sheet (MCS)
- ZENITE™ Liquid Crystal Polymer (LCP)
- CRAFTIN® PBT Polyester
- ZYTEL® Polyamide (PA)
- ZYTEL® High Temperature Nylon (HTN)
- RYNITE® PET Polyester
- KAPTON® Polyimide Film
- MYLAR® Polyester Film
- MELINEX® Polyester Film
- KALADEX® PEN Film

For information on those insulation systems, please contact the DuPont Engineering Polymers office listed at the end of this brochure and request a copy of the following brochure: *“Thermoplastics for UL/IEC Electrical Insulation Systems: Transformers, Motors, Coils, Relays, and Encapsulation”*.

## **Insulation System Specifications and Options**

The enclosed tables list current options in insulation systems based on NOMEX® Brand paper. The data conform to DuPont’s UL File E-57692 as of the date of preparation of this brochure, and are subject to change with material availability.

**For More Information, Please Contact Your DuPont Representative**

**USA**

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Customer Inquiry Center  
5401 Jefferson Davis Highway  
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Tel: (800) 453-8527  
(804) 383-4400  
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