# Cellulose paper enhanced with Nomex® aramid gives extra reliability to GSU transformers in Egypt

Nomex® 910, an aramid-enhanced cellulose paper, 130°C thermal class, in mineral oil and 140°C in natural ester has been chosen by Tamini for generator step-up transformers subject to hot climate conditions as well as constant high load. This insulation system enhances reliability and ensures extended life of the equipment.

310 MVA GSU transformer using aramid enhanced cellulose paper (photo courtesy of Tamini Trasformatori Srl)

## Transformer aging

Studies show that most failures of power transformers are not just related to age of a transformer in general, but are typically related to more localized damage or insulation aging. These might be due to issues in the design, manufacturing, operation or maintenance. Various components of a transformer insulation system age at different rates and in different ways. Many factors, including thermal and cooling designs, loading and faults, can all affect the rate of insulation aging. While the nature of the failures can vary between thermal, dielectric, mechanical or other aspects, it is proven that the long-term insulation performance is critical for reliable and long life of a transformer.

While the inter-turn failures could be more of a dielectric nature, they can be typically connected to the conductor insulation performance as well, since the strength of the insulation paper is affected by the thermal aging over the transformer life.

It is important to remember that the typical life expectancy of transformers is more specific to network or distribution transformers. These units normally have relatively low loading factors and do not see many severe overloads. The transmission or distribution networks are often designed with built-in redundancy in transformer capacity to ensure safe loading of transformers. However, in some specific applications, loading patterns are less predictable, or average loading is much closer to the nameplate than in the case of a typical network transformer. Unexpected overloads or other anomalies can accumulate thermal effects in winding insulation. Insulating

Aged and brittle conductor insulation (photo by DuPont)

paper is the most sensitive component as it is directly exposed to the conductor temperature, especially in the hottest spot area. It is also a critical component of the transformer insulation system exposed to the highest dielectric stress.

## Some transformers are more sensitive to aging

A specific category of transformers facing possible issues with reduced life expectancy, are generator step-up transformers (GSUs). They are often designed to match the rating of the attached power plant, and therefore are continuously loaded close to their nameplate ratings. Although they might not be exposed to overloads, the continuous loading and constant winding temperature close to the standardized limits causes the aging effects to be more severe than that observed in typical network or distribution units.

IEC Loading Guide 60076-7 gives a special precaution for GSU transformers: "For GSU transformers connected to base load generators and other transformers supplying constant load or operating at relatively constant ambient temperatures, the actual lifetime needs special consideration."

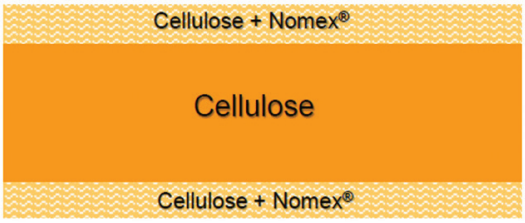
## Nomex® 910

To respond to increasing need for a paper with improved performance vs. cellulose, DuPont developed and launched on the market a 130°C thermal class insulation solution.

DuPont™ Nomex® 910 is a unique insulating material composed of high-quality electrical grade cellulose pulp and web-like binders made from the same high temperature polymer as other Nomex® brand papers. These ingredients, individually well-known and used for many decades in the insulation of liquid-immersed transformers, are combined in a novel three-ply structure to form a paper consisting of a single consolidated sheet. Since the product comprises both cellulose and Nomex® aramid ingredients, it exhibits properties that are between Nomex® Type 410 and cellulosic papers. The proprietary technology for manufacturing such papers allows the production of papers with improved thermal resistance and better electrical properties compared to standard cellulose papers.

## GSU transformer for hot climate installation

When Tamini got a request for three 310 MVA, 220 kV GSU transformers to be installed in hot climate installation in a refurbished power plant in Egypt, the consideration was made for the enhanced paper Nomex® 910. The installation was in a hot climate area, and the units were expected to operate continuously close to their nameplate ratings.




Structure of aramid-enhanced cellulose paper DuPont™ Nomex® 910

Rectangular conductor insulated with aramid-enhanced cellulose paper DuPont™ Nomex® 910 (photo by DuPont)

Although the specified rated winding temperatures were reduced by the customer to accommodate for the expected high ambient temperatures during the year, the insulation of thermal class of at least 130°C was still required. As the most economical option, the aramid-enhanced cellulose paper was selected for conductor insulation.

Successful processing and wrapping tests conducted by the conductor supplier confirmed the possible use of this insulation material in large GSU transformers. The CTC cables were supplied for HV windings and rectangular single strand wires for regulating windings.

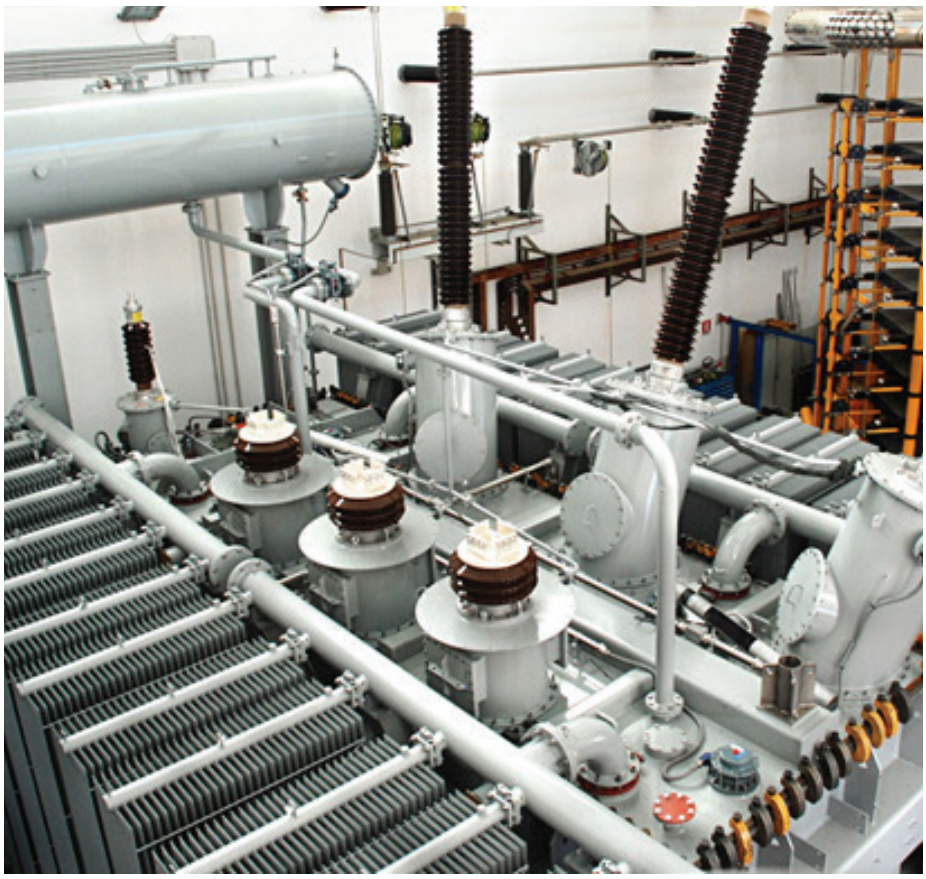
The three units had successfully passed their type testing at the manufacturer.

Basic characteristics of the transformers (data courtesy of Tamini Trasformatori Srl)

| | |
|---|---|
| **Type:** | Generator step-up |
| **Rated power:** | 186 / 248 / 310 MVA<br>(ONAN / ONAF-1 / ONAF-2)<br>V1=220 kV ± 4 x 2.5%<br>(with off circuit tap changer)<br>V2=15.75 kV |
| **Connection:** | YNd1<br>Three-phase, 50 Hz |
| **Reference standard:** | IEEE |

"For GSU transformers connected to base load generators and other transformers supplying constant load or operating at relatively constant ambient temperatures, the actual lifetime needs special consideration."

*Source: IEC 60076-7 Power transformers – Part 7: Loading guide for liquid-immersed power transformers*



310 MVA GSU transformer in a test bay (photo courtesy of Tamini Trasformatori Srl)

**Insulation:** Thermal class at least 130°C, full hybrid insulation windings acc. to IEEE C57.154 "IEEE Standard for the Design, Testing, and Application of Liquid-Immersed Distribution, Power, and Regulating Transformers Using High-Temperature Insulation Systems and Operating at Elevated Temperatures"

## Key benefits:

- Extended life of conductor insulation and entire transformer insulation system
- Reduced impact of high ambient temperature on insulation aging
- Reduced impact of full continuous transformer loading
- Reduced sensitivity of transformer insulation to temporary overloads

## About Nomex® papers and pressboards

Nomex® is a synthetic aromatic polyamide offering exceptional electrical, chemical and mechanical integrity, and resistance to high temperatures. It is widely specified as hybrid insulation for Class H transformers because of its upper temperature capability of 220°C, building in a safety margin that comfortably exceeds actual operating conditions. DuPont markets different types of Nomex® papers and pressboards in high, medium and low density, and in a range of thicknesses, for many insulation applications.

For more information, visit: nomex.com

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