DuPont’s Heritage in Hot Gas Filtration Application

For over 4 decades, a filter media made of Nomex® brand fibre has been considered as the “state of the art product” in typical filtration applications such as asphalt production and cement clinker coolers. In order to better serve these industries worldwide, DuPont has developed a new product: Nomex® KD. This special blend of DuPont’s aramid fibres Nomex® and Kevlar® is able to increase the surface area of the filter media which consequently allows the creation of new and more efficient solutions for enhanced filtration.
To better serve the Asphalt and Cement Clinker Cooler industries worldwide, DuPont introduces **Nomex® KD**, an innovative blend of **Nomex®** and **Kevlar®** which significantly increases the surface area of the filter media allowing designers new and more efficient solutions for enhanced filtration. To maintain DuPont’s high quality level standards, it will bear the DuPont Quality Label to ensure that the use of genuine DuPont brand fibre material is used.

**WHAT IS THE DUPONT NOMEX® BRAND FILTRATION QUALITY PROGRAM?**

It is an agreement between DuPont and quality minded Bagmakers to use 100% Nomex® brand products. The identification is made by visible labels guaranteeing a high Quality and full traceability for the end-users.

**THE MECHANISM OF NOMEX® KD**

The particular mechanism of Nomex® KD is based on a splitting effect of part of the fibres in the filter media called fibrillation. To visualise this effect of fibres in a simple way, we can imagine how a trunk of wood can be split into smaller pieces when hitting it with an axe.

This fibrillation is created “in situ” during the non woven densification process such as needling. Not many fibres have this quality to split into microfibers. In this case, it is related to the specific chemical structure and arrangement of the molecules of the Kevlar fibre. Kevlar® fiber is a para – aramid, meaning that the molecules are aligned in a very linear structure and can therefore be split into smaller pieces by the weaker hydrogen bonds.

**A HIGHER FILTRATION SURFACE AREA**

The Scanning Electron Microscope (SEM) photograph show the difference between the surface of standard Nomex® filter media where all the fibres have the same thickness (linear density 2.2 dtex) or have an average diameter of 14 microns. However, the SEM of Nomex® KD shows fibres of different diameters, the thickest one being 2.2 dtex but with the finer fibers ranging from 14 down to 1 or less micrometers.

Consequently, finer fibers have by nature a higher specific surface area for the same mass and should be able to retain more and smaller dust particles during the filtration process. In order to measure this change in surface area we have selected the BET equipment and conducted the test in argon gas.
The graph above shows the results from a laboratory study (BET equipment, test run with argon gas). The column on the left represents the baseline surface area of a 100% filter media of Nomex® which results in 0.2024 m$^2$ per gram of material. Depending on the design and non-woven processing conditions, the increase in surface of the filter media made of Nomex® KD ranges from 5% to 43% (or an average 25% as plotted in the right column).

**CHEMICAL AND OXIDATIVE RESISTANCE**

Another important filtration characteristic for the increased reliability of a filter media is the chemical resistance of the filter media in use. DuPont’s unique filtration flue gas test equipment, the “Artificial Stack Tester” (photo below) is able to provide accelerated chemical degradation results for Nomex® in about 1 month in order to predict an expected 2 years bag life exposure in use. The standard test conditions of the test flue gas consists of a mixture of hot air at 200°C with 10% humidity and 1’000 parts per million of sulphur dioxide acid gases.

**Chemical Stability: Artificial Stack Tester at DuPont Lab**

Test simulates accelerated chemical degradation of the filter media

**Flue Gas Test Conditions:**
- Air (79%N₂ + 21%O₂)
- Water vapor (10%)
- 1’000 ppm SO₂  (Sulphur Dioxide)
- Temperature: 200 °C

Typical testing time: 0, 7, 14, 21, 28 days

Not only the chemical resistance but also the oxidative resistance of a filter media is an important filtration performance related parameter. This test is conducted in a simple hot air laboratory oven. (photo below) The samples are exposed for up to 2,000 hours at an elevated continuous temperature of 210°C in air at 21% Oxygen. Molecular degradation as well as loss in tensile and tear strength are qualifying this oxidative filtration property.

**Oxidative Stability: Hot Air Test Oven**

Test simulates accelerated oxidative degradation of the filter media

**Test Conditions:**
- Air (79%N₂ + 21%O₂)
- Temperature: 210 °C
- Hours of exposure: 0 - 500 - 1000 - 1500 - 2000

In both test methods, we have selected a typical representative set of results demonstrating that there is no or only a slight difference in chemical or oxidative degradation.
NON BREAK OPEN BEHAVIOUR BY HEAT AND FLAME.

This testing method determines the effects of a source of ignition. To run this test, the metal nuts are heated up to 900°C in a test oven (photo above) and then exposed for 30 seconds onto the filter media. The results illustrated in the above right photographs show that the hot metal nut makes its way through the test specimen of Nomex® in 5 seconds but without igniting the filter media. Applying the hot metal nut onto Nomex® KD results after 30 seconds into a carbonisation of the filter media without breaking or opening the structure.

Therefore, in cases of filtration applications requiring spark resistance, the dimensional stability of Nomex® KD in heat and flame conditions may help to maintain bag integrity and to resist break open.

COMPARISON OF FILTRATION BEHAVIOUR BETWEEN NOMEX® AND NOMEX® KD NEEDLE FELTS

A comparison was made between 11 commercially made needle felts from different global producers of Nomex® KD and 11 benchmark needle felts of Nomex®. These were tested under VDI 3926 (Testing of cleanable filter media) filter test conditions. The graph below shows the average results of all 11 tested felts of each quality.

Filtration behaviour of Nomex® KD needle felts compared to a woven glass fabric with a PTFE membrane, a commonly used benchmark filter media.

Again, at a 30% lower basis weight, Nomex® KD has a better performance in dust retention and pressure drop than a woven glass with a PTFE membrane filter media under the VDI 3926 Filter Test conditions.

KEY ADVANTAGES OF NOMEX® KD VERSUS FILTER MEDIA OF NOMEX®:

- Up to 60% better filtration efficiency for the same filter media weight …or up to 30% reduced filter media weight for the same efficiency
- Enhanced filtration of less than 2.5 micron particles
- A potential to reduce operating energy costs
- A potential to reduce material costs
- High dimensional stability, could lead to long-term durability and longer bag life
- An improved spark resistance resulting in reduced “break open” effect.

To summarise, we can conclude that:

NOMEX® KD ENHANCES FILTRATION PERFORMANCE AND INCREASES RELIABILITY AT LOWER COST
Nonwoven structures for the Hot Gas Filtration

WHAT ARE NONWOVENS?
Nonwovens are special engineered fabrics offering cost effective solutions for an increasingly wide variety of applications.
A more formal definition of “nonwoven” by ISO 9092 is:
A manufactured sheet, web or batt or directionally or randomly orientated fibres, bonded by friction, and/or cohesion and/or adhesion, excluding paper and products which are woven, knitted, tufted, stitchbonded incorporating binding yarns or filaments, or felted by wet milling, whether or not additionally needled.

HOW NONWOVENS ARE MADE?
The production of nonwovens takes place in three stages, although modern technology allows an overlapping of the stages. In some cases all three stages can take place at the same time.
1) Web formation
2) Web consolidation
3) Finishing treatments

WHAT IS THE KEY DIFFERENCE BETWEEN NEEDLE FELTING AND SPUNLACING?
It takes place during the web consolidation
• Needle felting is using metal needles of different shapes and gages
• Spunlaced structures uses high pressure water jets instead of needles.

NON WOVEN PROCESSING TECHNOLOGIES DIFFERENCES
For the last 40 years needle punching is considered the “state of the art” technology for producing filter media for the hot gas filtration segment and is practised all over the globe. In contrary, spunlacing technology for heavy filter media structures (300 to 600 g/m²) has been available for a decade only and is currently used by a small number of manufacturers.

Work on Single fibre in :
NEEDLE FELTING

Spunlaced structure is more homogeneously distributed

The modern, very sophisticated spunlacing technology improves the fibre distribution in the nonwoven structure, keeping the dust particles more at the surface. This results in a lower dust leakage and ensures a lower pressure drop (dP) during its life time.
Modern spunlacing technology allows production of up to 600 g/m² structures with or without scrim support that offers the following advantages versus classic needle felt structures:

- Excellent sheet uniformity
- Improved filtration efficiency
- Similar or improved physical, thermal, chemical properties
- Smoother surface, ideal for membrane application and singeing may not be necessary in many cases
- Offers cost savings to bag makers and end-users (lower weight)
- Improved flexibility in fabric construction (inorganic scrims, etc)

BENEFITS FOR SPUNLACED STRUCTURES IN HOT GAS FILTRATION APPLICATIONS

Modern spunlacing technology allows production of up to 600 g/m² structures with or without scrim support that offers the following advantages versus classic needle felt structures:

- Excellent sheet uniformity
- Improved filtration efficiency
- Similar or improved physical, thermal, chemical properties
- Smoother surface, ideal for membrane application and singeing may not be necessary in many cases
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- Improved flexibility in fabric construction (inorganic scrims, etc)

VDI 3926 – comparison of commercial made felts

![Graph showing filtration performance comparison](image)

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