Precision woven synthetic filter fabrics – the fine arts of design and performance

Introduction

Worldwide, there is a vast number of industrial solid/solid and solid/liquid separation processes. Many of these require a corresponding variety of highly specific, mechanically and chemically resistant, high-performance filter media. The advent of synthetic monofilament fibers offered the possibility to create a large range of tailormade filter elements from woven synthetic fabrics. After 170 years of focusing on precisionwoven fabrics for sifting and filtration, Sefar has an established worldwide reputation for its high-quality products and services. In particular, the basics of how to approach possibilities to increase the value of the filter media to the enduser in various industries and applications are described.

Filter fabrics are used in a large number of industrial sifting or filtration applications ranging from medical filters in infusion sets to waste water treatment, from dye particle separation bags to food processing and drying belts.

Typical expectations – almost to «square the circle» – have always been:

- highest flow rate, clearest filtrate
- highest lifetime, least blinding
- best mechanical, chemical and thermal properties and resistance
- lowest cost

More stringent standards imposed by environmental protection laws demand that modern production processes achieve ever greater efficiency and are increasingly costeffective. Such standards can only be attained by developing innovative filtration and separation products.
The two major reasons for the success story of Sefar are its 170 years of focusing on precisionwoven fabrics for sifting and filtration and its combination of:

a) relying whenever possible on the advantages of monofilament synthetic fibers in surface and cakeforming filtration processes.

b) aiming always for the most appropriate selection of raw material, product design and special product treatment to enhance its performance; and last but not least, using the most advanced and up-to-date techniques of fabrication and making-up skills.

Depth versus surface and cakeforming filtration

Depth filtration (Fig. 1, left): Filter media consist of a mass that forms a tortuous path having many entrapments to stop the particles. Separation takes place within the filter media. It may be used down to very fine particle size distribution (10 microns) or very low rate of fines in slurry.

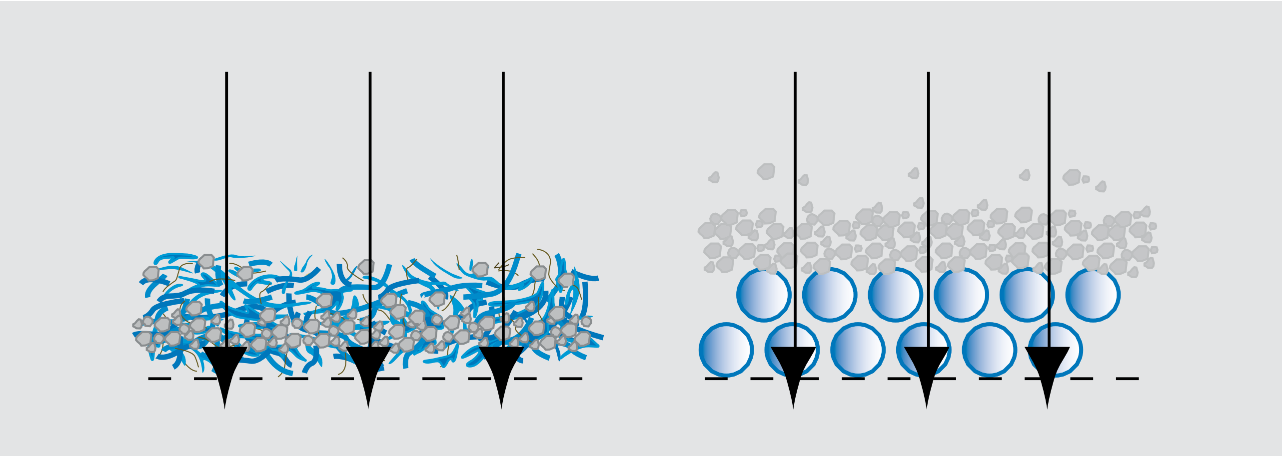


Fig. 1: Comparison between depth filtration (left) and surface filtration (right)

Typical media are needled felt, paper or sintered metals. There is high probability that particles will be quickly trapped, leading to the quicker occurrence of blinding and falling performance. At this point, the cloth must be either completely cleaned with some aggressive acid or alkaline rinse or be discarded. The fabric used is therefore generally regarded as an expendable item.

Surface/cake-forming filtration (Fig. 1): The simplest application would be a dry screening process. The filter media largely removes the particles by direct interception. Particles larger than the pore size are stopped at the upstream surface. Particles principally retained at the media surface can be easily removed. Typical media are fabrics woven using synthetic or metal wires. The cake-forming approach to the process of filtration means that the fabric itself serves as the filter media in the initial stage of the process, after which the built-up cake will itself become the (very fine) filter in the following process cycles. The fabric then mainly functions as a support for the filter cake. These media are designed to be washed or cleaned and reused many times.

Best suitable raw material – monofilament synthetic fibers

As illustrated in Fig. 2, a multifilament fiber consists of several fine monofilament fibers spun together. Staple fiber yarns consist of individual cut pieces of fibers that are spun into a continuous yarn.
In contrast, monofilament yarns are single extruded synthetic filaments, produced in diameters from approx. 28 microns up to 2 or 3 mm. Such a monofilament fiber has a sleek and solid precise geometrical form. This is of major importance if it is to be woven into a precision fabric.

The first polyamide 6.6 monofilaments produced were used to replace silk in flour mill screens. In addition to these original fibers, monofilament fibers are also produced from polyamide 6, 11 and 12, polyester and polypropylene.

For more stringent requirements, a significant number of high-performance materials such as PEEK, PTFE, E-CTFE and PVDF have also become available. Because of this wide choice now available in the fabrication of filter media, Sefar's experience has demonstrated the importance of always conducting a thorough investigation to determine the most suitable synthetic material for each individual filtration process.

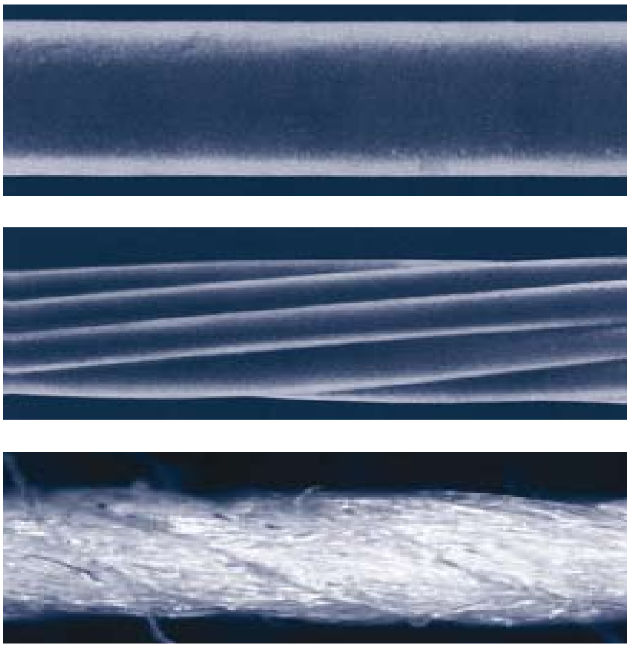


Fig 2: Yarn types (monofilament, multifilament and staple fiber yarn)

Monofilament woven fabrics offer several advantages when compared with multifilament or staple fiber woven fabrics in both categories of surface filtration, and even more when compared with non-wovens. A monofilament woven fabric will have relatively more open area than a multifilament or staple fiber woven fabric, and so permit the highest possible flow rate. Another advantage of monofilaments is the absence of the danger of small pieces of filament separating from the multifilament or staple fibers and passing downstream and resulting in contamination of the product. Monofilament fabrics offer the smallest number of interstices in which foreign particles may become embedded to either clog the fabric or to later become detached and result in contamination of the solvent. Obviously any filter cake or particles can be most easily removed from the surface of monofilament woven fabrics. This property also makes them the most suitable choice for medical or aerospace applications that require a high level of cleanliness.

Today monofilament synthetic fabrics have also replaced metal wire cloth in applications such as filter or dryer belts, sifting screens, automobile filters, rotary filters and many more. This rapid change has been the result of their many performance and economic advantages. Industry demands chemical-resistant materials for use in corrosive conditions, often at elevated operating temperatures. The wide variety of chemical-resistant synthetic materials allows the most ideal fabric at the most favorable price level to be chosen.
As a further bonus, synthetic materials offer good flexing resistance and better mechanical and elastic properties when compared with metal-based materials. Due to their ductile and ‚memory' properties, synthetics may be flexed repeatedly without workhardening and fatigue. Less weight and easier making-up properties complete the argument made for its preference over other materials.

There is rarely the ‚one and only' best yarn to be selected. Further explanations will show that other parameters do even more to influence final performance. In the pursuit of the optimal solution the choice of one parameter never overrules all other factors. The ability to be able to choose certain combinations in order to make the best use of fiber, fabric design and making-up properties is of far greater importance.

Conversion factors: Air permeability

	To	**CH**	**F**	**DIN**	**US**
From		l/m²/s @ 200 Pa (1)	m³/m²/h @200 Pa (1)	l/dm²/min @200 Pa (1)	ft³/ft²/min @ 125 Pa (2)
CH	l/m²/s @ 200 Pa (1)		x 3.6	x 0.6	x ~0.123
F	m³/m²/h @ 200 Pa (1)	x 0.278		x 0.167	x ~0.0342
DIN	l/dm²/min @ 200 Pa (1)	x 1.67	x 6		x ~0.205
US	ft³/ft²/min @ 125 Pa (2)	x ~8.1	x ~29.2	x ~4.9	

Remarks:
(1) *200 Pa = 20 mm WC*
(2) *125 Pa = 12.7 mm WC = 1/2 "WC*
approximation, assuming that air permeability is proportional to Delta „p"
ft3/ft2/min @ 125 Pa = cfm

Weave pattern variation of monofilament fabrics

The first monofilament fabrics were woven in plain square weave pattern (Fig. 3). A plain square weave creates a minimum flow restriction because its mesh openings are straight through the fabric.
This is the most simple, symmetric construction, and creates the most even mesh openings that are limited in aperture only by the wire diameter.

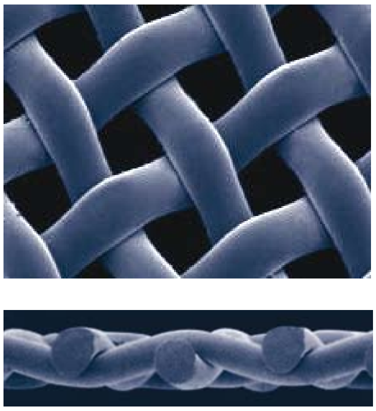


Fig 3: Plain square weave PLN 1/1

Further advantages of the plain square weave are its positive open area/weight ratio and the residual elasticity due to the maximum number of crossings per wire.
Again, the plain weave offers excellent throughput capacity and easy cleanability, but there are major drawbacks. Finer micron ranges are consequently very delicate (due to the fineness of the wire diameter), are damaged easily and are therefore limited in their use to the filtration of very fine particles. Filter fabrics able to withstand the environment of various vacuum and pressure filters, handling heavy slurry and batch loads and in a filtration range of > 10 to approx. 250 micron ratings must have a more rugged construction.
A first variation is the plain reverse dutch weave. This fabric is produced by using a differentsized thread diameter in the warp direction than in the weft.

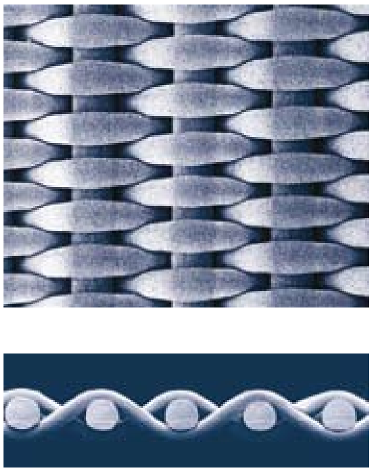


Fig 4: Plain reverse dutch weave

Warp is the longitudinal direction of the weaving machine, weft is the transverse direction. A plain reverse dutch weave creates two openings, one on the surface of the cloth between two parallel fibers, and a second triangular or teardrop-shaped opening in a diagonal position within the fabric body. Dutch weave fabrics are highly suitable for filtration of crystalline-type particles. Such particles are easily backwashed from the dutch weave fabric and therefore blinding is minimized. On the other hand, colloidal or slimy particles can easily clog the triangular pores and are difficult to remove.

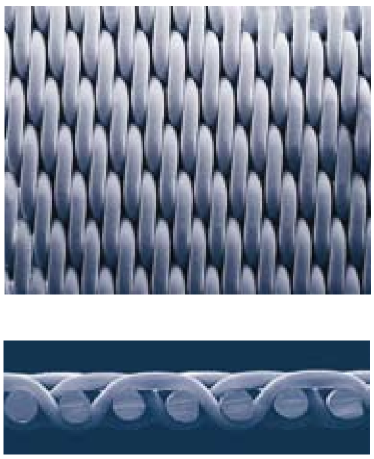


Fig. 5: Twill weave TWL 2/1

Another construction called twill weave (see Fig. 5.) was introduced to reduce this clogging when filtering colloidal or slimy particles. In this weave, one warp monofilament first passes under one and then over two weft monofilaments in a row. There are other combinations possible such as 1:3, 2:2, 2:3, etc. All of them are stronger fabrics mainly in warp, and have lower elasticity and finer pore apertures, but still allow some high flow permeability. Additionally, such a weave pattern will result in ‚two-sided fabrics' having a smooth or slick filter/cake side and a reverse side having a different profile and characteristics. The fabric design permits particles that have passed through the upper surface of the cloth to flow freely downstream through funnel-shaped openings that prevent blinding.
As mentioned earlier, many variations in weave patterns are now available, all obviously resulting in different characteristics of the cloth. Satin weave as shown in Fig. 6, for example, can offer an even higher resistance against wear and tear and high flow rates combined with a very smooth surface. In this example, one warp monofilament first passes under one and then over four weft monofilaments in a row.

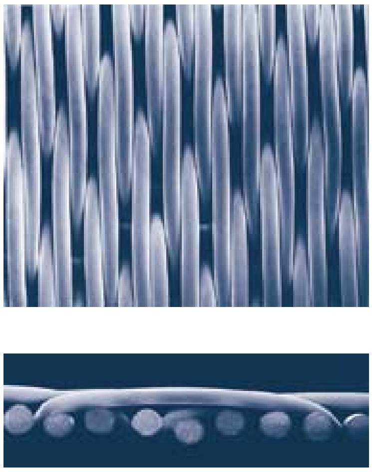


Fig 6: Satin weave

At this point, the finishing of the fabrics should be mentioned. All of Sefar screen and filter fabrics are heat-treated in order to stabilize the fabric. By means of this heat-setting, the yarn of the fabric receives a new molecular «program» to keep the bending induced in the yarns due to the weaving process properly oriented even when subjected to periodical abuse or deformation. Finishing allows fabrics to be used without severe shrinkage or elongation during their service life, or to «build in» precise shrinkage on purpose, for example on disc filter bags. It is also possible to control-shrink the fabric to reduce its micron rating beyond those obtainable in a raw fabric.
A particularly sophisticated application used on filter fabrics is the calendering process.
This is a combined heat and pressure application that serves to flatten fabrics, smooth their surface and reduce or level out their pore sizes.

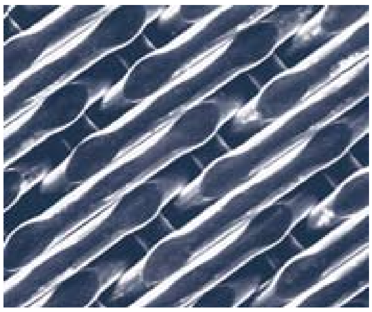
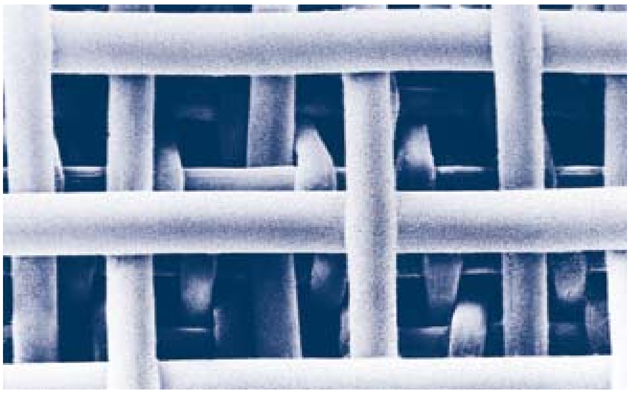


Fig 7: The effect on the surface of a precision woven monofilament 1:3 twill weave fabric after the calendering process

Synthetic woven monofilament fabrics – the future has already begun

Combinations of hybrid monofilaments and multifilament fabrics are produced having various characteristics. One is a ductile fabric having many of the performance characteristics of monofilaments, but easier for caulking onto drum filters. Similarly, a monofilament/ textured multifilament fiber filter fabric for use on disc filter segments has also been produced. It is elastic and the fabric is able to expand during the blowback stage, thus helping to remove the cake. During the vacuum stage the elasticity of the fabric returns it to its original size without creases or folds. Heavy dense monofilament fabrics are available that are able to withstand the tremendous physical demands of large belt or automatic filter presses. High permeability fabrics in the filtration range of 1 – 10 microns withstand this environment for more precise filtration in smaller elements.

The latest prospects of process filtration are doublelayer weave fabrics. This approach of SEFAR TETEX® DLW filter fabric construction is a very precise combination of two weave patterns used to construct one single product. This combination of very dense twill- or satin-like patterns made from fine mono- or multifilament yarns on the cake side together with large and open constructions on the reverse side significantly enhances its performance, particularly when calendered. High separating efficiency, easy cake release, strong running side and high transverse stability together with the avoidance of distortion or formation of folds all aim maybe not for the cheapest filter cloth per square meter. However, the high performance and long lifecycle together provide the most economic overall process configuration.



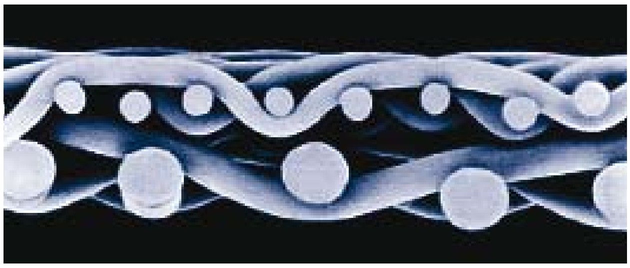


Fig. 8: SEFAR TETEX® DLW, view from reverse side (above); crosssection (below)

Industry	**A**	**B**	**C**	**D**	**E**
Alumina	X	X	X		
Mining/ores	X		X		X
Coal refining	X				
Zeolite	X	X	X	X	X
Vitamins	X		X	X	
Phosphate	X				
Paint / lacquer	X	X			
Metallic oxides	X	X	X	X	X
Waste water	X		X	X	
Paper/pulp	X				

A: monofilament fabrics *B: mono/multifilament fabrics*
C: multifilament fabrics *D: staple fiber fabrics* *E: needle felt*

Table 1: Abstract of most suitable or most common filter fabrics used in particular applications

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