

MINIFIBERS, INC.

Choosing The Proper Short Cut Fiber

ABSTRACT

You have decided that your web needs a synthetic fiber. There are three important factors that have to be considered: generic type, diameter, and length. In order to make the right choice, it is important to know the chemical and physical characteristics of the numerous man-made fibers, and to understand what is meant by terms such as denier and denier per filament (dpf).

PROPERTIES

Denier

Denier is a property that varies depending on the fiber type. It is defined as the weight in grams of 9,000 meters of fiber. The current standard of denier is 0.05 grams per 450 meters. Yarn is usually made up of numerous filaments. The denier of the yarn divided by its number of filaments is the *denier per filament* (dpf). Thus, denier per filament is a method of expressing the diameter of a fiber.

Obviously, the smaller the denier per filament, the more filaments there are in the yarn. If a fairly closed, tight web is desired, then lower dpf fibers (1.5 or 3.0) are preferred. On the other hand, if high porosity is desired in the web, a larger dpf fiber - perhaps 6.0 or 12.0 - should be chosen.

Here are the formulas for converting denier into microns, mils, or decitex:

Diameter in microns = $11.89 \times (\text{denier} / \text{density in grams per milliliter})^{1/2}$

Diameter in mils = diameter in microns x .03937

Decitex = denier x 1.1

The following chart may be helpful. Our stock fibers are listed along with their density and the diameter in denier, micron, mils, and decitex for each:

Generic Type	Density	Diameter			
		Denier	Microns	Mils	Decitex
Acrylic	1.18	15.0	42.39	1.67	16.5
Low Melt PE	0.93	6.0	30.20	1.19	6.6
Lyocell	1.5	1.5	11.89	0.47	1.65
Nylon	1.14	1.0	11.13	0.44	1.1
		3.0	19.29	0.76	3.3
		6.0	27.28	1.07	6.6
Polyester	1.38	3.0	17.53	0.69	3.3
		6.0	24.79	0.98	6.6
		25.0	50.60	1.99	27.5

Generic Type	Density	Diameter			
		Denier	Microns	Mils	Decitex
Polypropylene	0.91	1.5	15.27	0.60	1.65
		2.1	18	0.71	2.3
		3.0	21.59	0.85	3.3
		7.0	32.97	1.30	7.7
		16.1	50	1.97	17.7
Viscose Rayon	1.5	0.8	8.68	0.34	0.88
		1.5	11.89	0.47	1.65
		4.5	20.59	0.81	4.95

Length

The length of the preferred fiber is directly related to the diameter. This is referred to as the aspect ratio. Aspect ratio is found by dividing the length of the fiber by the diameter (using the same unit of measure for each). The ideal aspect ratio is 500:1. An example follows:

$$\begin{aligned} \text{Length} &= 250 \text{ mils} \\ \text{Diameter} &= 0.491 \text{ mils} \\ \text{L/D} &= 250/0.491 = 509 \end{aligned}$$

When the correct aspect ratio is used, you receive an optimum amount of strength, as well as good dispersion. As the aspect ratio increases, the fiber becomes more difficult to disperse; as it decreases, there is a loss of strength resulting from poor binding capability.

End Condition

Diameter and length are both very important factors, but if there is a poor end condition on cut fiber, all has been in vain. We like to refer to our product as precision-cut fiber -- fiber in which all ends are squarely cut and not fused together (Figure 3).

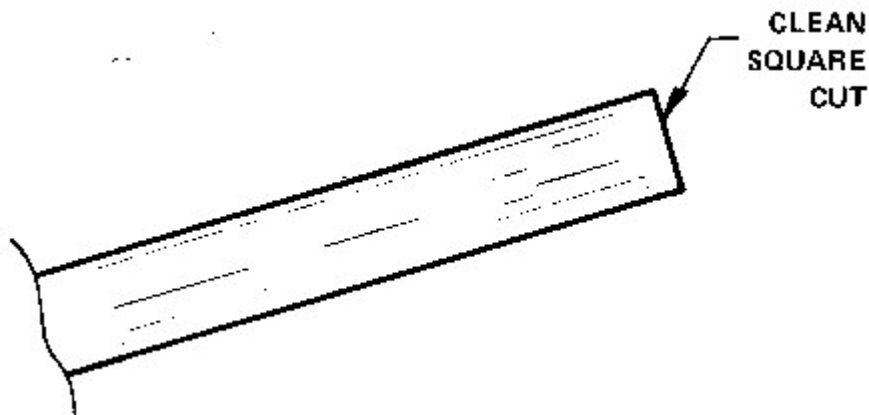


Figure 3

Any end condition that tends to entangle another filament is not acceptable. Such end conditions are the split end (Figure 4), the fused end (Figure 5), the fused log (Figure 6), and the fused daisy (Figure 7).

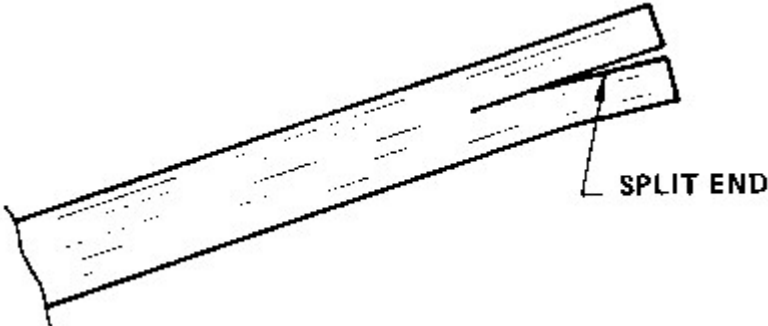


Figure 4

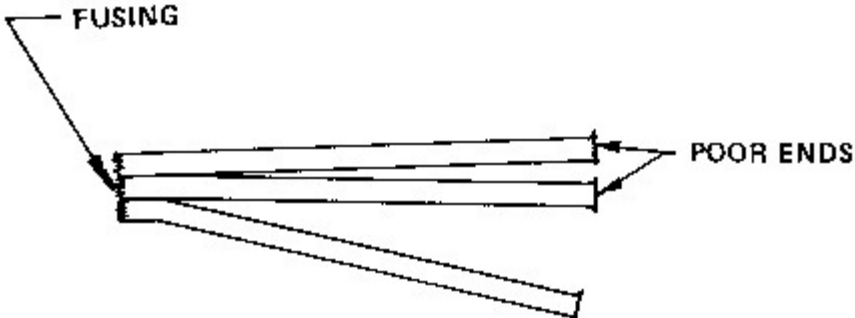


Figure 5

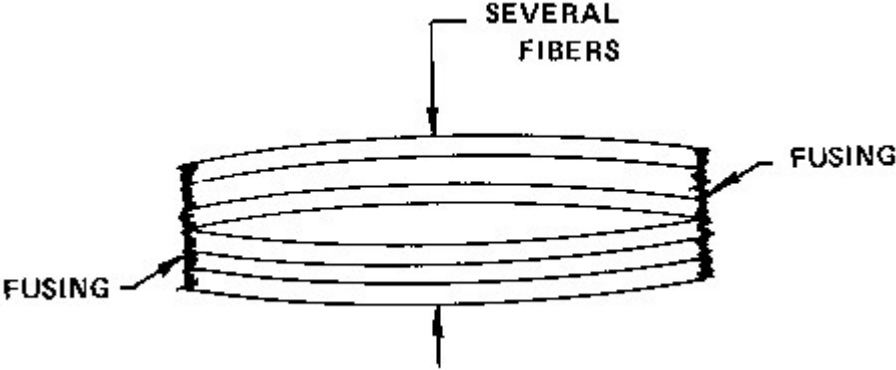


Figure 6

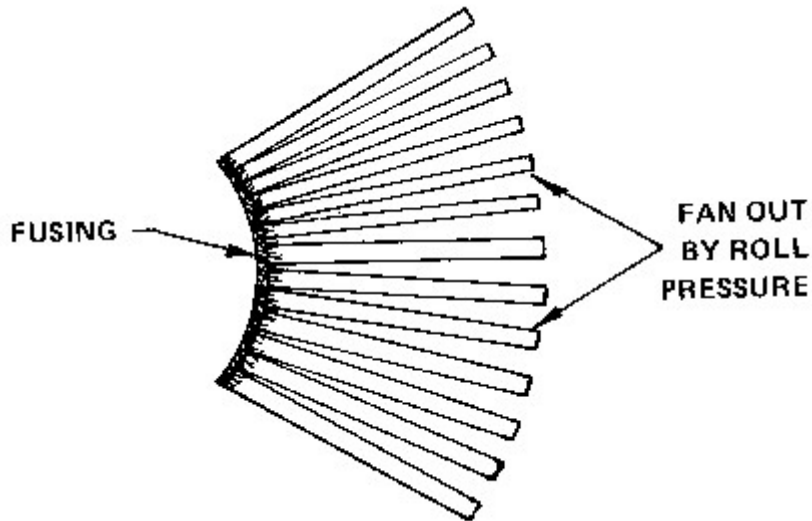


Figure 7

Even though it may be possible to eventually cause poorly cut fiber to disperse, much valuable time is wasted, and the risk of an inferior web still exists.

SYNTHETIC FIBERS

We will limit our discussion to our common stock fibers: acrylic, rayon, nylon, polyester, and polypropylene. Our main intent is to discuss the most frequently asked questions about synthetic fibers.

Viscose Rayon

For many centuries, there had been a dependency on natural fibers; therefore, the first man-made fiber was one which possessed many of the same characteristics. Thus evolved rayon, a regenerated cellulose very similar to cotton. Rayon has a high moisture absorbency, with a normal moisture regain of 11-13%. This enables it to be very versatile and helps to prevent it from generating static electricity. The rayon filaments most familiar to our industry are flocking tow and high tenacity tire cord.

Rayon flocking tow is moderate in tenacity, normally about 1.9 to 2.3 grams per denier (gpd). The typical elongation at break is 20-25%. It is a soft and pliable fiber with an average stiffness of 6 to 6.16 gpd. It does not melt; however, there is a loss of strength at about 300°F, and decomposition occurs at 325 to 464°F when exposed for extended periods of time. Hot dilute and cold concentrated acids will disintegrate the fibers. Strong alkalis tend to swell the fiber and cause loss of strength. Our standard deniers for flocking tow are 0.8 and 4.5 dpf, though many deniers are available.

When it has a proper aspect ratio and is well cut, rayon flocking tow is one of the easiest man-made fibers to disperse in both aqueous and non-aqueous systems. It is often used in combination with other synthetic fibers, especially when a web of high absorbency is desired in conjunction with a higher tensile strength. One of the most popular blends is flocking tow and polyester. There are many areas of application, but two of the most familiar are disposables, such as baby diapers, and filter media.

High tenacity rayon, commonly referred to as tire cord, differs somewhat from flocking tow in that its tenacity can be as high as 5.3 gpd. It is often used in webs where dimensional stability and rigidity is desired. The average stiffness varies from 13 to 50 gpd depending upon the manufacturer. Since it cannot be fused in the fiber cutting process, rayon is also an easily dispersed fiber.

Nylon

Nylon was the first hot-melt fiber to be commercially produced. The fiber forming substance in nylon is a long-chain synthetic polyamide with less than 85% of the amide linkages attached directly to two aromatic rings. There are many varieties of nylon; therefore, we will limit this discussion to the nylon which is stocked by MiniFibers.

Our regular tenacity nylon fibers are 1.0, 3.0, and 6.0 dpf and have a tenacity of 2.3 to 6.0 gpd. Nylon is a fairly rigid fiber. The stiffness of regular tenacity nylon is 5.0 to 24.0 gpd. Average toughness values are .21 gpd for regular tenacity nylon. MiniFibers also has a high tenacity nylon available in 3.0 dpf.

This combination of properties has resulted in numerous applications for nylon, including those where rayon and others have failed. Nylon has a higher melting point - about 500°F. It has low moisture absorbency, and therefore dries quickly. It is superior in abrasion resistance and has excellent stretch and recovery properties. It is affected by mineral acids but resists most alkalis. Two popular applications of nylon are industrial filters and adhesive backing.

Polyester

Polyester is perhaps the most interesting of all the synthetic fibers. There are numerous areas of application because of its physical characteristics and relatively low cost. Polyester, which is often referred to as PET (polyethylene terephthalate) melts at 495°F and has a good resistance to most acids and alkalis. It provides strength and resilience and gives excellent dimensional stability to a web.

There is a multitude of types of polyester; therefore, we will discuss in general terms the high tenacity polyesters stocked by MiniFibers. Our high tenacity polyesters are 3.0, 6.0, 10.0, and 12.0 dpf with a tenacity of 6.8 to 9.2 gpd. High tenacity polyester produces a more rigid web. The average stiffness of high tenacity polyester can be up to 77 gpd, the highest of the commonly used synthetic fibers.

There are many different trade names for polyester, and just as many applications. Filter media, felts, disposables, and wall coverings are just a few of the many products in which it is used.

Acrylic

Acrylic is a synthetic fiber formed in a polymerization process and composed of at least 85% by weight of acrylonitrile monomer. Acrylic has a tenacity of 2.5 to 3.0 gpd and an average stiffness of 6.0 to 8.0 gpd. This fiber has a generally good resistance to mineral acids and weak alkalis, and a moderate resistance to strong alkalis at room temperature. A high tensile strength of 30,000 to 45,000 psi and an elongation at break of 25-40% are also characteristic of acrylic fibers.

Acrylic does not melt, decomposes at temperatures in excess of 500°F, and maintains some integrity after burning, making it an ideal substitute for the more expensive, specialty fibers frequently

used in high heat applications. It can be fibrillated to provide more surface area. The most common applications which utilize acrylic fibers are water filtration and friction products.

Polypropylene

Polypropylene is an olefin, which are long-chain synthetic polymers composed of at least 85% by weight of propylene or other olefin units. Polypropylene is an exceptionally lightweight fiber resulting in webs of good bulk and coverage. It offers superior toughness, and its abrasion resistance is exceeded only by that of nylon.

Polypropylene has a tenacity of 2.5 to 5.5 grams per denier. Its low melting point of 325-335°F makes it an excellent binder, though lower melt olefin fibers such as LLDPE are available for this purpose. Polypropylene has excellent resistance to acids and alkalis; however, it is not resistant to oxidizing agents.

CONCLUSION

With the above fiber descriptions at hand, it will now be easier for you to decide which generic type of synthetic fiber fits your need. As you consider all of the above points, you will be better able to choose the specific type of fiber, denier, and length for your next web.

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