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MAXIMUM SAIL POWER

CHAPTER 3
FROM THREAD TO FINISHED FABRIC
How sailcloth is made - Part 1

So many fiber choices leave fabric engineers with the interesting and complex task of deciding how to use them. Indeed, the possibilities are endless. Not only can engineers group different amounts of the same fiber in a fabric, they can group different amounts of different fibers in the same fabric, orient them in any number of ways and then adhere them to a substrate that is baked in an oven, all in an effort to end up with a superior sailcloth. It's a sort of one-plus-one-equals- five scenario. Not surprisingly, the process can become extremely complicated, and in fact this is one of those areas in which sailmaking departs from the fixed limitations of science and delves into the area of art. It's why the subject is so fascinating. In this chapter we will look at how the fibers discussed in Chapter 2 are used to their best advantage and how some fabrics are designed for certain specific applications. In a later chapter we will look at new technologies like mold-ed sails and tape-reinforced sails, but this chapter is specifically about creating fabrics from which panels are cut and sails are made. By understanding these different techniques you will begin to understand which fibers, and by extension, which fabrics best suit your needs.

This chapter is divided into three sections:

Woven fabrics — those fabrics that are manufactured on a loom in a conventional manner.

Laminated fabrics — fabrics that comprise two or more layers glued together; these fabrics can have a woven substrate, but they do not rely solely on the woven part for stability and stretch-resistance.

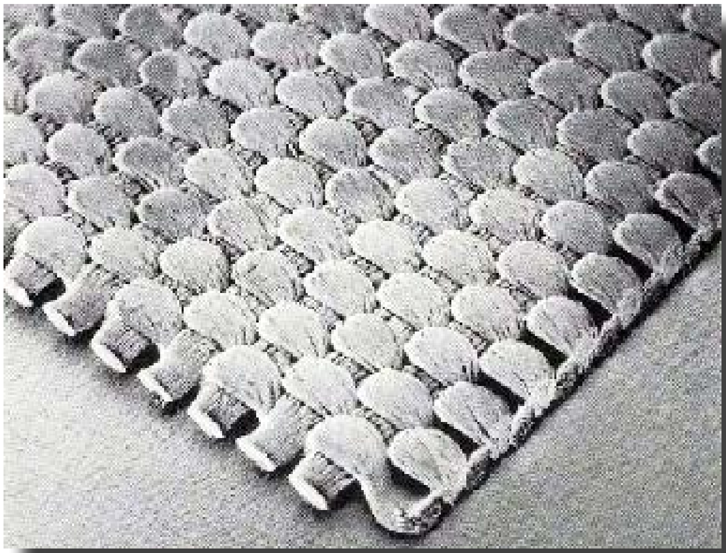
Membrane sails — a whole new way of creating sails where the fabric and the sail are made at the same time.

These are three quite different ways of creating fabric, but the end goal is the same: to create sailcloth that is light, cost effective, and stretch-resistant, both along its principal axes and on the bias. Like the sailmaking business in general there are two main ingredients that account for the price of fabric: labor and raw materials. The least labor-intensive way of making sailcloth is to weave and finish it, followed by lamination, with membrane sails being the most labor intensive. In terms of the base fibers, polyester, from which sails are woven, is much cheaper than Spectra or one of the other "exotics." Therefore a woven Dacron sail will be the least expensive. Your aim when thinking about new sails is to choose a fabric that suits your needs perfectly. You don't want to pay extra for something you don't need, but by the same token, you don't want to choose a fabric that is not up to the task for the sake of saving a few dollars. By reading and understanding the different manufacturing techniques you will be much better informed when it comes time to make your own purchase.

WOVEN FABRICS

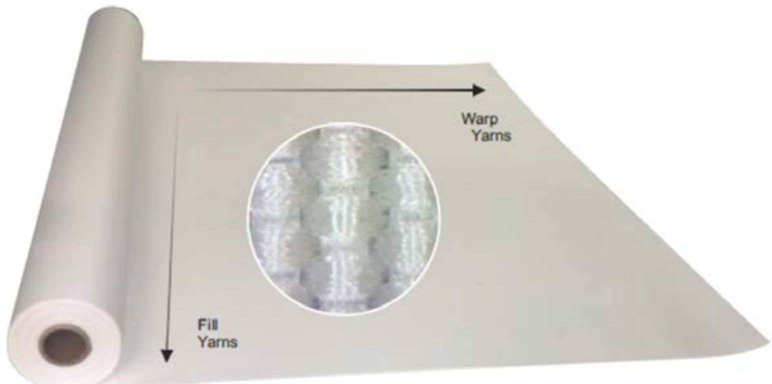
With the perspective of time it's easy to look to the past and think about how simple it must have been to design sails back in the good old days, even at the grand prix level. There was only one fiber to think about — polyester — and only one way to use that fiber to make sailcloth — by weaving. We for- get, however, how hard it was to engineer a sail within even these seemingly limited parameters and have it perform efficiently. Weaving, for example, was an inexact process in the past that allowed many variables, so that when combined with a restricted panel layout, the task of engineering a sail to hold its shape was daunting. Therefore, to fully understand the difficulties faced by sailmakers, both yesterday and today, we need to look at the weaving process to understand how Dacron sailcloth is manufactured, the problems manufacturers encounter and how they strive to overcome them. We also need to know some of the terminology used to describe sailcloth and its various components since this goes to the very heart of how woven sailcloth is manufactured.

Warp and Fill



Woven Dacron magnified to show the warp and fill yarns

The warp refers to the yarns running the length of the fabric while the fill refers to the yarns running across the fabric. Another name for the fill is weft, but most sailmakers and sailcloth manufacturers prefer to use the more modern name. A fabric engineer can design a fabric to be warp-orientated by using heavier yarns running the length of the fabric or he can design a fabric to be fill-orientated by using heavier yarns along its width. Balanced fabrics, as their name implies, are equally balanced between the warp and fill so the fabric will exhibit equal strength in both directions.



Denier Per Inch

Dacron at its most basic is a collection of tiny filaments or single fibers of poly- ester that, when twisted together with other fibers, become a yarn. The fabric engineer actually gets involved in the process as soon as a single filament gets twisted around another. The number of twists per inch and the number and thickness of each filament has an effect on the bulk and strength of each yarn, and by extension, the characteristics of the woven fabric. In order to have a basis from which to work, fabric makers have a system for coding filament yarns and fibers based on something called a denier, a term that you will come into contact with during your search for fabric for your new sail. Specifically, a denier is the weight in grams of 9,000 meters of a given fiber. The lower the number, the finer the fiber. When talking about a woven fabric, the relative weight and strength of the fabric is expressed in terms of denier per inch, or DPI as it's known in the trade. This number is critical to a sailcloth's performance. For example Challenge Sailcloth, a fabric manufacturer that specializes in woven Dacron fabrics, makes a 7.62-ounce fabric that has a DPI of 220 in the warp and a DPI of 570 in the fill. The company also makes a 9.62-ounce fabric that has a DPI in the warp of 220 and a DPI in the fill of 880. These numbers tell the sailmaker how strong the fabric will be and how best to use it. By engineering fabric strength in a certain direction, as in the 220 x 880 cloth, the fabric designer is sending a message to the sail designer that this fabric has a lot more strength in the fill direction and therefore should be used accordingly. The sail designer will take advantage of the fabric's strength and orient the cloth so that the stronger fibers will bear the bulk of the loads generated by the wind. Both of these fabrics are fill-orientated and should be used for sails where the loads run principally up the leech of the sail. To give you some perspective on how these abstract figures relate to the real world, the 7.62-ounce fabric would be good for a mainsail on a 30-foot daysailer, and the 9.62-ounce fabric would be good for a high-aspect blade jib on a 40-foot racer/cruiser.

The Loom

Armed with these basics we can now begin to look at the mechanics and challenges of producing high-quality sailcloth, both yesterday and today. There is no need to go all the way back to flax and cotton. Those sails simply projected an area to the wind and the boats that used them were blown along in a fairly inefficient manner. It is instructive, however, to look at the challenges sailmakers faced when they first began to work with synthetics. For it was at this time, as sail designers came to have a better understanding of aerodynamics and the way in which certain sail shapes allowed sailboats to sail into the wind, that the need for stable fabrics and stable panel layouts became increasingly necessary; stable in this context meaning sails that did not stretch out of their intended aerodynamic shapes.

The art of weaving goes back centuries, and while modern looms for producing sailcloth are more sophisticated than those used either in the past or for producing household fabrics, the basic process is the same. First, the warp yarns are stretched horizontally side by side and fed through the loom where they are held under tension to get the most benefit from each individual thread. During the actual weaving process, each alternate yarn is pulled vertically apart while a shuttle containing the fill yarns is sent back and forth across the fabric at high speed. After each pass, the fill yarn is slammed into place by an appropriately named "beater" and the warp yarns are reversed so that the yarns that were on top become the yarns on the bottom and the yarns that were on the bottom end up on top. The shuttle then races back across, putting in another fill yarn, which is once again slammed into place. This process of alternating the warp yarns, shooting the fill shuttle and slamming the beater takes place at lightning-fast speed, and with each new fill thread, the length of woven sailcloth increases.

Industrial weaving loom for making sailcloth

Not surprisingly, the width of a panel of sailcloth is dictated by the width of the loom and most modern sailcloth looms are 60 inches wide resulting in a fabric that is 54 inches wide once it is finished and the edges trimmed. The length of the fabric is only limited by the amount of yarn each bobbin can hold, and finished rolls of sailcloth are usually hundreds of yards long. Setting up the loom is extremely time consuming so the fabric makers strive to produce long runs of sailcloth each time they make a particular style of fabric. Obviously, the way in which the loom is prepared goes a long way toward determining what the finished product will be like, so the manufacturer needs to know exactly what he wants from the very beginning of the process.

If, for example, he is planning on making a heavy Dacron to be used on bigger boats and in stronger winds, he will load his loom accordingly. He might use a 300 DPI yarn for the warp and a 1,000 DPI yarn for the fill so that the finished product, weighing 10.0 ounces, will be good for a working genoa on a Beneteau 456 or a mainsail on a Cabo Rico 38. If on the other hand, he wants to build a light Dacron fabric for a one-design dinghy fleet, he will load the loom with 150 DPI yarns in the warp and 250 DPI yarns in the fill for a fabric that weighs 3.9 ounces and can be used to make a mainsail for a smaller boat like a Laser.

During the actual weaving the conditions in the mill need to be carefully regulated since both heat and humidity have an effect on the process. Specifically, the temperature must not rise above 70 degrees Fahrenheit, and the humidity must remain below 53 percent. Otherwise the Dacron yarns will shrink prematurely or unevenly, compromising the density and strength of the finished product. With a strictly controlled environment, high-tech custom looms, and carefully engineered yarns, the initial stage of Dacron sailcloth is complete.

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