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MAXIMUM SAIL POWER

CHAPTER 3
FROM THREAD TO FINISHED FABRIC
How sailcloth is made - Part 2

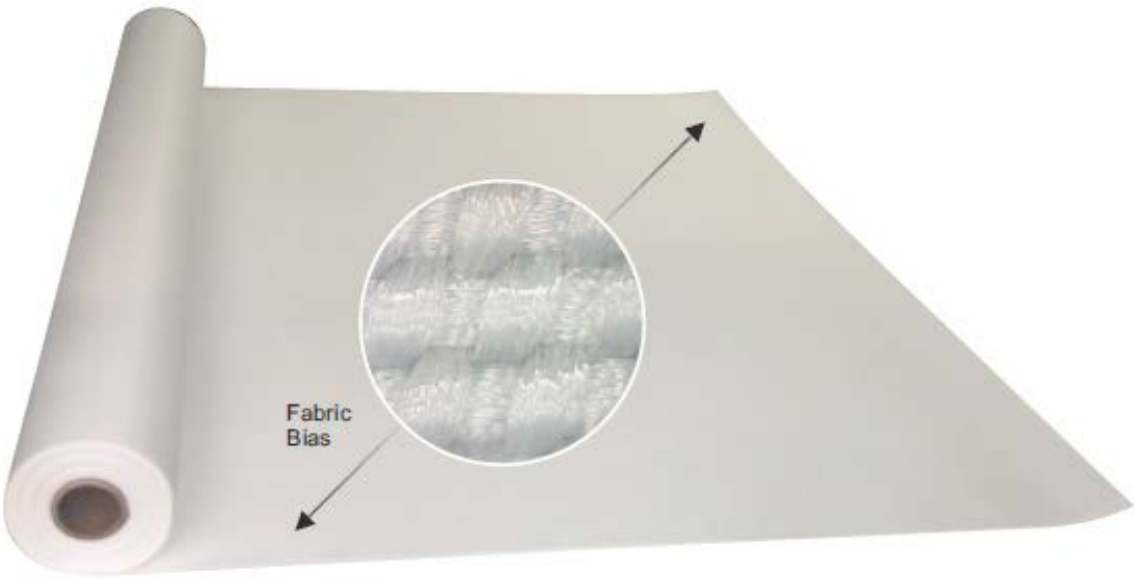
WOVEN FABRICS

Bias Stretch

While the bobbins holding the warp and the shuttle holding the fill are important, it's actually the beater that plays the most important role in weaving sailcloth. As noted above, the finished fabric has strength both along and across the cloth, since pulling in those directions means pulling along the length of the yarns. But it is weak along the diagonal since forces working in this direction are pulling at an angle to the yarns and can distort the weave. To minimize this "bias stretch" as it's

called, the weave has to be tight, and the harder the beater slams into each fill yarn, the tighter the weave.

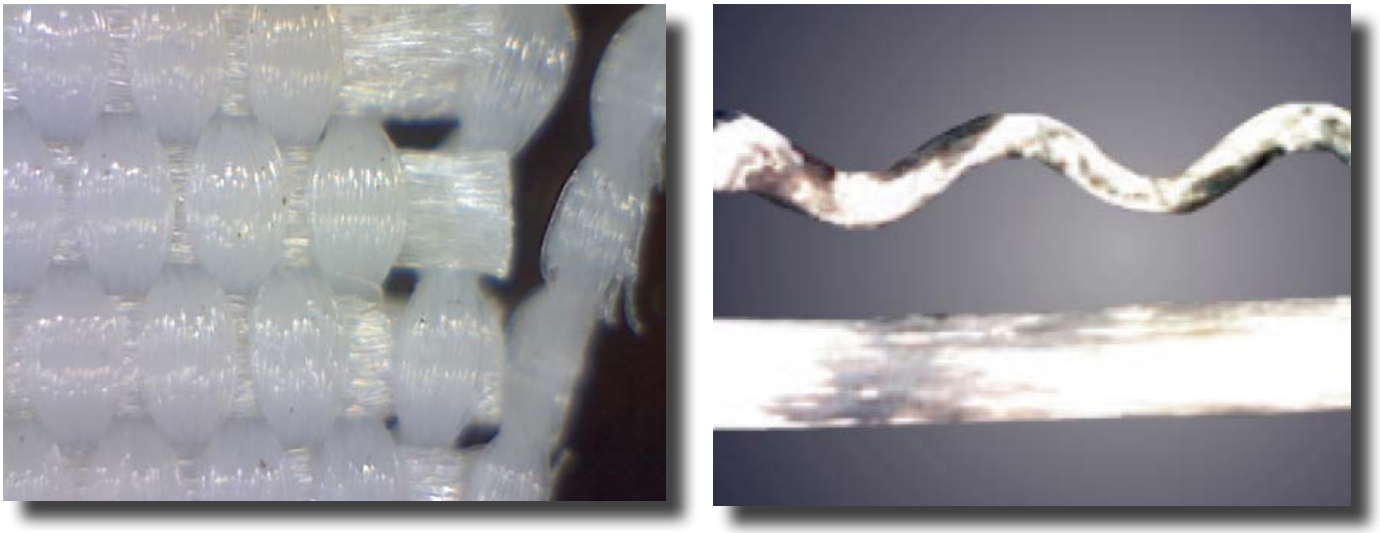
In fact, much of the weaving process is designed to eliminate, or at least minimize the bias stretch of the finished fabric, so let's study this aspect of fabric design in more detail. By way of illustration, take any household fabric and look closely at the warp and fill fibers. Assuming that it's a conventionally woven fabric, try stretching it by pulling in either the warp direction or the fill direction. Chances are you will meet with some pretty substantial resistance as you tug directly against the dozens of tiny yarns. Now take that same fabric and pull it from corner to corner, in other words on the bias. Immediately, the fabric will stretch and distort. Now imagine what can happen to sail shape in a heavy breeze when the load no longer travels along the engineered load paths, but rather comes onto the bias. The sail will stretch and distort and the carefully crafted shape will no longer resemble anything the sail designer had in mind.



Crimp

This problem of sails stretching is further exacerbated by another inherent aspect of woven fabrics known as crimp, a word that

comes from the Dutch word meaning "to shrivel." Because the fill yarns are shot across the fabric by the shuttle, they tend to be laid down absolutely straight. But since the warp yarns go over and under the fill, the angle at which they are forced into place by the beater means that there is a lot of room for elongation once a load is exerted on them and the yarns try to straighten out . Like bias, this phenomenon is impossible to completely avoid but can be minimized through careful processing of the cloth after its initial weaving. In fact, at this early stage in its production the fabric, which is known as Greige cloth, a term that comes from an old French word meaning raw silk, bears little resemblance to the finished product that most sailors are familiar with. Specifically, it is very soft, ragged along the edges, and somewhat dirty from the weaving process. In the United States the refined French word has been turned into a somewhat more descriptive one, namely "gray" cloth. There are still a number of additional stages to complete before the finished fabric is ready for the sailmaker. These stages are all aimed at minimizing distortion.



You can clearly see crimp in the warp yarns of this magnified Dacron fabric

Heat Setting and Fillers

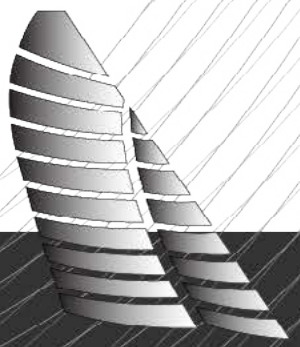
The most important of these steps is heat setting, a carefully regulated process that takes advantage of the previously mentioned fact that Dacron shrinks when exposed to high temperatures. In fact, one of the reasons Dacron became such a popular sailcloth fiber in

the first place is that, in addition to being easily woven, this shrinkage results in a fabric that, despite having a bias, is fairly stable when used for making sails. Immediately before this all-important step, the fabric is scoured with hot water and detergent to remove dirt and other impurities like oil drips. The hot water and detergent also remove a kind of a glaze called "sizing" that is added to the yarns to prevent them from breaking during weaving. The sizing gives the yarns extra strength to handle getting yanked and tugged during the weaving process. The fabric is then dried and either passed through an oven or over heat- ed rollers where each strand of Dacron is exposed to a temperature of around 400 degrees Fahrenheit for approximately one minute. At this point a chemical reaction locks the fibers together, shrinking the cloth by as much as 15 to 20 percent, most of it in the warp direction because of the crimp.

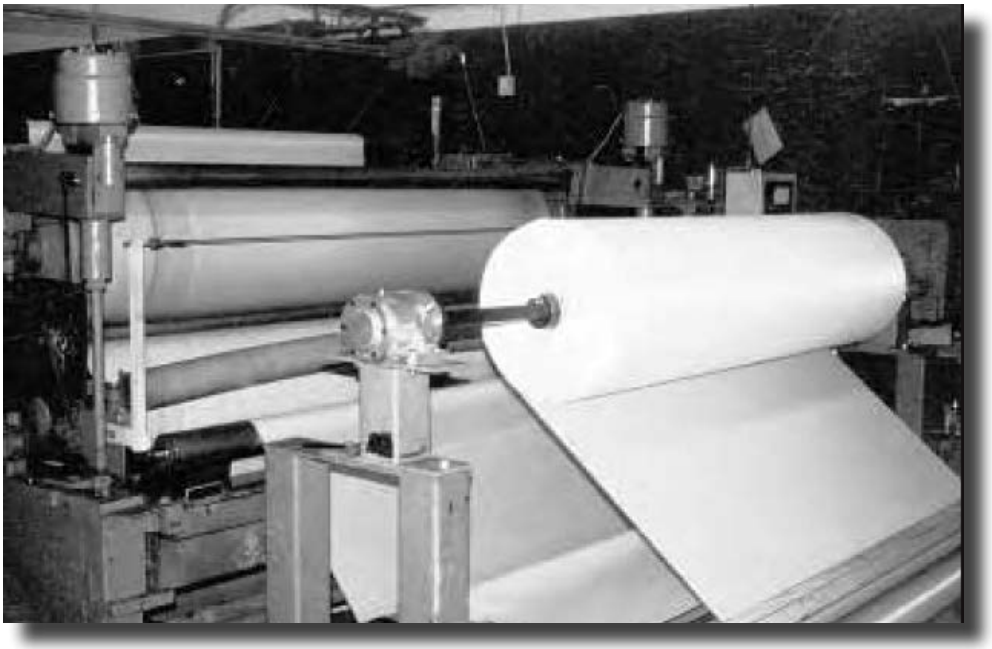
As heat setting became more of a science, fabric makers experimented with varying temperatures, and a series of progressively hotter stages allowed some control over the integrity of the finished product. Early Dacron fabrics were manufactured using this process alone, and the resulting sails had good, if not perfect shape-holding characteristics. They also had a nice soft feel to them, which was important to many sailors since it allowed them to be comfortably handled, and the sails could be folded into small packages and stowed in bags that did not take up much room on board. In the years that followed, fabric engineers found that they could further reduce crimp and bias stretch by adding chemical fillers that would further stabilize the fabric, however, because these fillers took away the nice soft "hand" and replaced it with a stiff, hard-to-handle finish, some say they gave the fabric a performance edge not worth the ease-of-handling trade-off. The sail-handling versus performance debate continues to this day, and has become more pronounced with the advent of new yarns and fabric technologies.

Fillers

Once the fabric has been heat set, the next step is to add fillers. This involves dip- ping the newly woven cloth into a bath of melamine



resin — the same resin that is used to build fiberglass boats — so that when the treated fabric is heated, the yarns and solution, which are chemically similar, become one as the chemical properties in both align themselves to form a durable, relatively low-stretch fabric. By using different varieties and concentrations of melamine, a fabric maker can produce a number of different kinds of sailcloths all based on a single weave. These fabrics vary radically in terms of feel and stretch resistance. Think of the hardened melamine filling the gaps between yarns so that when the fabric attempts to stretch on the bias, the filler braces the square configuration of the weave making sure that it does not elongate into a diamond, thereby resisting bias stretch.



Dacron fabric is passed through a trough of melamine resin to fill the gaps between the yarns and prevent bias stretch.

Finishing

In addition to adding melamine filler, fabric engineers also learned to further stabilize and refine the fabric by passing it through additional baths of other resins in what is called "finishing." Different resins are used for different fabrics. For example an acrylic finish is used for Dacron and a polyurethane finish for nylon. As the fabric comes out of the bath it is squeezed between a roller and a sharp steel blade that both forces the resin into any gaps or indents in the fabric and removes the excess. This part of the process is known as "yarn-tempering," and the final result is a smooth finish that ensures the fabric is non-porous and even more stable.

Calendering

Finally, after the fillers and resins have been added, the bolts of fabric are passed between two giant heated rollers that apply tremendous pressure on the fabric, flattening and further tightening the weave in a process called calendering. The pressure exerted can be as much as 150 tons, and some fabrics are passed through the calender a number of times, until the fabric takes on a high sheen. At this point the woven Dacron fabric is as nonporous and low-stretch as it's ever going to be, so there's nothing left to do but trim the edges with a hot-knife and roll the finished fabric into bolts for shipping.

Note: In Part 3 of From Thread to Finished Fabric we will look at ways to improve Dacron and other characteristics of good sailcloth

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