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February 28, 2001

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Dear John,

Instead of presenting my opinions on the merits of allowing Laminates to be used in Star sails, I have put together some information that, hopefully, will clarify some of the confusion surrounding this subject. I have only used the Star mainsail for the following comparisons, but the Jib would be similar.

The first issue is the relative cost of allowing Laminates sails. I have enclosed a graph of several Dacron fabrics that are currently being used (on the left), and to the right, several possible laminates that would be suitable for a Star main. I am assuming that the class is not going to consider using any "High-Modulus" laminates such as Kevlar, Vectran, PBO, Spectra, etc. Most classes such as the J-24, which allow laminates to be used in the genoas, specifically disallow these types of laminates, and limit the cloth to "Polyester" Mylar laminates.

As you can see, there is considerable variation in the relative cloth cost in a Star main. These costs are based on the retail price published by the various manufacturers, and the estimated yards necessary to build the main as either a simple cross cut for the "fill" orientated fabrics, and a "Triradial" panel layout for the "warp" orientated fabrics. I have enclosed a diagram of a simple cross cut Star main, and the current panel layout that I am using in my Triradial main. The cross cut sail uses considerably less cloth than the Triradial.

As you can see, the most expensive cloth/panel options (on the left) are the Pentex Dacron fabrics used in the Triradial Star main. Both these fabrics are currently legal to use for Star sails. The "165s Pentex" is a Dimension/Polyant Yarn Tempered Pentex Dacron, the "3.8 Cont Pentex" is a similar product from Contender. Pentex is a Polyester, but has a higher modulus than standard Dacron. These Pentex fabrics are about 30% more expensive than the same style of cloth in Dacron.

The Mylar laminates that I have chosen for this comparison, however, are NOT necessarily more expensive than Dacron. In fact, the cheapest fabric of all, even with the Triradial panel layout, is the “PX15 Poly Mylar”, which would only cost about \$244 to build a Star main.

Triradial mains would require more labor to build, as it takes considerably more time to assemble the 55 panels in a Triradial main than the 14 panels in a cross cut main. If we combine the relative cloth and labor costs, I have listed below the relative change in the price of the finished sails:

Cross cut Star Main using “3.8 Cont RS Fill”=		1.00
Triradial Star Main using “PX15 Poly Mylar”=	+ 7%=	1.07
Triradial Star Main using “PE15 Pentex Mylar”=	+ 23%=	1.23
Triradial Star Main using “3.8 Cont Pentex”=	+ 32%=	1.32

In short, the most expensive sailcloth option and panel layout is currently legal, and allowing the use of Polyester Laminates would not necessarily increase the current cost of sails.

The second issue of durability is not so clear-cut. Durability is dependent on a variety of factors, some of which have nothing to do with the choice of fabric. I have listed what I believe are the most important of these:

- 1.) The level at which the skipper competes: If you are trying to win the World’s, or the Olympics, you will not take any chances on the potential loss of speed with use. I don’t think anyone would compete at this level without new sails, regardless of how durable the fabric is.
- 2.) How the sail is designed: If the cut of the sail is such that any slight loss of strength will begin to show, the durability would not be considered good. For example, if the leech of the main has a very straight exit, any increase of stretch as the fabric ages will show flutter sooner than a design with a tighter exit. If the designer wants the sail to be fastest the first time out of the bag, then any change in stretch will probably have a negative impact on speed. In my opinion, I have not found Star sailors to be very tolerant with the design concept that it takes a few races for the sail to reach it’s peak performance.
- 3.) Finally, the question: does a laminate sail last as long as a Dacron sail? Again, there is no simple answer to this. It depends on the type of Dacron or Laminate, and just as importantly which batch of fabric is used. I have included a second graph. This one shows the relative change in stretch properties after the cloth has been “Impact Fluttered”. We have been testing cloth for the past 25 years, and without getting into the details of this testing, we put a tremendous emphasis on

the results of our Impact Flutter tests that we perform on virtually every batch of Dacron and Laminates that we purchase. The variation within one type of fabric from the same manufacturer after flutter is as dramatic as the variations between different fabrics as shown in this second graph.

The relative stretch of the “new” (unfluttered) fabric versus the stretch after flutter is a reasonable estimate of the fabrics’ durability. If the stretch after flutter is a many times higher than the stretch when new, it is fair to say the fabric loses more strength when fluttered and would have a greater change in shape with use. If the fabric when fluttered loses more of its strength on the threadline than it does off threadline, this shape change will be different than the opposite case where the fabric loses more strength off threadline. Looking at the graph, it is clear that different types of fabrics have large variations in their increased stretch after flutter. In general, Dacron or Pentex woven fabrics lose more strength off threadline as they flutter. In general, the opposite is true with Mylar laminates. Except for “165 HTP Warp”, all the Dacron or Pentex woven fabrics more than double their original stretch at 30 degrees off threadline after flutter. The threadline and 10 degrees off threadline samples lose less strength after flutter.

The Laminates, however, do not follow this trend. They tend to lose strength somewhat equally (in comparison) in all directions- the one exception to this is the “PE-15 Pentex Mylar”.

The relative merits of which type of flutter damage is least damaging to the sail performance, I leave to others to debate, I am simply pointing out the fundamental differences between woven Dacron and Mylar Laminates.

Finally, the third argument against the use of Mylar film fabrics is the subject of shrinkage of the film with use and its effect on sail shape. There is shrinkage with use, however, this is not unique to film laminates. We have measured shrinkage after our Impact flutter testing, and have found that it is greatest in the warp direction, not just on film fabrics, but woven Dacron fabrics as well. In fact some of the biggest “shrinkers” were in fact woven Dacrons that we used in our “Quilt-Cut” Star sails in the late 70’s and early 80’s. The problem with any warp-orientated cloth is that shrinkage is not constant in all directions, and is concentrated in the warp direction. The amount of shrinkage is also dependent on the severity and concentration of the fluttering at a given point, like the front edge of battens, or at the transition between a lighter and heavier fabric. These areas take a much higher degree of abuse when the sail is flogging than anywhere else in the sail, and will show shape discrepancies earlier than elsewhere in the sail. However, this is not a unique feature of Mylar film fabrics, perhaps just more pronounced.

As the class has adopted the use of a transverse top batten in the main, this step alone has enhanced the durability of the sail. A 2nd transverse batten up top would be even better for both Mylar and Dacron fabrics. Ditto for the Jib, which does not yet allow a transverse top batten. This should have been adopted at the same time as the main.

I think there is enough justification for laminates to allow some experimentation at the local level. We can test samples, but the only way to know if laminates are a viable cloth choice is to try them. Of course, if I had the fastest cross cut Star sail designs using 36" wide woven Dacron, I think I would not be anxious to jump into a Triradial paneled design using 54" film fabric. However, that's not exactly my current situation, so I would enjoy a wide open design scramble.

I hope this information helps.

Sincerely,

Steve Haarstick
President & Owner
Haarstick Sailmakers, Inc.