

PROJECT BOAT RESTORATION

Choosing sailcloth

Maximus needs a new sail wardrobe so Ali Wood calls in one of the world's oldest sailcloth manufacturers to find out more

PBO
**PROJECT
BOAT**



Computer-aided sailcloth cutting machine at Bainbridge International

During the survey of our Maxi 84, the PBO Project Boat *Maximus*, we were warned by a marine surveyor that there was only so much he could tell us about the sails.

"To see how good a sail is, you really need to take the boat sailing," said Ben Sutcliffe-Davies.

Maximus had been laid up in a boatyard for two years, and when Ben pulled out the genoa from a locker full of leaves and rainwater, he gave it a good scratch.

"It's got that nice little noise to it when you scrape it with your nails," he said. "However, the UV strip is completely worn and faded and starting to break down."

Due to very light winds, however, we had little opportunity to test the sails on our shakedown voyage from Chichester to Poole. Unfortunately, the high winds came later – when *Maximus* was moored at her



Dufour 32 flies an asymmetric spinnaker

new home in Cobb's Quay Marina. One morning after a storm I returned to the boat to find the UV strip in tatters. When I unfurled the headsail to check for further damage I was dismayed to see it was full of holes and tears.

Paul Lees of Crusader Sails kindly helped me free the halyard wrap and get it down. The genoa was destroyed, but when he checked out the mainsail he concluded

that wouldn't last much longer either.

"This is on its last legs," he said. "See how it's coming apart here. It's ready to go. If you spent any money on these sails it would be good money after bad."

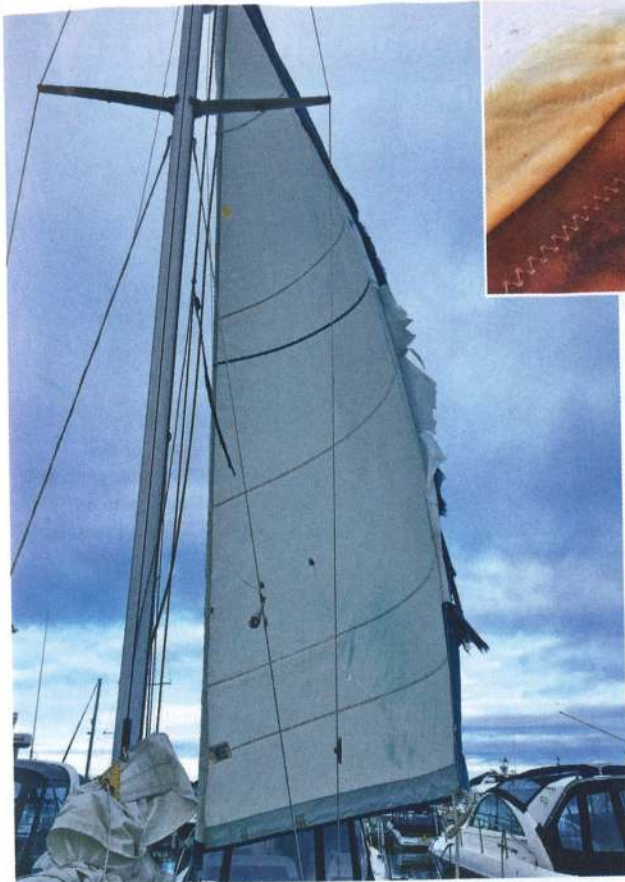
I emptied the lockers, hoping to find the storm jib so we could still go sailing, but this turned out to be in even poorer condition, with rusty, redundant hanks. While it is possible to sew a sleeve onto a hanked-on sail, so it can be fed into a furler, it wasn't worth it on this occasion.

Measuring up

I called Bainbridge International. Founded in 1917, they're one of the oldest sailcloth manufacturers in the world. If anyone could give me advice on new sails, it was them. Initially I spoke to Mike Cole, and explained the situation.

"It sounds like the UV has got to the polyester," he said. "Eventually it goes

Jean-Marie Liot



ABOVE Oh dear, *Maximus's* hank-on storm jib is well past its sell-by date

ABOVE RIGHT Surveyor Ben Sutcliffe-Davies checks out sail condition

LEFT After a storm raged through the marina, *Maximus's* headsail UV strip was in tatters

chalky, and you can damage the fabric simply by scratching it. The edges get worn and ripped as the fibres degrade."

Bainbridge offered to supply new sailcloth, to be made into sails by Southampton-based loft, T Sails (see next month). The first stage, however, was measuring up, a job tasked to Bainbridge technical manager, and former sailmaker, Daryl Morgan.

Daryl had been watching the weather keenly, and wasn't too impressed with the wind when he arrived at Cobb's Quay this summer. I soon understood why, when watching him winch a swaying tape up the mast on the main halyard. However, having been in the job for over 30 years, he wasn't phased, and managed to go away with some accurate measurements

of the P (mast) and E (boom) dimensions, among others.

Next, I visited Bainbridge HQ in Hampshire to watch the sails being designed. Not only was I getting a mainsail and headsail, but I'd opted for a cruising chute too.

Design in progress

"Sails are the most important investment you can make on your boat," said Daryl, as he booted up his computer and showed me some impressive 3D illustrations of *Maximus*. "They're not expensive when you consider what you get out of a sail. If, for example, you spend £5,000 on some sails for a 35ft yacht, in 10-15 years time you still have those sails. If you spend £2,000 on the latest gizmo

that goes bleep, it'll be out-of-date as soon as it's out of the box. That will never happen with sails. Every time you pull them out they'll make the boat go forward. They're worth the extra cash."

It was impressive to watch *Maximus's* sails come to life before our very eyes as Daryl sheeted them in virtually, eased them off, and simultaneously flew the mainsail, the genoa and a smart looking cruising chute. What was more exciting, was that the sails he'd designed were grey! That would be a first for any boat I'd sailed on.

There's no material advantage to having grey sails over white. In fact, they're slightly more expensive, as they need to be dyed, but racing trends often feed down to cruisers, and grey sails are becoming increasingly popular. It would be nice to try something new.

Cutting table

Outside Daryl's office was the sail-cutting machine itself, a huge table covered in white cloth, which was being trimmed to shape by a computer-guided blade. The sail panels are nested together using a computer programme, and the virtual co-ordinates are sent to the cutting machine, which is accurate to less than a hair's width.

The process was supervised by technician, Ana, who occasionally stopped the machine to climb onto the table and adjust the position of the cloth. It was hypnotic to watch, but noisy because of the vacuum sucking the cloth onto the table. Given that the process would take several hours, Daryl agreed to send me a time-lapse video of the whole event when it came to cutting the sail for *Maximus*.

Usually your sailmaker will decide the best cloth for your boat, cruising ground and budget, but it definitely pays to understand where your money goes, and what the pay-off is between performance and durability. It was time to quiz Daryl all about sails...

New sails made to look old

Clarionet, the famous 1966 Sparkman & Stephens One Tonner, has been restored to her former glory with the help of some new classic looking sails.

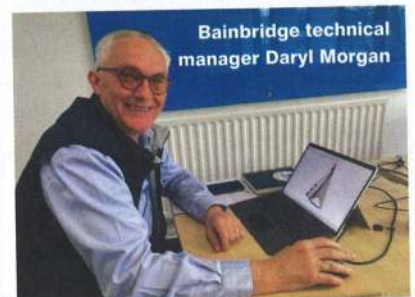
Built in Cowes on the Isle of Wight, the yacht was previously optimised for the IRC handicap, but has now been returned to the way she was in order to race in classic regattas.

Work included the

restoration of her original deck, solid wooden rig and unique 'plank boom'. In keeping with her new look, Bainbridge worked with Bank Sails to replace her laminate racing sails with a narrow panelled mainsail and mitre cut headsails made out of polyester woven sailcloth. The new 'old' look was created with Bainbridge SPX Classic Cream sailcloth.



Classic S&S One Tonner *Clarionet*



Bainbridge technical manager Daryl Morgan

Jean-Marie Liot

SAILMAKER Q&A

Daryl Morgan talks through advances in sailmaking

What tools did sailmakers use before computers?

A sailmaker would always have a set of drawing board tools such as a trusty scale ruler, pencil, protractor, calculator; those sort of items. You'd sit at a drawing board and start pencilling out the sails to a scale of 1:50.

The downside of paper and pencil, is you only get a 2D aspect of the sails. They're flat. With more advanced computer software these days you can describe the sail's aerofoil shape.

Is sail design a lot quicker these days?

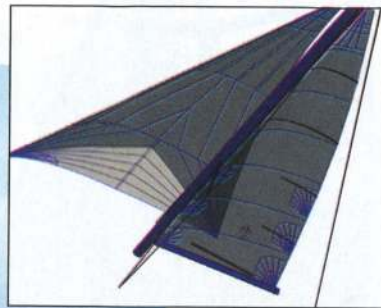
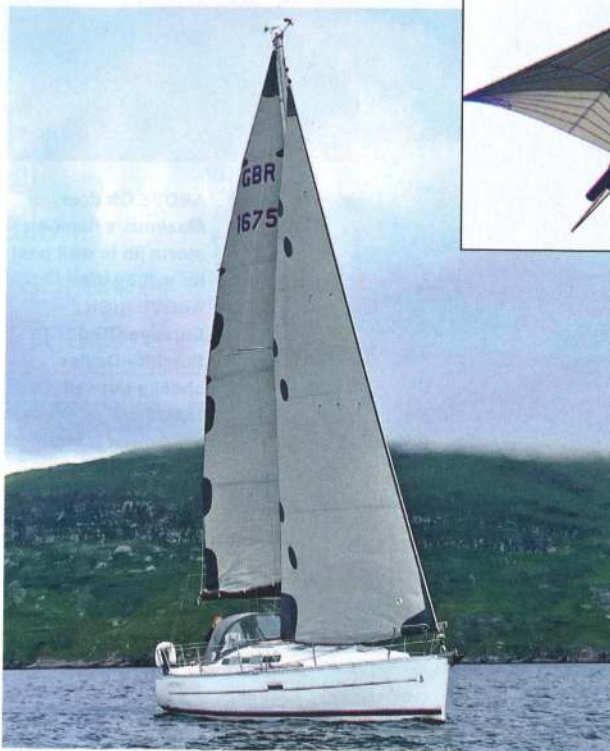
It's more about the accuracy. To create the rig, pencil and paper is actually super-fast, especially when you're as old as me, but to cut the sail and design the sail shape, a computer wins every time. If it's a standard mould, nothing flash, you can do it in 15 minutes. In the old days, when you chalked out on the floor, it would also take 15 minutes, but you had to draw it to the actual size. If your sail was 30ft by 10ft you'd need that much floorspace. You'd then lay the panels out and give it all to a machinist. Nowadays it's done on a little A4 screen and away you go.

What detail do you get with 3D design?

We can see how the sail sits on the main and boom, check the clew height is correct so that the sail sheets correctly onto the track, and doesn't impact the rig by crashing into the spreaders, for example. You couldn't do that with pencil and paper, but with foil shapes now on the computer you can describe rod size, wire, shrouds, spreaders, etc. and zoom in to get really accurate detail. You can look at the flying shape and height of all three sails in combination – main, headsail and cruising chute. We've gone as accurate as we need to be with the Maxi 84, but for a really big racing boat project we'd drill down even further.

Do fully battened sails have benefits?

Lot of sails are fully battened, ie battens



ABOVE Designing a sail for the PBO Project Boat *Maximus*
LEFT Full battens in the mainsail can prolong the life of the sail and make single-handing easier if used with lazy jacks and a stack pack system

Bainbridge

that stretch the whole width of the sail, from leech to luff. This increases longevity, helps prevent flutter and general abuse. If sailing single-handed, you can go fully battened with a set of lazy jacks and stack pack arrangement so that when the sail drops it's guided down into the boom bag out of the way. It's very easy. The battens control the sail. It's not going to fall off the boom and flop all over the place.

Are there any downsides?

The downside of a fully battened sail is that when hoisting and lowering you need pressure cars on the luff because of the increased friction from the full length of the battens. They work on compression; the batten pushes into the mast, so when hoisting and lowering, you need something to release compression and reduce friction. Hoisting is relatively easy, but lowering is what it's all about. You

need to be able to reef or lower the sail quickly in an emergency. There's also a bit of extra cost for hardware and longer battens, but to be frank, these days, the costs have gone down and it's a viable option. We've been making our own range of batten cars for 30 years. They're a proven design, they won't fail.

What's a typical batten setup?

A lot of sails are hybrid these days, so a 1 plus 3, or a 2 plus 2, where the top ones are full length and the lower 40% the width of the sail. This reduces cost, compared to a fully battened main, as you have fewer batten cars. The sail low down is less likely to flog anyway, and it's easier to fit the reefing points.

What's the J measurement?

The J measurement is the length of the foredeck from the stemhead fitting at →

SIMPLIFIED COSTS BASED ON 28FT YACHT MAXIMUS

Option	Requirements	Material/lifespan in years	Main (15m ²)	Roller furling genoa (22m ²)
Best value	Cruising/ long lasting sail	Woven polyester (15+)	£1,250	£1,750
Mid-range	Cruising/ club racing/ long lasting sail/ holds shape	Premium polyester (15+)	£1,450	£1,950
Cruiser/ performance	Bluewater cruising/ racing	Cruising laminate or hybrid polyester (7-10)	£2,375	£2,650
Racing	Racing	Laminate (3-5)	£2,985	£3,245
Grand prix racing	Winning!	Membrane (1-3 seasons)	£3,375	£4,000

*Note, example data from a sailmaker, not Bainbridge. A nylon cruising chute for a 28ft yacht would cost around £1,700 for 45m²

Measuring the boat for sail size



1 Daryl attaches the tape measure to the stemhead with some string.



2 The measurement from stemhead to mast is the J measurement.



3 The next measurement is from the stemhead to the cap shrouds.



4 The track measurement determines the largest overlap for the genoa.



5 Next Daryl attaches the tape measure to the forestay halyard shackle and sends it up the furler.



6 Windy conditions make it trickier for accurately measuring the rig.



7 Maximum hoist available is measured to the furler drum.



8 Back to the cap shrouds then track – essentially the same measurements but vertically. This creates a 3D triangle.



9 Maximum foot length (the E dimension) is taken from the aft face of the mast to the black band on the boom.



10 Sail height (P dimension) is taken between the black bands at the top and bottom of the mast. Daryl measures from the top of the mast and will compare it to the stated P dimension in the yacht's original specification for accuracy.



11 This mast gate will need to be replaced with a flush version to accommodate the battens.



12 Knowing the position of the reef points is really important to allow the correct sail shape.

Step
by
step

World Cruising Club



World Cruising Club

ABOVE and RIGHT
Using a pole on a symmetric spinnaker can improve speed and stability when charging downwind – as these ARC boats are doing

the tack to the front face of the mast. So the clew location for a 130% overlapping headsail, for example, is $J \times 1.3$, or 130% of the J measurement.

That 135% is a really nice all-round size for a roller furling headsail. It can do the whole range of wind and sea conditions you can expect on a cruising boat; you can sail at 5 knots and also at 25 knots. That's a lot of range for one sail.

How do furling headsails compare to hanked on sails?

On a furling headsail, a good overlap with the genoa is 135%, the LP. Previously, with hanked-on sails, you'd have had number 1, which is a 150% overlap, a number 2, which is 140% and number 3, which was lower still, as well as a working jib at 80%.

The combination of these sails would enable you to sail in any condition. Of course, the lighter the wind, the larger the overlap. However, if conditions change, you'd have to drop the sail, climb onto the foredeck, bag it, take another bag, hoist it up – and all this while conditions are getting worse, and probably getting dark.

As the wind increases you need to reduce sail area by reducing the LP, that's the luff perpendicular, and is a percentage of the J dimension. So you make smaller and smaller sails as the wind gets up. A boat will reach hull speed very quickly if

you have a number 1 up in 15 knots, but you'd be excessively heeled and struggling to go upwind well. It's uncomfortable; you'd want a smaller headsail so would opt for a number 2. The boat would be more upright, point better, and be far more comfortable.

A roller headsail has to do everything so you have to maximise its optimal sail area. You'll find that 135% gives you best performance in light winds, and as the wind increases in the afternoon, you can sail with a smaller area. When it goes to 16, 18 then 20 knots, you can roll it up and you still have an effective sail shape suited to the conditions.

It's an intermediate sail, but of course, the more you furl the sail and reef it up, the less efficient it is, so it's all about trying to find that nice mid-point.

Do I need a storm jib?

If you're going offshore or on an extended passage, you need a storm jib. But these days, how do you deploy it? There are a few options. You can have a jib that wraps around the furled headsail. On a 28ft yacht like *Maximus*, it'd be around 6m² but again it's a compromise. Another option is to rig an inner stay and hoist it up there.

For coastal sailing, dare I say you don't need a storm jib? But sometimes your insurers will insist on that.

There are certain requirements for storm jibs if you're doing offshore races, and if passage-making you'd definitely need a storm jib. But 10-20 mile hops between ports? You're not going to use it, because you'd be picking your weather windows.

What's a typical cruiser sail wardrobe?

In the old days, you'd have had a mainsail, No1 genoa, No2 genoa, working jib, storm jib and a spinnaker. Nowadays you'd typically have a mainsail, a furling genoa and a cruising chute.

How do cruising chutes compare to spinnakers?

I made my first cruising chutes in the mid-1980s; back then it was called an MPS – multipurpose sail. They became commonly used in the 1990s. The fundamental difference between a spinnaker and a cruising chute is that the spinnaker is symmetrical; the two leeches are the same length. A cruising chute is asymmetrical; the leading edge, or luff, is longer than the trailing edge (ie the leech).

Unlike a spinnaker, a cruising chute doesn't need a pole to set it efficiently. This does away with the need for a spinnaker guy, pole hoist and pole downhaul.

With a cruising chute you simply bear away, furl in the genoa, get the cruising chute out of the bag, hoist it, put the sheets on and go sailing. You'd probably deploy it in a snuffer, or sock, blow the tack, pop it down, put it in the bag, put the genoa up and go back upwind.

Can you use a pole on a cruising chute?

Yes, and you'll have a more projected area. But without one, you just ease the tack line, the sail will lift and project to weather anyway. Ease the sheet to sail downwind. With a pole you'll be a bit more stable, especially in a seaway, and can charge downwind better, but it's not essential. After all, a cruising chute is there to make life easy so why complicate it?

What's the cruising chute wind range?

Cruising chutes are optimised for a 140°-150° apparent wind angle. That's when they're at their most comfortable. Any lower, and the sail is wobbly. Anything higher, and you're on your ear and a bit hectic. But it's all about wind speed and sea state. If it's blowing 20 knots and you've got a 1.2m Solent chop, you don't want to put up a cruising

Mike Robinson/Alamy

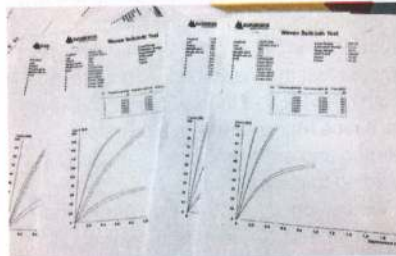


High visibility storm jib set on a yacht on passage from Tasmania to New Zealand

Cutting the cloth



1 The tensile properties of sailcloth are tested: the first, middle and last roll of sailcloth are tested in each batch for warp, fill and bias numbers.



2 Daryl checks the print-out from a sailcloth sample. A selection of all cloth is kept on file. This firm 6oz cloth takes 23.74lb to stretch it just 1%.

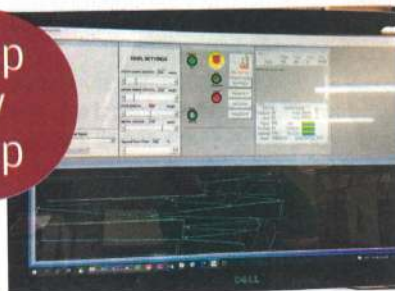


3 Daryl begins the sail design process by entering all the boat's previously measured rig dimensions into a computer programme.



4 Daryl designs a crosscut mainsail, a tri-radial headsail and cruising chute for *Maximus* using a 3D computer design programme.

Step
by
step



5 The sail panels are nested into an efficient pattern on a computer, which sends the co-ordinates to the sail cutting machine.



6 The sail cloth is cut into panels on a 10.6m-long table. This 7oz white Vectran cloth will eventually be a radial headsail for a Contessa 32.



7 A vacuum sucks the cloth down onto the table surface to stop it moving during cutting. The pre-programmed pattern is then cut by laser.

8 For a single sail there might be 60 or more cloth panels that Bainbridge have woven and cut. Here Daryl holds one of a table-full of cut panels that have been rolled up ready to go to a sailmaker for stitching and finishing.



Other sail components



1 Luff tape begins life as a 500m roll of 5mm rope and a 500m roll of slit tape. The rope and threads all come from UK manufacturers.



2 The tape and rope are fed through a machine that combines them to make Super Luff. Bainbridge keeps 4km of this on site in their UK warehouse.



3 Fibreglass Aquabatten battens come in sizes ranging in thickness from 6mm to 30mm. They're tapered, stiff at the back and flexible at the front.

chute. On a 60° reach you'd break the sail and break yourself. But if it's nice, flat water, 5 knots and you wanted a nice reach, you could easily do 70° or 85°. It would be a flat sail; proper champagne sailing – but as the sea state or wind increases you need to bear away.

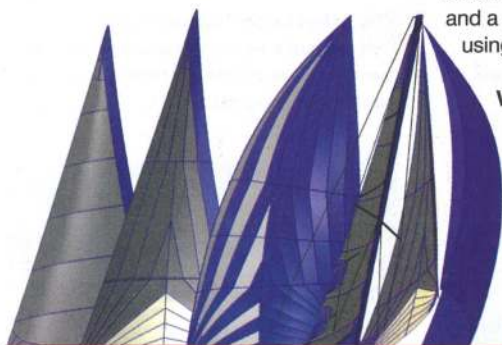
Which cloths will be used for Maximus's sails?

The mainsail will be crosscut woven polyester, and for the headsail we're using a hybrid woven sailcloth that's polyester

and Vectran [a manufactured fibre spun from a liquid-crystal polymer]. These unique properties enable us to cut in both radial and cross-cut sections (see below).

What's unique about Bainbridge's Vectran cloth, HSXV, developed five years ago, is that the Vectran can be used in both directions of the sail cloth. This gives us a nice matrix grid which reduces stretch and adds longevity and shape-holding to the material.

We can cut the cloth in two directions – either crosscut or radial cut. We've chosen a radial design for the headsail and a crosscut for the mainsail, both using 6oz cloth.



What about the cruising chute?

We've chosen a radial construction for the cruising chute. It performs so much better. We've

FROM LEFT Computer images of crosscut sail, radial cut sail, cruising chute, and all three

opted for blue and white – PBO's colours – and an asymmetric colour scheme so you always know what's the front and the back. They don't work well if you put them up back to front, but it does happen!

Our BI-70 is a multipurpose spinnaker nylon, which is a high-tenacity with good stretch and very good tear strengths. It's 1.5oz, 65gsm, and will set in 3/4/5 knots of breeze but you can set in 10-15 knots. You can choose a lighter weight, but this ticks all the boxes. For short-handed or family cruising it will fine.

What are the other options?

Your least expensive option is crosscut woven polyester. You'll get a sail that will do everything you want it to do, it will last a lifetime, and I mean it. Woven polyester sailcloth is so tough these days, but it's the sail shape in 15 years that will be appalling. Crosscut polyester is durable, relatively cheap, long-lasting and you'll be able to abuse it like you wouldn't any other type of material

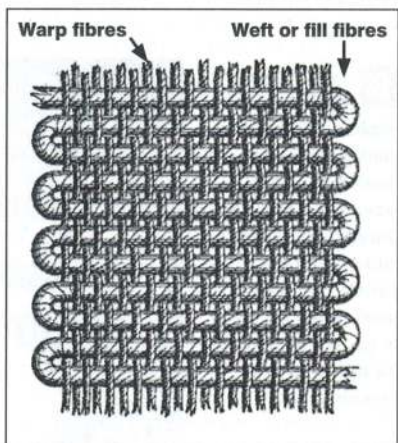
WHAT ARE MY OPTIONS?

Comparing different sailcloths and types of sail construction

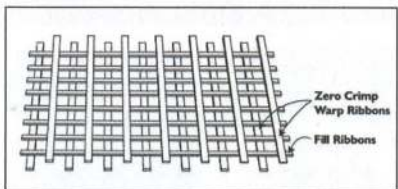
Which cloth?

Woven polyester

Though technology has advanced, the basic principles of weaving sailcloth haven't changed since sailing began, with warp fibres (which run along the cloth) being bent around fill fibres (which run across the cloth). The yarns have to snake over and under each other, and this is called 'crimp'. When the cloth is loaded, these yarns straighten, resulting in stretch. Most woven sails are made from polyester (also called Dacron, a DuPont trade name) that was introduced by Bainbridge as a replacement for cotton in the 1950s. Wovens are durable and economical, making them ideal for cruising sails.



ABOVE Fibre layout for woven cloth
BELOW Scrim for laminates is bonded into a lattice



Woven nylon – cruising chutes

Most spinnakers and cruising chutes are made from woven nylon because it has good tear strength. Nylons come in generic families ranging from 2.2oz down to 0.4oz, though these numbers do not directly relate to the cloth weight. Nylons can also be coated or impregnated and warp or fill orientated, but the important thing is the relationship between stretch, tear strength and weight. Heavier nylons do not always have lower stretch and better tear strength. A high quality light fabric can easily outperform heavy, low quality products.

Laminate

Laminates are made by bonding together layers of different materials to form a

sandwich. A simple laminate will consist of an open scrim of fibres with a layer of film bonded to each side. The film stops air blowing through the laminate while the load is taken by the scrim. Laminates are far more efficient than wovens as the scrim in laminates is 'forced' and not woven. The process bonds flat ribbons of fibre into a lattice. No weaving means no

crimp and hence less stretch.

There are dozens of laminate products on the market, almost all of which contain three essential elements:

- One or more layers of film
- Fibres (such as Kevlar, Vectran, Spectra, carbon or polyester) that are laid into the laminate to enhance the strength in a particular direction.
- Taffeta (a woven fabric glued to the outside of the laminate).

One of the advantages of laminates is they're much stronger for a given weight. A double taffeta cruise laminate might not be much lighter than the equivalent polyester but it will be much stronger resulting in far more stable shapes and better performance. Though stronger and better able to hold their shape, the downside to laminates (apart from cost) is that they're not as durable.

Cruising laminate

Many people associate laminates with high-end race sails, but one of Bainbridge's fastest growing markets is cruising laminates, a hybrid of woven and laminate. Based on race products, they are equally as strong, but have a light woven fabric bonded to both sides to give them durability.

Which cut?

1 Crosscut

Crosscut sails are usually constructed from woven polyester panels of cloth that run horizontally across the sail. As fill fibres

As it's a woven cloth, however, so over time the tightness of the weave will loosen up. At the time it was made it would have been optimum for your boat, but over time it will get fuller and deeper and won't perform as it did when brand new. Will it make the boat go forward? Yes. Can you use it in 5 and 20 knots? Yes. But 20-knot performance will be terrible!

Your next choice, to maintain the weave, is a hybrid woven then you're looking at cruising laminates. I started making these back in the 1990s. It's a similar process to building a GRP boat – you add layers and end up with a hull shape. With sails, you have various scrim, made up of different types of yarn and glue them all together. The two outer laminates are encapsulated in woven polyester. There are lots of varieties including Kevlar, carbon, Dyneema, and the bigger the boat, the bigger the loads, so the more exotic the material you use in the laminate.

The downside of laminates is that they'll let go at some stage. A woven cloth will



HSX is a tightly packed premium woven sailcloth and now available in grey

never let go. It'll lose its shape but you don't get catastrophic failure.

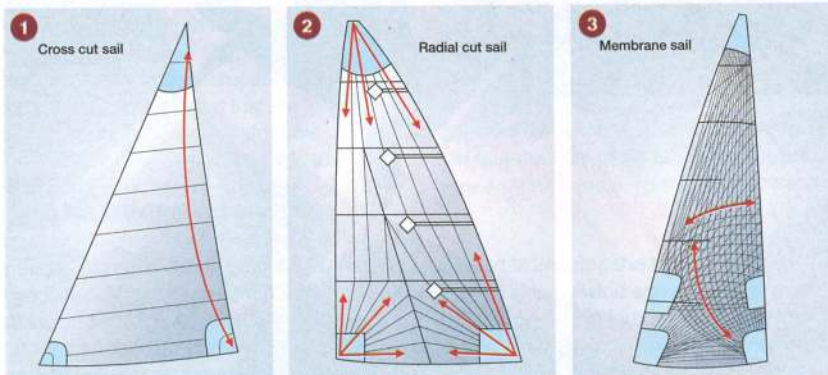
How long will a laminate last?

Eight to ten years for a cruising laminate would be good. Three to five years is average, but the thing about laminate is that the shape will be consistent for the lifetime of the sailcloth. That's the trade-off: durability over performance, but when spending a lot of money on sails, it's important to look at the lifetime cost, not just the initial outlay.

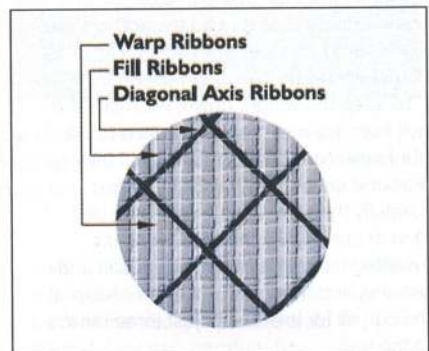
What about second-hand sails?

If you're buying a second-hand boat, take the sails to your local sailmaker and ask for their opinion. Sailmakers are honest. They want you to come back and use their services every year; laundering, stitching, maintaining batten pockets, etc. No sailmaker is in it for the quick buck. Most people will take six months or longer to progress with a quote. Choose the right cloth, and the right sailmaker for you.

Graham Snook



Examples of different types of sail construction



This DIAIX laminate cloth by Bainbridge has a diagonal scrim

have less crimp, a woven cloth stretches less across its width than along its length. Bainbridge takes advantage of this by using larger (sometimes 400%) fill yarns than warp yarns.

2 Radial cut

Radial cut constructions more closely follow the load patterns on a given sail, with the loads mostly travelling along the length of the cloth. They're usually made from laminated sailcloth – that is, any fabric consisting of two or more layers adhered together. Radial cut fabrics are much stronger in the warp direction than the fill, which means they can be used in a different way. The panels can be cut in long, narrow triangles and trapezoids with the strong warp fibres aligned with the loads in the sail that radiate out from the corners.

3 Membrane

The most advanced sail construction type is a membrane sail, which is custom-

made. Individual panels are constructed on a table with the fibres being arranged with the boat owner's usage in mind. Once complete, another layer of film is added, the air gets sucked out and the whole lot gets pressed and heated so you end up with a custom panel.

Individual panels are then glued together to make up the complete sail, with the seams being stronger than the laminate itself. This more complex solution for load distribution means better performance.

Understanding bias

The sailmaker will know how the loads in your sail radiate out from the corners, but

with so many variables, not all loads will exactly follow the yarns, meaning some of the stress is 'off threadline'.

To reduce this, Bainbridge try to minimise bias (diagonal stretch) in woven cloth by locking the warp and fill yarns together by impregnating with a resin to chemically bond them together.

Thanks to

- Bainbridge International, bainbridgeint.com
- T Sails, tsails.co.uk
- MDL Cobb's Quay Marina, mdlmarinas.co.uk

Thanks to all the supporters of the PBO Project Boat...

