SP Systems

Composite
Engineering
Materials

Building Custom Sailboards and Surfboards

Introduction

This guide has been produced to assist the increasing number of D.I.Y. enthusiasts who wish to emulate the top custom board producers and build a surf or sailboard using the SP 115 epoxy laminating system. The guide is not intended to take the place of the numerous books covering the subject of board construction but to provide supplementary information where the user wishes to build an epoxy rather than polyester board. In this area the present information available is often scarce and at times inaccurate.

Epoxy custom board construction is now well established with both professionals and amateurs and is widely acknowledged to be superior to the more conventionally constructed products. However, due largely to the additional time required to construct an epoxy board and the additional care needed with the products, they usually carry a price premium elevating them to the top of the price league and outside the budget of many who aspire to one.

With the possession of some basic skills in draughtmanship and an eye for detail, it is quite feasible for the average amateur builder to come somewhere close to producing a replica of the professional product at up to one quarter of the cost. However, it must be realised and accepted that the design and the evaluation of top performing shapes is largely the perogative of the professional builder who has invested time and money to achieve his standards and to build his reputation. To achieve a better all-round product than the professional is almost impossible, but it is quite feasible for the D.I.Y. amateur to build three or four for the price of one professional board and have the satisfaction of producing a crafted product using the best materials.

The SP 115 Epoxy Resin System

SP 115 is a specially developed, low viscosity epoxy laminating system for building surf and sailboards. Unlike many other epoxy systems, which discolour noticeably in sunlight, SP 115 has good light stability through the incorporation of ultra-violet filters. These screen out the damaging effects of sunlight which cause resins to yellow badly and colours to fade. Although this is a noteable feature, the most important benefit of SP 115 is its outstanding strength and resistance to impact damage. The board will not only last longer, but it will also be stiffer and lighter.

The strength of the board is mainly a function of the weight, type and orientation of the primary reinforcement. However, it also depends on the quality of the bond between the laminate and the foam core, and the quality of adhesion between the layers of the reinforcement fibre (Interlaminar adhesion). In these respects SP 115 has proved to be outstanding, easily outperforming conventional polyester resins. Other benefits from the use of epoxy include greater resistance to moisture absorption, and lower fumes while laminating.

The common question is "*Why should I pay more for an epoxy laminating system?*". We think that we have given you some of the answers. However, there are other extremely important benefits which derive from the fact that polystyrene can be used as the core material in place of the more common PVC or polyurethane types.

Not only is polystyrene much less expensive, it can also be obtained in significantly lighter grades and it retains sufficient strength to allow boards to be built up to 20% lighter. It is mainly for this reason that most of the world's top board shapers use the combination of epoxy resin and polystyrene for prototypes, and therefore why it is such a popular and successful combination for race boards, and why it is the choice of professional surfers.

The SP 115 Epoxy Resin Epoxy System is excellent if clear laminate Surfboards are being produced. However, if painted finished surfboards are to be made it would be preferable to use the Ampreg 20 system which gives higher strength. It also offers a better range of hardener speeds than the SP 115, which is important if the builder follows our advice in the section "Advanced Construction Techniques."

Core Materials

The majority of professional builders use a core which is formed from polyurethane (PU) foam in a two-part mould by the foaming action of liquid components. The resulting "blank", as the core is called, is roughly shaped to a variety of sizes. The foam blank has a "skin" of heavier (higher density) foam over its entire surface which the shaper first removes. Blanks produced in this way are convenient for professional builders as they reduce the subsequent time spent shaping the blank and allow the use of either type of resin system for laminating the reinforcement. Foam density is typically 40-50kg/m^3.

For the amateur however, or professional whose intended board shape lies outside the parameters dictated by these "stock" shapes, the other choice is to use polystyrene foams.

Polystyrene foam is available in two forms from suppliers, and both types are popular for board construction. The first type is formed from small hard beads of raw material which are introduced into a mould, where they are made up to expand by the introduction of steam to form the desired shape. This is usually a rectangular block or sheet, but it can take the form of a "semi-formed" blank. Whilst some domestic and packing products are made in this way from the lighter grades of polystyrene, only grades of 20-25g/m^3 density are considered to have the necessary strength, consistency of bead diameter and working properties for board construction.

On the west coast of the U.S.A., "Hydrofoam" is a well known brand of expanded bead polystyrene produced by Lite Composite Systems, and has proved excellent for surfboard building. A lack of any delamination of the blank from the laminate in working use (which is a common failing with polyester and urethane construction) has been attributed to the Hydrofoam's excellent resilience, structural memory and the use of SP 115 laminating system.

Another type of styrene foam is an extruded foam produced by Dow Chemical under the trade name of "Styrofoam". Popular in the building trade as "Styrofoam IB", it is used for insulation applications but is sufficiently strong for some structural applications as a core. The typical pale blue/grey colour is attributable to the incorporation of a fire retardant and does not affect any of the other properties. "Styrofoam" is approximately twice the price of bead foam, and is significantly heavier at 28kg/m^3. However, it is structurally superior and because of its closed cell construction, it does not, like bead foam, absorb water when immersed. In addition, the cells are elongated in one direction to give noticeably improved properties in one plane, especially compressive strength. These features have ensured that "Styrofoam" is a popular choice with board builders.

Like bead foam, "Styrofoam" is available in the U.K. in sheets up to 150mm thick and the width and length to cover most board sizes. These sizes mean that it is often necessary for sheets to be glued together in order to obtain sufficient thickness for nose rocker, etc. "Styrofoam" is widely available throughout the U.K., as the blue variant "Styrofoam IB", but recently a white "Styrofoam" has been produced and is available from limited outlets at higher prices.

Stringers

The term "stringer" generally refers to the vertical wooden panel which is fitted down the centre of a board blank from nose to tail and extends from deck to bottom. Stringers are intended to provide longitudinal strength and stiffness and to help the board keep its intended shape, as well as providing a firm foundation for fin and mast boxes. In the past, thin plywood stringers have been incorporated into polyurethane foam blanks where polyester resin systems were used for laminating and all such blanks were supplied with one incorporated during manufacture.

When epoxy and styrene foam became popular it was found that surfboards up to 250cm long could be built "stringer-less" without compromising strength. However, it was often left up to the individual builder to decide whether a stringer should be incorporated, depending on the board's usage. All sailboards generally have stringers, since, being longer than surfboards, they are more likely to break, particularly if used in severe conditions.

Either one or two stringers may be incorporated and they are usually of thin 3-4mm plywood. However, it is possible to make stringers of other materials such as glass or carbon, or of higher density foams with fabric laminates, to perform the same function as wood.

The traditional type stringers may be omitted and replaced by carbon fibre unidirectional fibres running the length of the deck and bottom to form a rigid "girder" within the top and bottom laminates. Additional information on stringers can be found in the "Advanced Construction Techniques" section (see later).

Reinforcement

The strength of custom boards is largely derived from the mechanical properties of the reinforcement fibres which compromise the top and bottom skins (laminates). The laminate properties also control board stiffness in the absence of a central stringer.

Woven Reinforcement

E Glass, woven on a loom with a warp and weft is the normal reinforcement type as it has good impact strength and is economical to buy. E Glass is available in a variety of weights (expresssed in grammes per square metre), weave styles and widths. For boards, a plain weave fabric is usually chosen since it shows suitably good handling characteristics for normal board shapes.

Plain weaves have the most stable weave configuration and are ideal for flat surfaces or gently curving surfaces. Twill weaves have better handling characteristics for areas of compound curvature but they are more difficult to handle on flat areas. The choice of fabric weave configuration is a matter of personal preference but plain weaves are by far the most popular woven type currently used.

The total weight of the fabric used controls strength. The normal fabric weight for a top laminate is around 600gms/m^2 (18oz/yd^2) with 400gms/m^2 (12oz/yd^2) for the bottom of boards up to 3.90m in length. These weights are usually achieved in 3 and 2 layers respectively using a 200g/m^2 woven E Glass. One layer, of the equivalent weight is insufficient as this would be prone to porosity with plain weave fabrics. Specification however, may change depending on rider weight, usage, type of board and length. For a short surfboard of 180cm the user may find two layers of 165gms/m^2 (4oz/yd^2) on the top and two layers of 200gms on bottom (6oz/yd^2) adequate even without a stringer.

The following are important considerations when choosing a fabric:

Clarity

Laminate clarity is generally important if a true custom board with the traditional graphics display is to be built. Clarity is largely dependent on the type of finish applied to the fabric during manufacture, in addition to (but to a far lesser extent) the nature of the weave. SP Systems RE210D E Glass shows excellent clarity but RE165 is also very good although it may show a faint green tint which is more apparent on rolls of the fabric than in thin laminate form.

Width

The most economical width for a board fabric is 80cm which is sufficient for the deck and rails of most boards without too much waste. This width is the industry 'standard' for board construction. Offcuts from nose and tail laminates can be used for additional reinforcement 'patches'.

Working Properties

A plain weave E glass which is soft and loosely woven will wet out well and allow air to be dispersed easily. Air release is an important consideration and will give a laminate which is clearer and with significantly improved mechanical properties.

Non-woven or Unidirectional Reinforcement

Having fibres orientated in one direction is important for specific reinforcement in one direction. Unidirectionals have 80-100% of fibre in one direction, and therefore differ markedly from conventional woven materials in which approximately 50% of the fibre is at right angles to the other 50%. Unidirectional E glass is sometimes used on lightweight boards to replace one layer of woven fabric, whilst the use of carbon unidirectional is fairly popular in providing stiffness particularly on boards without central wooden stringers. The greatest benefit from unidirectionals will be seen on long boards which are used for racing, where they are invariably used over the whole length of top and bottom laminates.

The specific strength (i.e. strength per unit weight) of carbon is approximately twice that of E glass but carbon has approximately four times the stiffness. The laminate on a typical long race or speed board may include a carbon band 100-300mm wide of 200gms/m^2 unidirectional carbon (SP Systems UC200). Because carbon is relatively brittle and easily damaged it is usually located under one or more protective layers of woven E glass on the deck and bottom.

Other Reinforcement Types

Woven aramid (Kevlar or Twaron) is not popular in clear custom boards as it is degraded by ultra-violet light and therefore discolours in sunlight, turning from a pale yellow to a golden brown. However, aramid is sometimes used on performance boards which have a painted finish.

Aramid is a low density fibre with exceptional strength and can replace an E glass laminate. As an example, one layer of 180gm aramid has equivalent strength properties to 300gm E glass and is approximately the same thickness. Aramid is often hybridised with carbon to give a carbon laminate with improved impact strength. A typical bottom laminate would be one layer of 240gm aramid-carbon hybrid woven fabric (SP Systems RAC240T) which could replace 2 layers of 210g/m^2 E glass.

Board Construction

Fitting the Stringer

After the blank has been selected, the first stage in the build programme is to produce templates from plywood or hardboard describing the side elevation and plan view of the board. For the design, we recommend that an amateur should base a design on a popular production board with the handling characteristics that they like, drawing the design out accurately on to squared paper. The design should then be transferred onto hardboard template material.

For the side elevation, two templates are needed which are each drilled at 750mm centres and fastened with 150mm nails to each side of the rectangular foam block.

Fig. 1

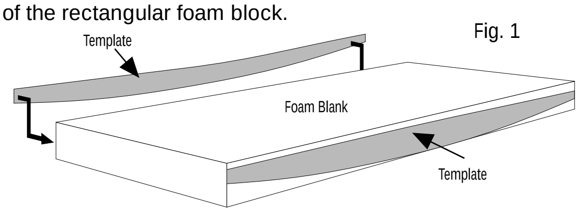
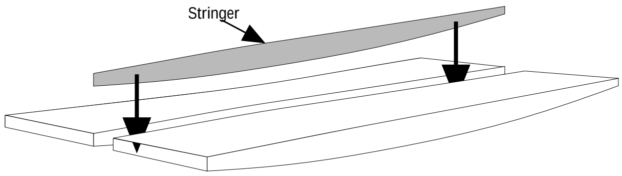


Fig. 2



Shaping the foam block using template 'guide'

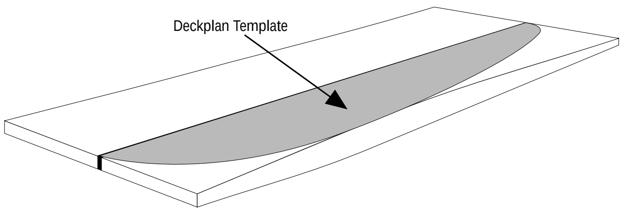
With the templates providing an accurate guide, the side elevation shape can be easily cut out using a hot wire cutter. For the best results this operation should be carried out by two people.

A centre line is then marked on the 'deck' and the foam is cut along this line with a fine toothed hand-saw. The two halves are then glued onto each side of a plywood stringer, corresponding to the shape of the side elevation template, using the SP 115 system to which SP Glass Bubbles have been added to make a thin adhesive paste. Masking tape can be used to hold up to three elements in place until the resin system has cured. The adhesive qualities of the SP 115 system are such that high clamping pressures are not required.

Blank Shaping

With the stringer glued into position the deck plan can be marked out using only one half of the pattern (to ensure symmetry) and cut out with a hand saw, taking care to keep it vertical. The foam blank is now ready for shaping.

Fig. 3



Blank ready to shape with deck plan marked out

The degree of care taken during the shaping operation is crucial to the board's final appearance and its performance on the water.

Professionals take great care regarding the lighting in the shaping room which normally consists of a series of fluorescent tubes mounted around the working area at the same height as the heavily padded stands. Equally, the 'shaper' should make sure that all tools are sharp and a few minutes practice on some scrap material before moving onto the actual blank can pay dividends.

Excess foam can be removed by using a Surform and/or an electric planer. It is probably best to completely shape one rail first and and then use it to take off templates for the other rail. Once the desired shape has been achieved, the board should be sanded smooth with a 3M carborundum shaping gauze followed by 60 and 120 grit aluminium oxide production paper. By viewing the board from different angles it should be possible to spot any irregularities.

For those people who would prefer not to shape the blank, some manufacturers can supply shaped blanks to order.

Sealing the Blank

When using a polystyrene core many builders favour sealing the surface of the polystyrene with an initial clear SP 115 resin mix which is simply scraped over the surface. This may then either be laminated over shortly afterwards (30-60 mins), or allowed to cure to a hard 'shell'.

If the board is to be painted eventually then SP Glass Bubbles or SP Microballoons filler can be incorporated into the resin mix to bulk it and make the sealing coat easier to sand.

Sealing the blank in this way does ensure that, when laminating, resin will not drain out of the fabric and into the foam to leave air pockets. Whilst sealing would be an essential operation with the relatively porous bead type polystyrene, the use of "Styrofoam" can render this operation unnecessary. The "Styrofoam", however, will require sanding to a fine finish with 150 grit production paper, which will help with the graphics definition. For clear laminates, artwork may be applied onto the epoxy sealed surface some two or three hours later at 25°C.

Art and Airbrush Work

Prior to painting, all dust should be removed from the blank with a soft brush attached to a vacuum cleaner. If the painting is to be carried out in the 'shaping room' the area should be cleaned and a polythene sheet laid on the floor to protect against overspray. For the best results the blank must be checked for smoothness and where irregularities exist on the sealing coat, they should be sanded with 120 grit paper.

Graphics are best applied to the foam with an air brush using water-based acrylic paints which can be obtained from most art shops. All areas which are to be left unpainted should be masked-off with good quality masking tape such as 3M Scotchlite. Line work and detail areas can be masked with fine line tape which can be obtained in a variety of widths from an auto accessory shop or a car refinishing outlet.

To avoid the finished board absorbing excessive heat when left out in the sun, most custom board producers avoid using black and other dark colours and tend to favour pastel shades.

Once the paint has dried, a clear lacquer (e.g. ICI Clearcoat) is applied to seal the surface to ensure that the laminating system does not damage the graphics.

Laminating Preparations

Before commencing with the laminating stage, the foam blank should be kept at a temperature of between 25-30°C for a few hours. The fabric should also be stored in a warm and dry environment and ideally throughout the laminating process. The ambient temperature should be between 18-25°C for optimum results during the laminating stage.

All cloth should be cut to the approximate shape prior to the actual laminating process.

With the deck facing downwards and protected by a sheet of polythene held in position with masking tape, the two layers for the bottom of the board should be cut from the roll. The first layer should be cut so that it wraps around the rail and overlaps the masked area of the deck, whereas the second layer should finish some 50mm short of the edge of the first layer.

The three layers for the deck should then be cut out. The first layer is the largest and will extend down to the bottom edge of the rail, the second layer should finish approximately 25mm short of the first and the third layer should finish approximately 50mm from the second.

This lay-up method ensures a minimum of three layers of cloth on the rails and four on the deck edge.

Lamination

When using SP 115 epoxy resin system it is essential to measure the volume of resin and hardener in the correct ratio of 5 parts of resin to 2 parts of hardener by volume. Do not vary the ratio for any reason or the full cure will not be achieved.

Once mixed it is necessary to use the epoxy resin quickly as the curing reaction will have commenced. Pouring the resin over the laminate and spreading out with a brush is the usual way to extend its working life as well as avoiding the build-up of heat (exotherm) in the mixing container.

A table at the end of this section gives the user an approximation of the volumes of resin and hardener used for each stage in the building programme for a typical 2.9m long board.

An epoxy resin mix, like polyester after adding its catalyst, has a defined period during which it can be worked on the laminate. Whereas polyester will have a sharply defined and characteristic gel stage, epoxy will thicken gradually as curing progresses, eventually becoming unworkable. After this gelation stage it continues to harden and will eventually cure fully.

The essential principles of laminating are the same whatever resin type is used. The aim is to apply successive layers of glass and wet them out adequately without air entrapment using the minimum volume of resin. A plastic or rubber squeegee is necessary to apply pressure to the laminate which has the effect of forcing the glass layers closely together and, in doing so, squeezing out excess resin and air.

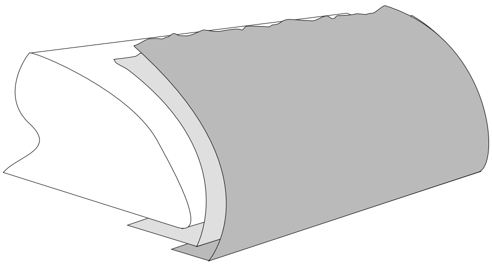
It is good practice to both lay each individual layer of glass into wet resin and to laminate only one layer at a time. This technique ensures that the laminate uses the least resin and has the minimum amount of air entrapment even though it is slower than some other methods.

After the first layer has been laid the second layer of glass is placed carefully over it and additional resin mix applied if necessary. The laminate should be consolidated with a squeegee until the glass is completely transparent and no air bubbles can be detected. A strong light at this stage is helpful in the search for isolated air bubbles which, if present, can be picked out with a sharp point before the resin has hardened.

Bottom Lamination

For surf and sailboards the following laminating sequence should be used:

Fig. 4



Bottom laminate uppermost showing masked-off deck and staggered edges of glass in rail area

With the board correctly supported, glass prepared and deck area masked off, the bottom can be laminated. The edges of the first and second layer on the rounded rail areas should be arranged as in Figure 4. On these areas there is a tendency for the laminating resin to drain more easily and thus introduce more air into the laminate. The laminating resin is therefore best applied in thin coats using a thin foam roller to aid consolidation. Sufficient coats need to be applied to give the necessary build-up over the glass.

When the resin has gelled sufficiently excess cloth should be removed by cutting with a sharp knife along the edge of the masking tape. A little epoxy solvent (SP Solvent A), as a lubricant, smeared onto the blade, will help this operation. Where the rails are hard, i.e. in the tail area, both layers of the cloth can be cut on the hard edge.

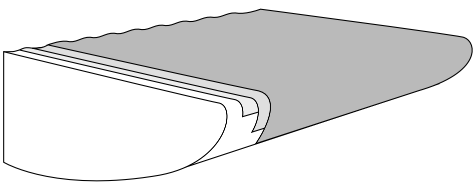
As the tail area is normally the weakest area of the board, bundles of unidirectional glass fibre can be laid parallel to the edge, under the woven material, to give additional strength.

When the bottom lamination is complete, the board should be left until the following day (approximately 12 hours) at workshop temperatures before the deck is laminated.

Deck Lamination

Before applying the deck laminate, the hard edge on the rails where the bottom and deck layer will overlap, must be sanded smooth to eliminate the risk of a "step" effect. This operation should be carried out using a sanding block and 60 grit production paper. The deck is laminated in the same way as the bottom, one layer at a time (Figure 5).

Fig. 5



The foot strap areas should be reinforced between the second and third layers with one or more additional layers of E glass fabric as a "patch". It is also worthwhile similarly reinforcing the nose and tail with an additional small patch of glass since these areas are particularly prone to impact damage.

SANDING COATS

Deck Sanding Coats

After approximately 30 minutes, when the deck laminate has become tacky, more resin mixture can be brushed on in order to fill the weave and provide a good covering in preparation for sanding.

When the resin has gelled sufficiently the cloth overlapping the hard rails can be trimmed with a knife.

Bottom Sanding Coat

The following day the bottom is sanded and the bottom sanding coat applied.

The surface should be cleaned with SP Solvent C (Cleaning Fluid) and the whole board sanded with an Orbital Sander using 60 grit paper until a uniform matt finish is obtained. The sanding coat can then be applied.

Fittings

The positions for the fin boxes and mast track should be drawn in with a pencil. Ideally the apertures should be cut out using an electric router and the boxes fixed into position with the SP 115/ Glass Bubbles mixture. Masking tape laid along the sides of the apertures will allow excess adhesive to be removed easily. Holes for foot strap plugs are drilled and filled with the resin/hardener/ glass bubbles mixture before the plugs are pressed home. Particular care must be taken to avoid local exotherm by using small quantities of resin.

Gloss Coats

The finishing coat or 'gloss coat' for the top and bottom, uses the clear, unfilled SP 115 mixture used for laminating. Under no circumstances should the resin mix be thinned with a solvent.

To prepare for gloss coating all sanded areas should first be cleaned and wiped with SP Solvent A (Fast Epoxy Solvent) to remove any contamination and dust. The deck area can then be masked off with polythene sheet to protect against drips and the board turned upside down. To obtain the best results, the resin and hardener components should be pre-warmed to approximately 25°C. The bottom gloss coat mix is most conveniently applied with a 4" soft bristle brush.

When the resin has gelled the masking tape can be removed and the resin allowed to cure overnight. The original line is then masked off, board turned over and the deck gloss coat applied.

Finishing Techniques

At this stage it is unlikely that the surface of the board will be blemish free and therefore it will require polishing to achieve a 'showroom' finish.

After gloss coating the board, it is best left for 48 hours, wiped with SP Solvent C (Cleaning Fluid) and sanded wet with 400 grit paper attached to a soft sanding block: this can be followed by wet sanding with 600 and 800 grades. Final finishing can be carried out either by hand or with a cutting compound such as ‘T Cut’. Polishing with a silicone car polish will give added protection and a high gloss surface.

An alternative method of finishing is to apply three coats of SP Ultravar 2000 two-pack polyurethane varnish (without intermediate sanding) after wet sanding the cured gloss coat with 400 grit paper and cleaning the surface with Ultravar 2000 Brushing Solvent. Three coats of Ultravar 2000 applied in this way are recommended before polishing with an ammonia-free polish

A non-slip finish can be applied, or incorporated, on the required areas of the deck by using one of a variety of techniques. Using a non-slip agent suspended in a clear ‘varnish’ is a popular option and the simplest to achieve. International Paints one-pack product “Intersurf” works well but requires renewing when it wears away. Another option is to use Hempel’s Glass Pearls which can be added to Ultravar 2000 two-pack polyurethane varnish and applied evenly over the surface. This technique has a finer texture than “Intersurf” and lasts longer. Many professionally built boards use sugar granules to provide non-slip qualities. More accurately it is the impression left in wet resin by the sugar crystals. The sugar is distributed over the deck into wet resin, the resin layer allowed to cure and then the sugar removed by dissolving in water. Another, and probably the best method for achieving a non-slip finish is to use Peel Ply.

Peel Ply is a silicone-free nylon woven fabric which will not adhere to the epoxy coating but which will leave its ‘print’ when removed from hardened resin. Peel Ply is best laminated as an extra operation onto the sanding coat. The boundary of the non-slip area should be masked-off and the Peel Ply cut slightly oversize to just overlap the tape. The SP 115 resin mixture should be applied with a brush followed up by a squeegee to avoid air entrapment and wrinkling. When the resin has cured the Peel Ply film can be ripped off to leave a non-slip deck area.

Schedule for Using SP 115 Epoxy Laminating System with Estimated Resin Quantities

The following table applies to constructing a typical 2.9m board using a polystyrene blank and plain weave E glass.

Total Approx. SP 115 resin system (resin and hardener) 3.23 litres

An additional 400-500ml of SP 115 resin system and 1 x 0.3kg pack of SP Glass Bubbles will be required if fitting the wooden stringer.

Notes:

Sealing the blank with a resin mix is recommended when using bead type polystyrene. If a PU or Styrofoam foam blank is being used, sealing is unnecessary - paint is usually applied directly to the foam followed by a sealing “lacquer” (e.g. ICI "Clearcoat") which is allowed to dry thoroughly before laminating the following day.

Day	Operation	SP 115 Resin (ml)	SP 115 Hardener (ml)
1	Deck seal Bottom seal	300 100	120 40
	Air brush		
2	**Bottom Lamination** (2 layers 210g/m^2 E glass)	575	230
3	Abrade rails & overlap area **Deck Lamination** (3 layers 210g/m^2 E glass)	850	340
	Deck Sanding Coat		
4	Sand bottom **Bottom Sanding Coat**	400	160
5	Fit fin boxes Sand deck Sand bottom **Bottom Gloss Coat**	300	120
6	**Deck Gloss Coat**	350	140
7	**Finishing** Sand and polish or sand & apply 2-pack polyurethane gloss		

Advanced Construction Techniques

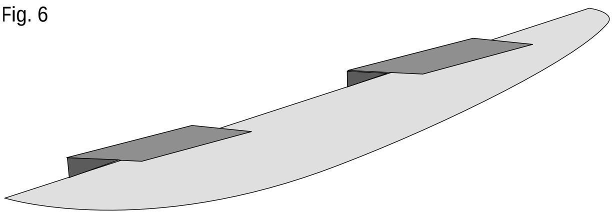
This section of the guide has been written to explain the use of more advanced methods currently being used by the world’s top custom constructors.
It is split into three parts:

Core Materials **Stringer Shape** **Sandwich Skins**

Core Materials

The use and advantages of polystyrene foam as a core material for a board has already been discussed. However, instead of using a homogeneous core material in your board you may wish to increase the strength in areas of high load and decrease the strength, and associated weight, in areas of low load. This can be achieved by the use of foam of different densities. High density foams are naturally heavier, but have higher strength and impact resistance. Common usage of this type of foam is to strengthen the core in way of the fin and mast boxes, as shown in Figure 6.

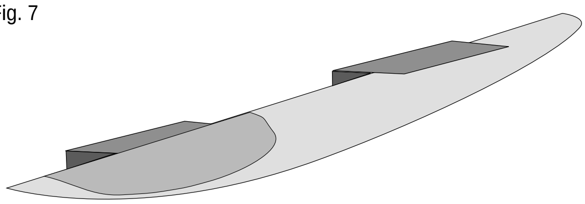
Fig. 6



Core reinforcement using PVC foam inserts to strengthen mast and fin boxes.

The type of high density foam used is usually a closed cell PVC foam such as the Divinycell, Airex, or Klegecell brands at 50-80kg/m^3 density. In way of the fin box and mast track these high density foam patches may pass completely through the depth of the blank so as to contact the skins in the finished board. Having excavated a hole through the finished blank, the high density foam may be bonded in with SP 115 resin system mixed with SP Glass Bubbles, Colloidal Silica, or SP Microballoons. The patches may then be finished to fair in with the blank top and bottom. Take care in sanding across the joint between the two foams as the lower density foam will abrade more easily. The additional support provided by high density foam patches makes this well worthwhile for wave boards that are likely to encounter severe use.
Additionally, a 3mm deck patch of high density foam may be set into the deck as Figure 7 illustrates:

Fig. 7



Core reinforcement for mast, fin and foot-strap area

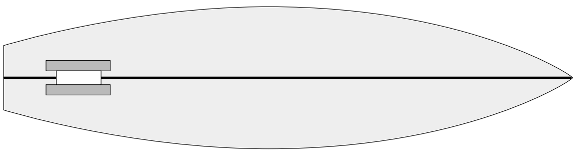
This is enough to prevent indentations from the heels of the rider when landing from high jumps, and from general compression of the core under normal use. A recess may be cut into the finished blank to the depth of the insert, and then the high density foam bonded in with a mix of SP 115 and SP Glass Bubbles, Colliodal Silica or SP Microballoons. The patch may then be finished to fair in with the blank.

Stringer Shape

Stringers not only provide a template to work to when shaping the blank but also act as a girder through the board to resist bending. An understanding of where the highest loads are exerted on the board leads us to design stringers to support these loads, which in turn result in a stronger and more durable board.

The most common form of stringer reinforcement is the 'woodie'. Two strips of plywood are laminated into the board from skin to skin, to support the fin box as illustrated in Figure 8. Again, this is only necessary for wave boards that are likely to experience extreme usage.

Fig. 8

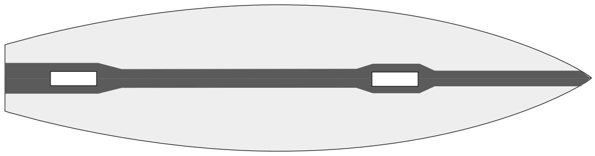


Woodies in a plywood stringered blank

Boards may be fitted with a single or double stringer. Some slalom boards which do not get any air time may even be designed stringerless in an effort to reduce weight. However, these boards are inherently fragile and should be treated that way, especially off the water.

Single stringers ranging in thickness from 1-3mm, are usually made of plywood in most amateur built boards and are usually untapered. However, a more advanced design would be to reduce the thickness of the stringer and hence its strength in areas of low stress and increase it in areas of high stress as Figures 9 and 10 illustrate.

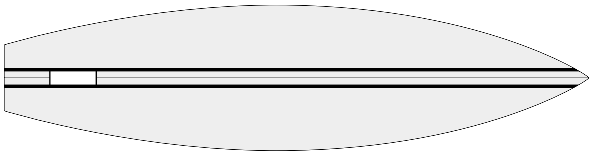
Fig. 9



Double Tapered Stringer

Alternatively, in a double stringered board, the stringers can be progressively tapered towards the nose, This is a good arrangement and one that works well with both plywood and high density foam.

Fig. 10



Double Tapered Stringer

As an alternative to the use of plywood or foam, a laminate of glass or carbon may be sandwiched between the two halves of the blank. This is the lightest possible method of stringering a board. However, you may wish to place additional support in the mast and fin box areas using high density foam as already discussed.

Sandwich Skins

In larger boards, such as slalom and race boards, it will usually be preferable to skin the entire board in a high density foam. This adds stiffness and impact resistance to the board, and cuts down on the number of laminate plies needed to maintain adequate skin stiffness and compressive strength. For example, on an advanced slalom board the laminates would be as follows:

Element	Laminate Layers	Material Type
Deck	RE165 RA175	Woven E glass (165g/m^2) Woven aramid (170g/m^2) outer skin
	3mm High Density Foam RA175	45-80kg/m^3 density Woven aramid inner skin
Core	Polystyrene	Additional local high density foam in way of boxes
Bottom	RA175 3mm High Density Foam RE165	Woven aramid inner skin 45-60kg/m^3 density Woven E glass outer skin

The high density foam should be tapered out around the rails and replaced by a full length strip of RE165 E glass. In this way the strength is built by way of a sandwich, providing inherent stiffness, whilst retaining the impact resistance. The second example illustrates the combined use of E glass with different weights of aramid, together with a novel method for obtaining more localised strength in the deck of a successful Div.1 race board. See Figures 11 and 12.

Element	Laminate Layers	Material Type
Deck	*RE165 RE165 Epoxy 'syntatic foam' filler mix RA60 Sealing coat with Glass Bubbles	Woven E glass (outer layer) Woven E glass approx 400-500kg/m^2 Woven aramid (60g/m^2)
Core	Polystyrene with carbon Stringers	Approx. 20kg/m^3 unidirectional fabric
Bottom	Sealing coat with Glass Bubbles RA175 RE165	 Woven aramid Woven E glass (outer layer)

*RE100 (100g/m^2) can be used as a substitute but as this is an aerospace grade material, it is some 50% more expensive.

A polystyrene core was selected for its light weight and the surface first sealed with a coat of SP 115 epoxy and SP Glass Bubbles filler which was simply applied with a plastic scraper. The first ply of woven aramid reinforcement was laid after only a short interval (perhaps 30 minutes) whilst the sealing coat was still tacky. On the deck an additional epoxy 'syntatic foam' filler mix (up to 2mm thick) was applied over the fabric both to help obtain a smooth fair finish and to give additional compressive strength. The last layer of E glass was laminated with a white pigmented epoxy resin mix to minimise the necessity for paint build-up.

An epoxy filler/fairing mix was applied to the bottom to obtain a perfectly fair smooth surface. The mix consisted of SP 115 epoxy and SP Glass Bubbles, not too heavily loaded as the mix was applied using a foam roller.

Div. 1 race board

Fig. 11 *Bottom Laminate*

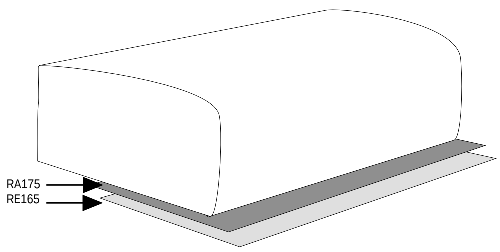
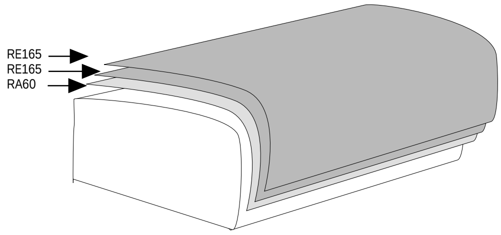


Fig. 12 *Deck Laminate*



All products referred to in this guide can be supplied by SP Systems or appointed distributors. Further information on the resins, fillers and reinforcements are obtainable from separate product data sheets or information guides supplied by SP Systems Technical Services.

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SP Systems therefore strongly recommend that representative test panels and component sections are built and tested by the user in order to define the best process and materials to use for the desired component. This should be done under conditions as close as possible to those that will be used on the final component.

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