Sheathing Wood with Glass Reinforcement

SP Systems

Composite Engineering Materials

Introduction

Although wood has excellent properties as a building material, peak performance can be achieved only when it is relatively dry, and protected with an effective coating scheme. “Sheathing” is the term used to describe a ‘heavy duty’ form of coating and is the process of bonding a woven glassfibre fabric onto the wood surface, using a thermoset laminating resin.

Being a relatively soft material, wood is particularly vulnerable to damage. Abrasion and boring worms cause direct damage while unchecked moisture absorption leads to degradation and rot. Whilst normal paints and varnishes do offer a reasonable amount of protection for limited periods, they are unable either to strengthen the wood or completely seal it. These coatings are also particularly prone to weathering and can easily peel away to leave unprotected bare wood.

The sheathing process effectively does 2 jobs in one go - it bonds the glass reinforcement fabric to the wood fibres and it seals the wood surface. Since the fabric used is a high strength structural material, sheathing can also strengthen and stiffen the thin plywood panels used to construct small boats and also give surface strength and protection to very soft timber (such as pine or cedar) on boat hulls or deck surfaces.

To be most effective, sheathing is only suitable for new or very dry and correctly prepared surfaces. Boat hulls using ‘modern’ glued construction (cold moulded, strip planked or plywood) which use low moisture content timber are generally the only types which are suitable for sheathing with epoxy. Boats of traditional construction, which rely on the wood absorbing moisture and expanding to form a plank seal, with or without caulking, should not be sheathed unless a complete rebuild can be undertaken, employing a glued form of reconstruction and an effective coating scheme.

An increasingly popular application is the sheathing of wooden centreboards and rudders which allows lightweight wood cores to be used. (See “SP guide to wooden foil construction”).

Sheathing can be either the more common ‘simple sheathing’ using woven fabric, or 'structural sheathing' where the form and extent of the fabric chosen complements the wood in producing a structure of the required strength and stiffness. Other types of fibre rather than glass may be used but a description of their use is not covered in this guide, which concentrates only on ‘simple sheathing’.

Epoxy resin rather than polyester (see a later section) has proved to be the most suitable and effective waterproof resin for sheathing wood and sheathing is now an acceptable part of the repertoire of wood boatbuilders and repairers.

Selecting the Correct Fabric

Fabrics (or cloths) are usually woven materials with warp and weft at 90° to each other. For general sheathing, isotropic properties are acceptable (same properties in both directions). Fabrics of between 165g/sqm-290g/sqm (or 5oz-8oz/sq.yd) are most common as they are easy to handle and can be used in multiple layers if necessary in areas requiring additional reinforcement. Unidirectional materials and some stitched multiaxial materials can also be used but their use is more specialized. Their specific fibre orientation and flat construction make them ideal for structural sheathing. However, for simple sheathing the following woven glass styles from the SP Systems range are commonly used:

Style	Weight (g/sqm)	Construction Type	Working Characteristics	Suitability for Clear Laminating Drapability
RE107P	105	plain	•	good
RE165T	165	2 x 2 twill	•••	good
RE210D	210	plain	•	very good
RE292H4Q	290	4-H crowsfoot	•••	blue tracers
WRE293H4Q	290	4-H crowsfoot roving	••	blue tracers

Drapability score

- • Moderate drape, gentle double curvature or flat surfaces only
- •• Good drape, good on multiple curvature but more difficult on flat surfaces
- ••• Excellent drape, well suited for compound curvature, difficult to handle on flat surfaces.

Cloth cards covering these and other styles are available from SP Systems on request.

Choosing the Most Suitable Resin Matrix

The first consideration is whether to use polyester or epoxy resin? Whilst polyester resins may be well suited for the construction of male and female moulded grp hulls, they are not recommended for sheathing wooden hulls. Polyester resin has neither the adhesive bonding strength nor the toughness of epoxy systems and hence a polyester resin skin added to an existing wood or grp surface may crack easily and peel away from the hull allowing moisture to penetrate. Although epoxy is more expensive it has proved the best resin for this application.

However not all epoxies are equally suitable. Some more viscous types may be better as glues whilst other types lend themselves more to this type of work. Although basic mechanical properties such as strength and temperature resistance are important, selecting an epoxy with the most appropriate working properties will allow you to carry out the work more easily. Table A reviews the epoxies from the SP range most commonly used for sheathing. These resins all have low viscosity for good penetration into the wood and effective wet out of the glass fibres; a choice of hardener so that pot-life and working time can be selected to match the application, good mechanical properties and the necessary moisture resistance essential for marine use.

From the range of possible SP epoxy systems - SP 106, SP 320, Ampreg 20, select a system which gives you the working time you require. This will of course vary depending on the area to be covered, the weight of fabric used, the air and hull temperature, and the number of operations involved.

Table A - SP Epoxy Resin Systems Commonly used in Glass Sheathing

Resin Hardeners	SP 106 R SP 106 HF SP 106 HSL	SP 320 R SP 320 HF SP 320 HSL	Ampreg 20 R Ampreg 20 HF Ampreg 20 HStd Ampreg 20 HSL
Rec. hardener for general sheathing @ 15-25°C	SP 106 HSL	SP 320 HSL	Ampreg 20 HStd
Gel time (mins) 150gm @ 25°C - Fast: - Slow:	14 24	17 40	15 HF 45 HStd 190 HSL
Approx. thin film working time (hrs) @ 20°C - Fast: - Slow:	1.5 3.5	2 4	0.5 HF 1.5 HStd 4.5 HSL
Mixed viscosity (cps) @ 25°C - Fast: - Slow:	1260 862	773 647	1680 HF 865 HStd 447 HSL
Colour stability - suitability for clear laminates	Poor	Good	Poor
Comparive wet-out performance with E glass fibre	Fair	Good	V. Good

Key: R = Resin; H = Hardener; F = Fast; Std = Standard; SL = Slow

The Working Environment

The importance of having the correct working environment cannot be overstressed and therefore every effort must be made to ensure that the work is carried out in conditions that are appropriate to the resins used. All SP epoxy systems are designed to display their best working characteristics within a temperature range of 18°C - 25°C. When the working temperature is too low then the viscosity of the resin/hardener mix is too high making it difficult to use. At low temperatures the following undesirable effects will be noticed:

- The resin and hardener do not mix effectively and the air bubbles introduced during stirring do not disperse
- Excessive quantities of resin will be used due to high viscosity
- The resin system will be slow to cure
- Excessive by-product on the resin surface will be apparent

Working indoors with adequate heating is the ideal situation, but this is impractical for many people working on boats in the UK in Spring. For many sheathing operations, erecting a plastic tent and installing electric fan heaters is effective. Certainly storing the resin and hardener near a source of warmth prior to use is most important. The resin should be easily dispensed without undue pressure on the pump system (if used). It should not be of the consistency of 'treacle'.

An electric hot air gun is indispensable in these situations both for warming small mixes and to help to obtain better resin penetration into the wood and into the glass fibres.

Which Hardener to use?

- For small sheathing operations, eg: centreboards and rudders, Fast hardener will usually give enough working time.
- For sheathing decks and hulls, SP 106 or SP 320 with Slow hardener is more appropriate.
- When carrying out the work in summer or in temperatures in excess of 20°C, use SP 320 epoxy with Slow hardener or Ampreg 20 epoxy with Standard hardener.
- At higher temperatures (eg 25°C-30°C) use only Ampreg 20 epoxy but change the hardener to the 'slow' type.
- For coating under 25°C use any system with Fast hardener
- For over 25°C a slower system may be preferable depending on precise application.

Procedure for Glass Sheathing

1. PREPARATION

Sand the surface to be sheathed with 60 - 80 grit paper at an angle to the grain direction; this will increase the surface area and promote good bonding.

Fill in all screw heads, hollows and voids with an epoxy filler based on either SP 106, SP 320, Ampreg 20 or Spabond 120 epoxy system with added filler powders (usually microballoons or glass bubbles with the addition of a smaller quantity of colloidal silica). Alternatively use SP Systems formulated epoxy filler S'Fill 400. Avoid using polyester based fillers such as car body filler as this may affect the curing of the epoxy.

Radius all external angles and corners with at least a 4 mm radius. Fillet all internal corners with an epoxy filleting mix. See SP Bonding Guide.

When the epoxy filler has hardened, sand thoroughly with 40 - 60 grit paper and clean the surface with SP Solvent A (Fast Epoxy Solvent) or Acetone.

2. APPLICATION

There are two basic methods of sheathing, the 'dry' and the 'wet' methods. The dry method is the application of fabric to a pre-coated and sanded epoxy surface or a dry wood surface. In either case the resin is introduced, a small amount at a time, through the dry fabric. The 'wet' method is laying the fabric onto 'wet' epoxy resin.

Which Method to Use?

i) **'Dry' method -** the preferred method for decks and inverted hulls. Faster hardener can be used as the operator can work at his own pace. Ideal for one person. Can give higher quality results but is overall a slower process.

ii) **'Wet' method** - the only method which can be used when working overhead or on upright panels. Requires more attention to resin working time and selection of a suitably slow hardener. At least two operators are required, and usually 3 or 4 when sheathing 20 - 30 ft hulls. This method can save time for the complete operation.

i) The Dry Method of Glass Sheathing

For the best results it is usually better to pre-coat the wood with one or two coats of epoxy first, allow to cure and sand thoroughly with 60 - 100 grit paper, used preferably wet, before laying the fabric. Although this takes longer it has certain advantages particularly if the wood is noticeably absorbent. The fabric can be moved about without 'snagging', since the surface is smooth, and more attention can be given to obtaining enhanced penetration of the resin into the wood. However the effectiveness of this technique does rely on efficient sanding and thorough preparation of the epoxy coating before starting to use the fabric.

Laying glass fabric on a dry uncoated wood surface (held with staples if necessary) and working resin through with a squeegee can be very effective when using lightweight open weave fabrics eg: RE210D (210g/sqm) but is not recommended for heavier cloths as there is a risk that insufficient resin will pass through the fabric and penetrate the wood fibres. It is assumed therefore that most sheathing will be carried out on a pre-coated and prepared epoxy surface when working on a vertical or overhead surface.

Procedure

Cut the fabric into workable lengths and roll temporarily onto a cardboard tube. Place the fabric strips in position - staples can be used to hold temporarily into position. Mix only sufficient resin and hardener for the piece of fabric being laid and pour over the cloth in small 'puddles'. Use a plastic or rubber squeegee to work the resin into the fabric to wet out thoroughly without any excess. Avoid 'floating' the fabric on the resin. Aim to use just sufficient resin to wet out and remove any excess. If the air temperature is slightly cold or the fabric is not wetting out quickly, a hot air gun passed occasionally over the surface of the fabric and 'pools' of resin will greatly help wetting out speed and eliminate any trapped air.

Aim to:

1. Wet the glass fibres thoroughly - do not leave any 'white' areas
2. Use the minimum amount of resin. This is indicated by the appearance of a semi-matt finish effect to the surface. There should certainly not be any 'glossy' areas.
3. Remove any trapped air with a squeegee.

If working on dry, uncoated wood it is most important that the work surface is pre-warmed before starting to laminate in order to avoid expanding air being released from the wood fibres. This can cause voids under the glass which are both unsightly and will reduce strength. If the wood surface is sealed with epoxy before laminating air cannot be liberated from the wood in this way. This is a major advantage of pre-coating the timber.

If the surface is to be clear finished then take special care to obtain a transparent effect using only the lighter glass fabrics (up to 210 g/sqm). For optimum quality we recommend storing the glass in an airing cupboard or warm room before use. It is important to remember that clarity will diminish as further layers are used. On sloping surfaces apply the resin with a foam roller or extra short pile (non-mohair) roller.

ii) The Wet Method of Glass Sheathing

This method requires organisation, speed and coordination between the operators. It is the *only* method which can be used for applying fabric to an overhead or vertical surface since the adhesion power of wet resin is used to hold the fabric in position. The wet method is also used with heavy reinforcement materials in 'structural sheathing' which require wetting from underneath to avoid air entrapment. Sometimes these fabrics may be pre-wetted and rolled before application to the hull.

Procedure

Firstly determine the area of hull or deck which can be treated whilst the resin still remains thin enough for wetting out . Usually it is best to apply resin to an area equivalent to no more than two widths of fabric. Whilst one person meters out, mixes and pours the resin into a tray, two others measure and cut the fabric required. Once cut, roll the fabric onto a cardboard tube for easy handling. Roll the resin onto the section to be sheathed. A 'slow' hardener is nearly always used here and it is important to know how much time the operators have to lay the fabric before the resin starts to gel. Consulting Table A is very important so that the right resin/hardener mix is selected. Lay the fabric accurately into the wet resin, lightly at first so that a little adjustment can be carried out, then consolidate down with squeegees or rollers until it is wet out thoroughly.

Sometimes, in order to save time when sheathing, relatively small areas of the hull can be pre-coated with a fast hardener mix allowed to gel slightly and then immediately overcoated with a slow hardener mix into which the fabric is laid. This technique has been used successfully for sheathing large wooden craft up to 80ft.

How to Lay the Fabric - Longitudinal or Vertical?

Whatever application method is chosen some thought must be given to the best way to lay the fabric with the fewest overlaps or joints. Where possible, on hulls lay the fabric fore and aft so that all joints are parallel to the waterline. This is easiest on multihulls and powerboat hulls which have more parallel sections. Overlap the fabric in the keel area starting here first. Inverted hulls are relatively easy to cope with in this manner but on larger hulls which are the right way up it is easiest to carry out the sheathing procedure by laying and applying the fabric in a vertical or transverse direction. Gravity will help the fabric to hang so start by fastening the material to the highest point and unroll gradually down towards the keel level. On a powerboat with spray rails in place the only way is to lay the fabric longitudinally dealing with the rails themselves first. Again use the fabric, pre-cut to the correct width, from a cardboard roll. Sometimes the rails can be removed which makes the operation easier and the fabric may then be laid vertically if preferred.

Overlaps and Trimming

Unless the hull is being sheathed for structural reasons a butt joint is all that is required. First overlap the previous piece of fabric with the new edge and consolidate the two together. Next, wait until the resin has gelled slightly and cut down the edge of the original overlapped piece, which is visible, with a sharp knife. Wearing gloves, take hold of and peel back temporarily the top overlapping edge of fabric. Remove the cut strip underneath and press back the top layer to form a perfect butt joint. The fabric is easiest to trim using a knife or sharp scissors when the resin is partially cured but not hard.

3. THE NEXT STAGE - USING PEEL PLY

Peel ply is a very important part of the sheathing process. Peel ply is a closely woven nylon fabric to which resins will not adhere. When used on top of any laminate and incorporated into the laminate *whilst the resin is still wet,* peel ply performs four important functions:

- Helps uniform consolidation of the reinforcement fibres.
- Protects the exposed resin surface of the laminate from air and thereby prevents the formation of surface by-product.
- Allows excess resin to be removed by squeegee action, moving the resin up between the peel ply fibres.
- Gives an evenly textured finish to the laminate which is ideal for bonding further plies of glass or any bonding, coating or filling operation.

Ideally peel ply should be used for all sheathing work, when using epoxy resins. If peel ply is not used, then in order to avoid sanding through any glass fibres, another one or two coats of resin must be applied. The decision to be made is whether the cost of the peel ply is outweighed by the price of the additional resin and the labour intensive stage of sanding it. Whereas peel ply gives the ideal surface for subsequent operations, sanding can never represent as good or as thorough preparation. For these reasons using peel ply is regarded as a necessary part of any high quality sheathing or laminating work with epoxy systems. The additional cost of material is usually more than compensated for by the labour savings it brings about and therefore *its use is strongly recommended.* Epoxy surfaces are never considered to be easy to sand - peel ply simply eliminates the need for it.

How is Peel Ply Used?

Peel ply is applied as the last stage in the laminating procedure when the resin is still wet. Cut the peel ply slightly oversize and lay in the wet resin without stretching. Use a squeegee to consolidate down. A little more resin may be needed to wet out the peel ply (about 70 g/sqm). Continue the consolidation with a squeegee until fully wet out. Remember to leave an unwetted area at the edge of the peel ply and off the edge of the laminate to get hold of. When cured the peel ply must be removed. Simply hold one corner and pull it away. This can be done at any time. In fact peel ply is often left in place for as long as possible to protect laminates. The excess resin on the surface of the peel ply and between its fibres will be removed when it is ripped away, and this will leave a textured surface which is a 'print' of its woven construction.

Overcoating the Laminate if Peel Ply is not Being Used

If peel ply is not used, the laminate must be sanded thoroughly before proceeding to the next stage. However, the glass fibres may be easily damaged by the abrasive paper and the surface will first have to be degreased so that the sand paper will not become clogged. Both these operations can be overcome by overcoating the laminate with one or two protective coats of additional resin mix whilst the laminating resin is still tacky. However, this is not as simple as it seems - timing is critical.

Application must be at the soonest opportunity, do not leave it until the underlying resin has gelled otherwise there is a risk of poor adhesion. Why is this? The reason is that epoxy coatings usually develop surface by-product during curing. The amount which develops is dependent on cure conditions. In warm, dry conditions it is minimal, but in cool damp conditions it develops readily at an early stage to form a discernable 'greasy' or 'tacky' layer over the surface. This layer will prevent adequate bonding of any filler, paint or resin to the surface on which it is found.

Sometimes the overlying resin is mixed with pigment to give a colour base before applying a high build primer. However, more usually, a thin filler mix is applied at this stage using glass bubbles or microballoons (with colloidal silica if required).

MATERIALS REQUIRED

The following procedure should be followed for estimating the quantities of materials (resin and glass) to be used for any sheathing work:-

Estimating Glass Usage

Calculate surface area - then add 20% to give the total area of glass which will be used including wastage.

Estimating Resin Usage

As the text shows, there can be various, different procedures for sheathing wood using either 'wet' or 'dry' methods, with peel ply or without peel ply. The resin required at each stage in the process should be calculated and added together for a total. The stages are:-

1. Resin to bond glass to wood
2. Resin to wet out glass adequately
3. Resin to provide a protective layer on top of the glass.

The following quantities relate to the resin required when sheathing with 210g/m^2 plain weave glass (RE210P or D).

Stage 1	-	Resin for surface pre-coating as a preliminary to dry sheathing	0.16kg/m^2
Stage 2	-	Wetting out glass fabric on pre-coated wood	0.2kg/m^2
		or	
	-	Wetting out fabric on bare wood	0.4kg/m^2
Stage 3	-	Resin for filling coats (if peel ply not used)	0.16kg/m^2
		or	
	-	Resin for wetting out peel ply	0.07kg/m^2

Add 15% extra for resin wastage to obtain the final figure.

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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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