



# Epiglass®

Multipurpose Epoxy Resin



## **ROGER MARSHALL**

For eight years award winning author Roger Marshall has been the technical editor for Soundings magazine where his articles are read by about 250,000 people each month. Marshall's experience as a writer spans for many years. His work has appeared worldwide as well as the New York Times, Daily Telegraph (UK), Sports Illustrated, Sail, Cruising World, Motor Boating and sailing, Yachting and many other newspapers and magazines. Marshall is also the author of twelve marine related books, two of which were translated into Italian and Spanish. His last book All about Powerboats was published by International Marine in the spring of 2002. He has another book Rough Weather Seamanship due in the fall of 2003 and is currently working on a new book, Elements of Powerboat Design for International Marine.

But writing is only a small part of Marshall's talents. He is also a designer of boats, both power and sail. After completing a program in small craft design at Southampton College in England, Marshall, who still holds a British passport, moved to the United States in 1973 to take a position at Sparkman & Stephens, Inc. in New York. He worked there as a designer for nearly 5 years and then left to establish his own yacht design studio in Jamestown, Rhode Island. As an independent designer he has designed a wide range of boats and was project engineer for the Courageous Challenge for the 1987 America's Cup campaign in Australia. In 1999 one of his cruising yacht designs was selected for inclusion in Ocean Cruising magazine's American Yacht Review.

Marshall has extensive sailing and boating experience. He has sailed at all levels including 12 metres and Admiral's cup boats (once with the British team on Qualio III, another time for the British team aboard Prime Minister Heath's Morning Cloud, and once with the Japanese team). He has also sailed in many world and national championships, in the half-ton worlds as the lone British entrant, 10 Bermuda races (twice with the British Orion Patch team), and 5 Fastnet races (twice with the British Admiral's Cup team, and the 1997 Atlantic Challenge from New York, to Falmouth, England, placing third. He has cruised on both power and sailboats in many parts of the world, especially the European, Mediterranean, and North American coastlines.

He has also built his own boat and is currently rebuilding an eighteen-foot Seacraft centre console, using Epiglass® and other International Paint Products.

## **KEITH RYMAN**

Keith Ryman is International Paint's Technical Manager for Australasia and has been involved with the marine industry for over 25 years.

Keith left university after gaining a degree in chemistry and computing and sailed from New Zealand to Hawaii on a plywood yacht and decided this was the industry he wanted to be in. Since starting work in the New Zealand laboratory to Hawaii on a plywood yacht and decided this was the industry he wanted to be in. Since starting work in the New Zealand laboratory he has been involved with formulating many unique products for the yacht industry and the industrial sector, involving constructional products as well as surface coatings and antifouling based on a wide range of chemistries including polyurethane, epoxy, polyester and vinyl ester.

Keith has also been involved in numerous epoxy composite constructions over the years dating back to New Zealand's first Americas Cup campaign, the so called Plastic Fantastic boat which was constructed from the HT9000 (Epiglass Epoxy). He has also formulated specifically for the Asia Pacific market a high tech wet layup post curable epoxy resin laminating system. Keith has built two small sailing craft and is currently involved with putting Epiglass® Epoxy into the air by way of building and flying a variety of large performance light weight radio controlled model aircraft using carbon fibre, glass cloth and Kevlar® construction.

## **KEN HICKLING**

After training in Yacht Manufacturing and Boatyard Management at Southampton UK, Ken Hickling spent four years working for epoxy experts SP Systems working with Marine and Automotive systems. Prior to this he has worked in boatyards and marinas in Cape Cod, USA and Emsworth, UK. After starting in 1994 with International as a Product Manager he was responsible for the introduction into Europe of the highly successful New Zealand epoxy system; Epiglass. After spending three years in North America working on Superyachts and as International Marketing VP he returned to Europe to manage Southern Europe which include the prolific superyacht building nations of Italy and Turkey. In the latter, Epiglass has been used for new buildings of wooden superyachts up to 32m in length.



## INTRODUCTION

**This application guide is designed to give information on how to get the best results using Epiglass® Epoxy. It is also designed with the professional user in mind.**

Epiglass has always been at the forefront in the supply of epoxy resin products to the marine industry. As far back as the 1950's, Epiglass resin technology was amongst the first to be developed in New Zealand specifically for marine use.



Since this time, International has developed new, easier-to-use products with an even higher performance. These products have been relied upon in the most demanding environments, including the America's Cup and Volvo Round the World races.

International has consistently set new standards of performance in Epiglass epoxy resins through a total commitment to research and manufacturing quality.

For those just starting to use epoxies, Section 1 is a must. The underlying principles of epoxies, coupled with an introduction to the various uses and components of the system are covered along with a glossary of common terms.

The more advanced user familiar with this type of product will find Section 2 most valuable.

Discussion of use of the system for various projects and some special application notes will give insight into how Epiglass can be an important part of boatyard activity. The section includes the ways that Epiglass Epoxy combines with the rest of the range to give total project approach.

For semi-production and custom boatbuilders, Section 3 is probably the most useful. Here the use of Epiglass in both composite and wooden building is covered along with a glossary of terms, and some discussion on choice of laminate reinforcement fibres and wood construction types.

Osmosis continues to be a challenge for boats made with polyester resin, and Epiglass Epoxy can be the best solution; turn to Section 4.

In Section 5 you will find all the facts and figures as well as safety information and frequently asked questions, including where you can use Epiglass away from the boatyard.

We hope you will find this guide useful and if you need further assistance, please contact International technical service.

**ROGER MARSHALL**

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# 1

## 1. Epoxy Basics

### THE EPIGLASS EPOXY RESIN SYSTEM

Epiglass Epoxy is a resin system that can be used to bond two materials together. The materials can be wood, fibreglass, metal, and many plastics. Epiglass Epoxy is a resin that thinks it's a varnish, a filler and a glue. It can be used to repair older wooden boats, to repair Fibreglass boats, to coat wood like a varnish for good protection against the elements, to glue two dissimilar materials together, or simply as protection against osmotic blisters on the outside of a Fibreglass hull. It can be thickened with the addition of various powders and fillers to enable it to be used as a filler of holes, large and small. It is water-resistant when cured and is part of the International family of high-quality coatings. In short, Epiglass Epoxy Resin is a highly versatile and effective resin system with a myriad of uses.

### WHAT IS EPIGLASS?



Epiglass Epoxy Resin is a polymer-based material. It comes in two parts; part A (the resin) and part B (the hardener). The hardener must be mixed with resin to effect a cure at a 4:1 ratio (by volume). There are some one-part epoxies, but Epiglass needs the addition of the hardener before it can be used. Epiglass is a light straw colour with a light sheen to it. When the hardener is mixed with the resin a chemical reaction takes place that makes the mixture harden. Once hardened, it can never become liquid again. The polymer is a 'thermoset' plastic because heat is given off during the chemical reaction.

The chemical reaction forms a three-dimensional cross-linked matrix that gives the epoxy its spectacular strength.

### WHY ARE THERE 3 HARDENERS?

Epiglass offers a 'fast' hardener that sets up within ten minutes or so, and a 'standard' hardener used for larger jobs that might take 20 to 30 minutes to set up. There is also a slow hardener available for use where an even longer working life is required, e.g.: in hotter climates.

Epiglass hardeners can be mixed together to get intermediate stages of cure. Mixing two hardeners together to adjust the cure rate will not necessarily give you a linear difference in pot-life or cure time. You will need to experiment with the faster and slower hardeners to adjust the cure rate. For example, you need less fast hardener and more standard hardener to slow the cure rate to about half. By adjusting the ratios of fast and standard hardeners carefully you can get set up rates that vary from about ten minutes to thirty minutes or more. **Do not, however,**

**vary the ratio of hardener to resin.** With Epiglass, these ratios are four to one by volume. Also, do not mix hardeners from other manufacturers with Epiglass. Other manufacturers have different resin to hardener ratios and may have a different chemical composition than Epiglass hardener.

Typically, small jobs require the use of fast hardener, allowing you to put the parts together, clamp them, and walk away. For larger jobs that require the application of large areas of epoxy, standard hardener allows you to coat the surface, apply the laminate, and get the job set up before the epoxy starts to cure. If the job starts to cure before all the materials are in place, the best option is to remove the partially cured material, let the cure finish, sand everything back, and start over.

## **DIFFERENT STAGES OF CURE**

When you mix epoxy resin and hardener properly, the setting process is initiated. This process is irreversible and will continue until the mixture is set hard (cured). But during the curing process the material goes through several stages.

### **A-STAGE**

The first stage, sometimes known as the A-stage, is when the chemical reaction is just starting. As the chemical reaction takes place, heat is generated, but if the resin mix is spread over a large surface, any heat dispenses harmlessly into the atmosphere. The Epiglass Epoxy Resin mix can be used and applied during this stage. If the mixture is held in bulk, the heat may become too great, prematurely curing in the pot. This is often referred to as an exothermic reaction.

### **B-STAGE**

B-Staging of an epoxy resin is that point at which the resin will not cure any further without the addition of heat. This is caused generally by the individual molecules not having sufficient energy to fully cross link. It mainly affects heat cured epoxy resins where, if insufficient heat is applied, the mix does not cure far enough to generate any useful mechanical properties. Such properties are utilized in some pre-pregs where the end user applies further heat to fully cure the resin. Room temperature cured epoxies used well below their designated curing temperature range will B-Stage to varying degrees. Once the temperature is raised to the epoxies required curing temperature range then the reaction will proceed further.

### **ALMOST TACK-FREE**

At this stage an additional coat of epoxy can be applied to the first and it will still chemically bond to the original layer. At the almost tack-free stage fingerprints can be left in the surface without any stickiness but most of the material is hard. This stage is also known as 'tacky' and is the last stage at which new epoxy can be applied and get a good bond.

### **TACK-FREE**

At the tack-free stage touching the surface leaves no mark. Typically this is 3 to 6 hours after the mixture has been spread. Even though the mixture feels cured, it will take another 24 hours to one week to gain 80 to 90% of its strength. This stage is sometimes known as 'hardening'.

### **MINIMUM SANDING TIME**

The minimum sanding time is important to know for a job that needs to be done quickly. With Epiglass the minimum sanding time is about 12 to 24 hours. By applying heat the minimum sanding time can be reduced.

### **CLAMP TIME**

After this time the piece can be released from any clamps or assembly jigs. Full strength has not been achieved, so care must be taken when handling and full loads should not be applied.

## **DE-MOLD TIME**

Similar to clamp time. After this point, a component can be removed from the mold without high risk of damage or distortion.

## **FULL CURE**

Epiglass will have most of its strength in about a week after it has been applied unless post curing has occurred. However, this time can vary according to the temperature and humidity levels under which the epoxy is curing. The epoxy should not be put under load during this time because the epoxy may not have achieved full strength.

## **THE ADVANTAGES OF USING EPIGLASS**

Epiglass is part of the entire International family of coatings and as such is compatible with the entire line of fairing compounds, primers, bottom paints, and topside paints. This is a major advantage when building a wooden or fibreglass boat where some epoxies may react with the primer or topcoat. The cure rate of Epiglass can be adjusted to suit the job. Epoxies, in general, have a more gradual cure process as they change from liquid resin to solid, than poly- or vinylester, making them easier to use. They are also stronger than these resins and have additional health and safety benefits. Epiglass Epoxy is styrene free which does not involve the use of dangerous peroxides, and represents a lower fire risk and environmental impact as it has no VOC's. Epiglass is easy to use, and comes in a number of different sizes, with various different extender powders.

Epiglass HT 9000 is available in a variety of convenient pack sizes, suited for projects or restoration jobs. Special calibrated pumps are available to enable exact measurement of the required amount every time.

When mixing Epiglass, mix only that amount of resin that you can use within the pot life time. Mixing larger batches often means increased wastage. When mixing a large batch in a pot beware of heat build-up in the pot. Heat build-up indicates that the material is curing and will soon be unusable. When mixing large batches pour the mixture into a shallow flat container such as a paint tray to prolong its working life.

## **EPOXY TERMINOLOGY**

### **AUTOCLAVE**

An autoclave is used to apply heat and pressure to the job as it cures. By applying heat and pressure the mechanical and thermal properties of the cured job are increased.

### **AMINE BLUSH OR BLUSH**

Blush is a shiny, slippery wax-like layer formed on top of the resin as it cures. It usually appears in slightly moist conditions and can clog sandpaper. It does no harm and can easily be wiped away with warm water and a soft pad, such as Scotch-Brite or a reasonably hard sponge. If you must sand a surface coated with amine blush, wet sanding will best remove the blush without clogging your sandpaper. The blush will have to be thoroughly removed before applying any paint as it may be otherwise impair adhesion of subsequent coatings.

Amine blush is a by-product if a reaction between the curing agent and moisture in the air. The chances of it occurring can be greatly reduced if the working environment can be kept warm and dry. This keeps the reaction between the curing agent and base moving faster than the secondary reaction with any moisture in the air.

## CLEANING

Always clean tools, brushes and other equipment immediately after use. Cured epoxy is very difficult to remove. If epoxy gets on your skin or clothing remove it with a rag or towel and a proprietary hand cleaner. You should not use solvents to clean epoxy off skin. Epoxy can be left to cure on flexible plastics and then cracked or broken off.

## CURE TIME (See also pot life)

Cure time varies according to the mixture and the type of hardener used. Epiglass has a thin film working time of 1 to 2 hours using fast hardener and around 2 hours using the standard hardener. Slow cure has a working time of 3 to 4 hours at 75°F (25°C). Cure time can be accelerated by raising the temperature to make the resin sandable in about four to six hours, but usually 24 hours should be allowed for a full, sandable finish. Full cure is only achieved after about 1 week.

## HARDENER

Often listed as Part B of the resin mixture. It is mixed with the resin to make it cure.

## HARDNESS

A fully cured resin is hard. A quick and dirty method used to check the cure of the resin is to press a fingernail into the resin to see how far it penetrates. If the resin is soft, it is not fully cured.

## MIX RATIO

The ratio of resin to hardener. Usually quoted by volume. Due to the different density of base and hardener, the ratio by weight is always different. So if you want to mix by weight, contact your local International support team. Epiglass uses a 4 to 1 resin to hardener ratio by volume. Different manufacturers use different ratios, so don't use anyone else's dispensing equipment with Epiglass Epoxy.

## MIXING



Resin Mix

Low Viscosity Mix

Filler Mix/ Fairing Mix

High Viscosity Mix

The resin and hardener should be mixed completely before any additives are added to the mix. In general, assume it takes one to two minutes of hard mixing to get the materials fully mixed.

## POST CURE

By raising the temperature after the resin has partly cured, increased strength properties can be obtained. There are three components to a post cure cycle: how fast you increase the temperature, how long you apply the heat, and how fast you let the job cool down. As a general rule, increasing the temperature by 1 - 2°C per minute and decreasing it at 3 -5°C per minute is safe. Too fast and distortion can occur. If wood forms a part of either a mold or the object being post-cured, slower speeds should be used. Once the post cure temperature has been achieved, the duration of the post cure will be dependent on the temperature. As an example, at about 40°C post cure should be for 16 hours, about 50°C for 8 hours and about 80°C for 5 hours.

## **POT LIFE**

Pot life is the amount of time a specific mass (usually 100 or 150 gm) of resin remains a liquid at a specific temperature (22 to 25°C). The pot life for 100ml of Epiglass using 'standard' hardener is 28 to 32 minutes depending on temperature. Using 'fast' hardener the pot life is 12 to 16 minutes. Higher temperatures help the mix cure faster, while lower temperatures slow it down.

## **PROPERTIES**

Epiglass is an engineering material. The mechanical and thermal properties are important for designers and builders. These are discussed in more detail in Section 5.

## **RESIN**

The resin mixture usually contains the epoxy resin and an accelerator. It is often listed as Part A and must be thoroughly mixed with a hardener before it can be used.

## **TEMPERATURE**

You can accelerate the resin curing time by increasing the heat applied to the job. Likewise you can lengthen the curing time by reducing the heat applied. Epiglass is usable over a wide range of temperatures from 10 to 35°C. Fast cure will even cure at temperatures down to 5°C. However, application properties are always better at temperatures of 10°C and up. The ideal is around 21°C. See 'Working Temperature'. In general, the lower the temperature, the slower the cure time.

## **VISCOSITY**

Basically, viscosity is the runniness of the resin. A low viscosity resin such as Epiglass, has a thickness similar to maple syrup or salad oil. Low viscosity resins have good penetration into fibreglass laminates and scrims. They spread well and can be easily rolled out. Epiglass also has a slightly higher thixotropy than many slow viscosity resins. This equates to the 'hold up' of the resin and helps prevent the epoxy from draining out of thick laminates. Higher viscosity resins have viscosities more like ketchup or salad dressing. They do not penetrate into fibreglass scrims as well, nor do they run into joints easily. Low viscosity resins can be easily thickened to the consistency of peanut butter by adding various extenders such as glue powder, wood powder, filler powder, or fairing compounds. Ambient temperature will also affect the viscosity of the mix. For example in cooler conditions the mix will appear like ketchup, whilst in warmer temperatures the same mix will appear more like salad oil.

## **STORAGE OF EPIGLASS**

Cold is the enemy of epoxies. Storing epoxies in a cold environment thickens the resin and hardener, making them difficult to measure and to pour. In extreme conditions, crystallisation may occur. To reverse this effect, gently heat the resin to about 25 to 30°C by putting the pack in a bath of warm water. Epiglass works best when the temperature is around 21°C. If you store your epoxy in a cold area, the night before you use it, move it to a warm area to allow it to warm up. If you have no method of warming the epoxy, you can place it in a wooden or metal insulated box with a light bulb or two to keep it warm and ready for use.

## WORKING TEMPERATURE

While Epiglass can be used in temperature as low as 10°C, it is best used at the same temperature at which humans feel comfortable 21°C. If the ambient temperature cannot be easily increased, a heat lamp or some other form of localised heating can be used to accelerate the rate of cure.



Epiglass has lower viscosity than many other resins on the market. This gives better penetration and wet out of fibreglass materials. Larger circles for the Epiglass (on the right) shows how easily it penetrates a 510g woven roving.

## HOW TO MIX & USE THE EPIGLASS EPOXY RESIN

Joining materials together using epoxy is relatively easy provided certain precautions are taken. Just like you would not paint over a surface with flaking paint, epoxy surfaces should be clean, oil-free, and ready to be glued. If you glue two previously painted surfaces together, the strength of the joint is not in the strength of the epoxy, but in the strength of the original paint. Consequently, to make the strongest joints it is best to join unpainted, uncontaminated, dry, and clean surfaces together. In addition, different surfaces require different preparation, so you need to be aware of the properties of epoxy relative to the material you are gluing.

Tools and materials should be organized before the epoxy is mixed so that you are not looking for a mallet or clamp while the epoxy is setting up. Workspaces should be clean and free of dust, sanding residue, or other contaminants. With good preparation, the job can be done quickly and easily, and the results will be extremely satisfying.

### PREPARATION

Before you can epoxy anything together, you need to make sure that the surfaces are carefully prepared.

#### STEP-BY-STEP

STEP 1: Ensure the surface is clean and dry. Use detergent or solvent like Thinners No.7 or Thinners 910 to clean surfaces if necessary.

STEP 2: Sand the area to provide a surface 'key' for the resin to adhere to. For wood use 100-180 grit along the grain; for fibreglass use 80-120 grit; for metal, use a disk grinder.

STEP 3: Brush or vacuum clean to remove sanding residue.

STEP 4: Wipe clean with solvent, such as Thinners No.7 to remove any remaining sanding residue and any surface impurities.

STEP 5: If any further sanding is required, repeat steps 2, 3, & 4.

STEP 6: Dry the surface carefully, first by wiping with paper towels, and, if the job needs to be done quickly, with a heat lamp, hair dryer, or hot air gun. This will also remove any particles missed by the solvent, but be sure that any drying system is waterless.

When working outdoors, make sure that there is no chance of rain or fog, which might contaminate the bond. If you are working indoors, beware of dust and dirt that might be disturbed before you have finished the job.

### SURFACE PREPARATION

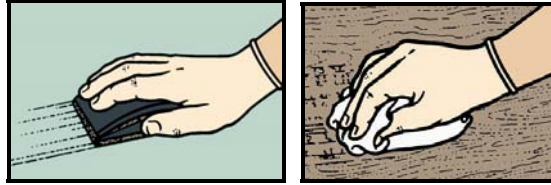
#### WOOD

Wood surfaces should be clean and free of any contaminants. If you have any doubts about how clean the wood is, flick a little water onto the surface. If the water doesn't soak in, but beads up, the surfaces still has contaminants on it. If you find contaminants, wipe the surface with Thinners No.7 solvent.

For making wood joints, roughen the surface by scraping it or sanding it with 80 to 100 grit sandpaper across the grain. Blow or wipe all sandpaper residue off the surface before applying any epoxy. Where high-quality finishes are required use a finer grade of sandpaper working with the grain as indicated in the Step-by-Step guide.

Some materials require special preparation. For example, teak is a very oily wood and is notoriously hard to glue or varnish. We recommend that you thoroughly wipe a teak surface with

YTA910 or Thinners No.7 solvent to remove the oils and allow it to dry thoroughly before applying epoxy to it. Other woods to be careful of are Iroko and White Oak. Sanding across the grain with these timbers is necessary to open up the wood surface to the epoxy. Most other woods, except for these resinous or oily woods, are relatively easy to glue provided basic cleanliness rules are observed.



## **FIBREGLASS**

Quite often a boat's topside has polish or salt water on it and needs to be cleaned thoroughly before epoxy can be applied. First, wash the surface completely with Yacht Line Super Cleaner. Work over small areas and keep checking to see if water beads up on the surface of the job. If it does, go over it with Yacht Line Super Cleaner again and wipe it dry.

Follow the Step-by-Step guide for preparation. Only after all these steps have been taken will you get a good bond to fibreglass.

## **METALS**

Because epoxy does not penetrate metals very well, metals should be ground back to bright metal with a good surface profile of 50 - 75 microns or blasted to Sa 2 ½. Aluminium has an oxidation layer on the metal, which must be removed before it can be epoxied. International recommends using a wet emery paper dipped in a resin and hardener mix and then leaving the residue to cure on the metal surface.

## **PLASTICS**

Some plastics cannot be bonded using epoxy. This usually includes most thermoplastics, but ABS plastics and PVCs can be sanded thoroughly, cleaned with a solvent, dried, and epoxied. Before epoxying plastics together, try a sample piece to determine whether it can be epoxied.

## **MEASURING AND DISPENSING PUMPS**

Always mix any epoxy and hardener in the proportions suggested by the manufacturer. Epiglass is mixed in the ratio of 4:1 by volume as measured by the pumps that are available. If you do not have a pump, you can use a measuring cup or a measuring stick dipped in a cup of resin and measure that against another cup or stick dipped in a cup of hardener. Alternatively, a graduated mixing cup is usually effective, especially if it is flexible plastic and can be re-used.

Pumps are available with professional Epiglass containers. These pumps automatically measure the correct ratios of four parts resin to one part hardener. Before using the pumps, they should be primed by pressing the handle a few times to get the liquid flowing. Once they are primed, calibrate the pumps by pumping resin and hardener into separate cups and measuring the amount. It should be four to one. Mixing is always critical when working with epoxies. Epoxies are not like poly- or vinyl esters, which will cure with inconsistently mixed ratios. Epoxies need to be very carefully mixed.

Occasionally, a pump may spit, especially if the pump hasn't been used for a while, or if it is cold and the resin has a higher viscosity. Keeping the resin above 21°C will give the best performance. Even though you use a pump, it pays to check the amounts before they are mixed to ensure accurate results.

## EPIGLASS® MIXING GUIDE (BY VOLUME)

Parts by volume Type of mix required	Volume of Mixed HT9000	HT110 Glue Powder	HT220 Wood Fibers	Lightweight Filler Powder	Filler Powder
<b>Fairing &amp; Filler Mix</b>					
Option 1	1	1		3	
Option 2	1	1			3
<b>High Viscosity Filler Mix</b>	1	1	1		
<b>Glue Mix</b>					
Low Viscosity	1	1			
High Viscosity	1	2			

**NOTE:**

The above chart indicates parts by volume of extender to be mixed with resin and hardener. Adjust volume to suit the particular job.

## MIXING

After dispensing both resin and hardener into a paper or non-plastic cup (you may find that the epoxy reacts with styrofoam or plastic cups), stir thoroughly for a few minutes to ensure that the two parts have mixed properly. Remember to scrape the bottom and corners of the cup. A poorly mixed resin will not set up properly and will have to be scraped off the job. Always mix the resin and hardener before adding any extenders. That way you will be sure that the epoxy is mixed properly.

Before starting work, determine how much epoxy mixture you will need and mix only that amount. Mixing large batches can lead to the resin setting up in the pot and generating a large amount of heat. In some cases the heat generated will melt the cup and has been known to start a fire.

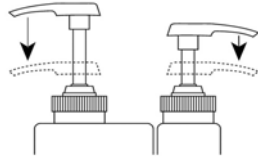
Using the right hardener is important. Use 'fast' hardener for applications when gluing or bonding and a fast set time is needed, or when temperatures are between 10 to 21°C. Use 'standard' hardener when laminating and multi-coating, especially in temperatures of 18 to 26°C because it has a longer potlife and a longer over-coating window that allows for better adhesion of a second coat. For climates where you would require an even slower cure, HT9003 slow curing agent is available and will ease application at temperatures between 20 to 35°C.

## MEASURING AND MIXING STEP-BY-STEP

**STEP 1:** If using pumps, prime the pumps to remove any air by pumping gently until the liquid starts to be dispensed. If you are using cups or measuring sticks, pour the resin into a pot, measure it, and then pour the hardener into another pot and measure it.

**STEP 2:** Mix the resin and the hardener together by pouring the hardener into the resin. If using pumps, put the resin in the mixing container first and then add the hardener. Count the number of pumps of resin and repeat the same number for the hardener. Remember, the pumps are calibrated so one stroke of each (base and curing agent) will provide you with the correct mix ratio.

**STEP 3:** Mix thoroughly for 1-2 minutes. Make sure you stir into the corners to get any unmixed resin. Add glue powder as required and mix to form the Epiglass glue mix. If you are laminating fibreglass, you will get better penetration without any additives.



PUMP RESIN (LEFT) & PUMP HARDENER (RIGHT)

STEP 4: If you are coating a porous material such as wood, prime the surfaces with Epiglass.

STEP 5: If you intend adding extenders, add them to the glue mix until the right consistency is achieved.

STEP 6: Apply to the joint and assemble the parts.

STEP 7: Tape or clamp components.

STEP 8: Remove excess glue mix with a spatula before the mix cures.

STEP 9: Wait until the glue mix is set up before moving the components.

EPIGLASS® MIXING GUIDE (BY WEIGHT)

Type of mix required	Volume of Mixed HT9000	HT110 Glue Powder	HT220 Wood Fiber	Lightweight Fairing Powder	Filler Powder	TOTAL VOL OF MIX
<b>North America</b>						
Filler	34 fl.oz (1 Ltr)	2 oz			10 oz	74 fl.oz
Fairing	34 fl.oz (1 Ltr)	2 oz		12 oz		90 fl.oz
Low Viscosity Glue Mix	34 fl.oz (1 Ltr)	2 oz				34 fl.oz
High Viscosity Glue Mix 1	34 fl.oz (1 Ltr)	2.5 oz				40 fl.oz
High Viscosity Glue Mix 2	34 fl.oz (1 Ltr)	2 oz	6 oz			
<b>Europe</b>						
Filler	1 Ltr	50 gms			290 gms	2.19 Ltr
Fairing	1 Ltr	50 gms		330 gms		2.67 Ltr
Low Viscosity Glue Mix	1 Ltr	50 gms				1.02 Ltr
High Viscosity Glue Mix	1 Ltr	50 gms	175 gms			1.17 Ltr

EPIGLASS® POT LIFE

	Fast Hardener HT9001	Standard Hardener HT9002	Slow Hardener HT9003
Pot Life @ 25°C	14 minutes	30 minutes	55 minutes
Application Temp.	10°C	15°C	25°C

**WORKING WITH EXTENDERS**

The low viscosity nature of Epiglass epoxy means that it is often necessary to add different powders to make the glue mix you want. A straight resin/hardener mix will probably only be appropriate for close fitting joints between non-absorbent materials such as Fibreglass or metal.

There are several extenders available to change the consistency of Epiglass. Make sure that every batch of epoxy is well mixed before adding extenders. For a low viscosity mix, such as one that is used in joints for gluing and bonding, use Glue Powder HT110 in a one-to-one ratio by volume to thicken the mixture enough to stop it from running out of the joint. Glue Powder is also used in conjunction with other additives to increase sag control and to make the mixture more creamy and easy to use.

With a one-to-one mixture of Glue Powder, the mixture will be runny (see picture). In all cases, a one-to-one mixture of Glue Powder should be made up before adding any other fillers. To stiffen up the mix, add double the amount of Glue Powder. Now the mix will not run when it is applied heavily. But beware that over-thickening the mixture can cause problems. It could result in a coat that is susceptible to solvent ingress of the paint applied. Above all it becomes difficult to handle when too thick.



EPIGLASS  
HT110 GLUE  
POWDER

For making a filleting mixture, add the Glue Powder in a one-to-one ratio and then add one part Wood Fibre HT220. Wood Fibre is used where a high-load fillet joint or bonding is needed. The mixture will be thick enough to stand up in peaks when touched with the mixing stick. Wood Fibre should also be added when the wood is particularly absorbent and the resin needs to be held at the glue joint rather than soaking away.

Similarly, for filling holes where wood may have rotted away, make up the mixture of Glue Powder and epoxy and add three

parts of Filler Powder. Again the mixture will be stiff, but a little smoother. Filler Powder is used as a filler mix primarily below the waterline. It has little or no water uptake but is harder to sand in comparison to the Lightweight Fairing Powders available in the market today.

Epiglass can be used for fairing too. Make up the one-to-one Glue Powder mixture and add three parts of Lightweight Fairing Powder. A fairing powder mix is thick and creamy and should be trowelled on. It can also be applied with a smooth edged spatula or special fairing tools. Before the epoxy mixture sets up make sure that you have applied it as smooth as possible. Any unfair areas will need to be sanded back after the epoxy has cured. Lightweight Fairing Powder is used whenever a lightweight fairing mix is needed above the waterline.

Additional Glue Powder can be added to increase sag resistance and provide a more creamy mixture. This mixture can be used below the waterline as long as it is sealed with 250 microns/10 mils of Interprotect epoxy primer Gelshield 200 or Epiglass resin. Because of its colour you can also add the Lightweight Fairing Powder to other mixtures to darken them to more closely match woods such as Mahogany. It is very easy to sand the Lightweight Fairing Mix.

When making up your mix with any of the extenders, it is best to make them a little thicker than you think you will need. As the Epiglass mix goes through A-stage cure, the exothermic heat produced warms it and reduces its viscosity. This can lead to sags or slumping, which will take time to tidy up later.

In addition to using the various additives, Epiglass can be used without these for applications other than gluing or bonding. All of these are discussed in more detail in the Project section.

## PREPARATION STEP-BY-STEP

### STEP 1:

Ensure the surface is clean and dry.



### STEP 2:

Sand to provide a surface key for the resin to adhere to. (For wood use 100-180 grit, for fiberglass use 80-120 grit, for metal use 80 grit grinder disk.)

### STEP 3:

Brush or vacuum to remove sanding residue.

### STEP 4:

Wipe clean with solvent to remove any surface impurities.

### STEP 5:

If further sanding is required, repeat steps 2, 3, and 4.



## ADDING FILLERS STEP-BY-STEP

### STEP 1:

Start with Epiglass® Epoxy Resin mix of the required quantity in a mixing pot with enough space to add the volume of extenders.

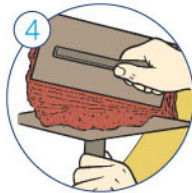


### STEP 2:

Add the appropriate volume of extenders as indicated in the Epiglass® Mixing Guide on page 10.

### STEP 3:

Mix slowly and carefully to incorporate all of the mixture.



### STEP 4:

The mixture is now ready to use.

### STEP 5:

When using larger mixtures, pour it into a paint tray to spread the mixture and maximize the working time.



## 2

## 2. Advanced Techniques & Projects

Epiglass can be used for virtually any project that does not need to be taken apart again. For example, it can be used to fill holes drilled in a sandwich-cored deck to prevent moisture from getting in. It can also be used to glue any wood together, or to glue Aluminium to steel, or wood to plastic. Note, however, that certain types of plastic cannot be epoxied together, but most can. It can be used to build new hulls and decks in wood or Fibreglass, It can be used to repair hulls, to repair or stiffen spars, to make simple joints, or to sheath an entire boat hull. Wherever the project calls for permanently gluing two surfaces, together you can use Epiglass.

In order to work with any epoxy you need to have the right tools, the right protection, and know to the right techniques. In this section we'll cover protection, tools, and what you can or cannot do with epoxy. We'll start with simple project and work up to larger, more complex jobs.

### BEFORE YOU START

Once Epiglass epoxy has been mixed, you don't want to be searching around for spatulas and the right extender. You will need to have all this equipment nearby. Before you mix any epoxy make sure the job is prepared properly, that the right gear is to hand, and that the ambient temperature is suitable or that you have a local heat source available.

### HAVING THE RIGHT DISPOSABLES

All the gear that you use once, such as gloves, wooden spatulas, mixing sticks, and mixing cups, and then throw out are classed as disposables. When working with epoxy, disposables are a large part of the overall expense.

You should have barrier cream and a box of rubber gloves handy. If a glove tears you should put on another. When measuring resin and hardener, use one measuring stick for the resin another for the hardener. That way you will not inadvertently contaminate either container. Other disposables that you might want to have handy are: wooden spatulas for stirring, mixing or rough spreading of a mixture thickened with extender; plastic or paper mixing cups (if you use plastic cups test them before starting to make sure that they do not react with Epiglass), plastic scrapers, spreaders, and spatulas to apply and fair the epoxy after it has been mixed with extenders, measuring cups for measuring liquids and additives, and masking tape for protecting areas that you do not want to get covered with epoxy. If you are working with joints that have deteriorated you might want to have an epoxy syringe handy to squirt glue into the joint. You'll also need solvents for cleaning tools, paper wipes, and possibly a vacuum cleaner to get rid of sanding residues.

One important disposable for the professional is Peel Ply. This is a nylon or polyester fabric that is laid onto the surface of the Epiglass at the end of the application. When this is peeled off, a surface layer of Epiglass is removed. This leaves behind a chemically clean, textured surface that is ready for coatings, secondary bonding, or over-coating without the need for sanding. Peel Ply saves a significant amount of labour time, which generally outweighs the cost of the Peel Ply itself. Additionally, while the Peel Ply remains over the Epiglass, the surface is protected from contamination and light damage. There is some debate about the use of Peel Ply to replace sanding in such fine tolerance applications as America's Cup racing yachts and so International suggests additional coarse sanding for joints that are to be highly loaded. This will provide double assurance of a good bond.

## **USING THE RIGHT TOOLS**

Not only do you need the right disposables but you should also have the right tools. By way of tools you might want to have several different styles of clamps handy to hold the job together, as well as an air-line to get rid of dust and dirt. You may need a pneumatic or electric sander to smooth down surfaces, scrapers, rollers, heat lamps, or a heat blower to cure the work faster. Then there are the specialized disposables such as round-ended spatulas and tools for making fillets and for other rounded edges. All the projects outlined in the following pages use some or all of the tools listed here.

## **THE RIGHT CONSUMABLES**

Having the right consumables can make your job a lot easier. If you are going to sheath a hull, for example, having the right style and weight of fibre reinforcement will make the job easy. Having too heavy a weight of fibre can cause wetting out and adherence problems. Of course, having enough Epiglass and extenders for the project is also essential. Typical consumables used in virtually every project are: Epiglass, hardener, extenders, Fibreglass rolls or sheets, wood and plywood, and fasteners such as bronze and plastic staples (non-rusting) for temporarily holding battens or Fibreglass in place. If you are laminating, vacuum bagging consumables may also be a part of the picture.

## **REINFORCEMENTS**

For high stress areas reinforcements are required. These reinforcements can take many forms, from the simplest E-glass to carbon or Aramid fibres such as Kevlar® (DuPont) or Twaron® (Akzo Nobel). Reinforcements can also be woven or lightly glued to scrim into many forms. Most common is chopped strand, although it is rarely used with epoxy. With epoxy bi-, tri- and quadraxial weaves and scrim are most popular.

(See Section 3 for information on the different types of reinforcements and cores.)



## SMALLER PROJECTS

As we saw earlier, there are certain procedures that are basic to every Epiglass installation. All surfaces must be clean and dry, well sanded, and wiped down with solvent. To get good adhesion on less than perfect surfaces, prime the surfaces with Epiglass Epoxy Resin mix and allow it to go tacky. Thicken the Epiglass mix with glue powder and other fillers to the required consistency before applying to the job. Make sure that you clean off as much mix as possible while the mixture is still soft. It will be a lot harder to clean after the mixture has set up. Epoxies work best with some glue thickness in the joint – about 1 - 2 mm. Make sure all clamped surfaces are not clamped so tightly that they squeeze all the glue out of the joint. Finally, if desired, coat the joint with Epiglass Epoxy Resin mix to act as a water seal.

### GLUING WITH EPIGLASS

You can use Epiglass as a glue anywhere a more conventional glue might be used. Epiglass gives a stronger, more stable joint that is easy to clean up and easy to epoxy over. To glue using Epiglass make sure the surface is clean and prepared. If the area to be glued is large, wipe it down with solvent. Measure Epiglass and hardener and mix well. You might want to prime the areas to be glued with Epiglass Epoxy Resin, or you can add glue powder and any other extenders. In general, the thicker the glue line the thicker the epoxy mixture (viscosity) should be. Coat surfaces to be glued with Epiglass and assemble them. Clamp as required, but do not overclamp as you may squeeze a lot of Epiglass out of the joint and weaken it. Remove surplus glue mix before the joint cures. Allow enough time for the joint to cure properly before removing the clamps and making a final cleanup.

When making joints, selecting the right design for the joint is important. Joints should be loaded in sheer or tension. Peel stresses should be avoided at all costs.

### FILLETING

T-joints are made by simply butting the end of a piece of plywood or composite against another and gluing the wood together. But without additional reinforcement the joint does not provide enough strength. Should the joint flex, as it might on a boat, the joint may fail. A fillet fills the area on either side of the joint and stiffens it to help it resist cracking. Fillets may be found, for example, on boats where a wood bulkhead is joined to the hull. A fillet can also be used to

### GLUING STEP-BY-STEP

**STEP 1:**

*Follow standard surface preparation guidelines.*

**STEP 2:**

*Measure and mix Epiglass® Epoxy Resin.*

**STEP 3:**

*For absorbent surfaces such as wood, prime the surfaces with Epiglass® Epoxy Resin (allow some extra mix for this when measuring).*

**STEP 4:**

*Add glue powder to remaining Epiglass® Epoxy Resin at a ratio of 1:1 by volume, and mix well to form the Epiglass® glue mix.*

**STEP 5:**

*Apply to the joint area and assemble the parts.*



**STEP 6:**

*Tape or clamp components in position.*

**STEP 7:**

*Remove excess glue mix with a spatula. Before the mix cures.*

**STEP 8:**

*Wait until de-clamp time before moving the component.*

reinforce a joint where the strength of the joint is unknown and it is too difficult to take apart and re-glue it. Fillets can be used in any bulkhead-to-hull joint, any angle joint less than 90 degrees, and for fastening plywood less than 6 mm in thickness. As the panel thickness increases above this size the fillet becomes progressively bigger and consumes more material. In this situation, fibre reinforcement tape (glass or carbon) is often used, with the best type having the fibres at  $\pm 45^\circ$  to the joint line.

Making a fillet is relatively easy, but keeping the job clean is more difficult. First, select the radius that you wish to use. The radius should be 1.5 to 5 times the timber thickness. (1.5 might be used for a high density fillet, and 5 for a low density fillet to spread the load over a larger area.) For example, if you wish to join a 12 mm bulkhead to the hull, the radius should be no smaller than 18 mm, but it could go up to 62 mm if the bulkhead were to be a Nomex cored, carbon reinforced material. Select or make a suitable radius tool. Most people use a large diameter spatula with rounded ends although the effect can be changed with a flat or oval ended spatula.

To keep edges of the joint clean you should mask off the joint on each side at a tangent point of the fillet radius from the corner. This will help to prevent getting filler on the adjoining wood. Wipe the masked-off area with solvent and dry-fit the parts to make sure everything goes together properly. If any surfaces are especially absorbent, prime them with Epiglass Resin mix and allow them to go tacky.

Make up your mixture by mixing Epiglass Epoxy Resin and hardener, then adding glue powder and other filler (usually wood fibres) until the mixture is about the consistency of creamy peanut butter. Trowel the mix into the joint and use the spatula to fair the mixture until it is smooth and the joint is filled properly. Peel off the masking tape just before the mixture starts to cure. (If you leave the masking tape until the mix has cured, it will not come off easily.) When the job is cured you can sand it and overcoat with a sealer coat of Epiglass and undercoat or varnish.

TIP: To get a really smooth result with no sanding after removing the tape, lightly brush on a straight Epiglass Epoxy Resin to resin-coat the surface and take out any roughness in the fillet.

## HOW TO MAKE A FILLET JOINT



STEP 1:  
*Mask off the job, as shown here.*



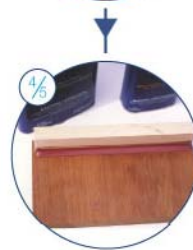
STEP 2:  
*Mix Epiglass® and add the glue powder or filler until the mixture is the consistency of peanut butter.*



STEP 3:  
*Trowel the mixture into the corner. Run the spatula down the joint to get a nice even finish.*



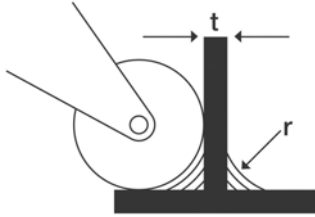
STEP 4:  
*Leave the mixture (to set) for a few minutes before peeling off the masking tape. If you leave the tape until the epoxy has hardened it will be glued in place and may never come off.*



STEP 5:  
*The finished fillet.*

**REMEMBER:** The high density mix is very hard to sand, so getting it clean and neat before the epoxy hardens will save a lot of time later.

### VOLUME CALCULATION



Volume (ml) of fillet mix = radius (mm) x radius (mm) x 0.25 x length (m)

### REPAIRING BROKEN JOINTS

If any type of joint has broken that cannot be taken apart to be repaired, such as onboard furniture, delaminating plywood, or even a chair back, you can fix it by making a mixture of Epiglass epoxy and injecting it into the joint. Simply mix the epoxy as per instructions. Add a little glue powder to increase the viscosity and pour the mix into an epoxy syringe. Use the syringe to inject epoxy into the joint. Once the epoxy has penetrated the joint completely clamp it clean up any overflow, and leave it until the epoxy has set.



HOW TO INJECT EPIGLASS INTO A JOINT THAT CANNOT BE TAKEN APART AND REGLUED

### REPAIRING DENTS AND DINGS WITH EPIGLASS EPOXY

If you have dinged up your boat's topsides or put a scratch in the deck, you can easily make a repair using Epiglass. If you are just starting with epoxies we suggest you start with a small job of this type and build up experience.

To fill dents and dings in the boat's hull, you need first to prepare the damaged area. Remove any loose material and sand or grind it back to solid material. If the crack is narrow and deep, scrape out a vee until you reach solid material. A vee rasp or file in a rotary hand drill or small grinding tool often makes it easier to grind away a small amount of material. For larger repairs, routing out the damaged area may be appropriate. Be sure to coarse sandpaper the groove to provide a key.

Make sure the job is clean by wiping the entire area with solvent. Next accurately mix a batch of epoxy to suit the area to be covered. Add glue powder to thicken the mixture and then add filler powder or lightweight fairing powder until it reaches the consistency of creamy peanut butter. Trowel the mix into the damaged area or crack. Build up the layers until the surface is level. Try not to get drips down the side of the boat or on yourself. After the Epiglass has set up, sand it smooth with 120 to 180 grit wet or dry paper. If necessary, repeat the process until the area is smoothly faired and indistinguishable from the surrounding area. Finish the repair with International primers, undercoats and topcoats.

Larger jobs take a little more effort. The area should be sanded first to give the epoxy a rough area to hold onto. Then wiped with solvent. To thicken the Epiglass, use glue powder and fairing

compound for a lightweight filler. Finish the repair with International primers, undercoats, and topcoats. (See Section 2 for more information on primers, undercoats, and topcoats.)

On very large jobs, such as the hull of a large boat, thin battens, about 1/4 inch (6 mm) thick, are often fastened to the hull a few feet apart and the hull faired to the battens, which are then removed and the batten groove filled.

### FILLING SMALL HOLES & CRACKS



**STEP 1:**  
*Remove all loose material and prepare surface. Open cut cracks back to solid material with a 'V' shaped scraper.*



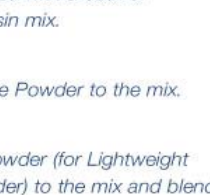
**STEP 2:**  
*Accurately measure Epiglass® Epoxy Resin and Hardener, mix well.*



**STEP 3:**  
*Prime the area with a coat of Epiglass® resin mix.*



**STEP 4:**  
*Blend in Glue Powder to the mix.*



**STEP 5:**  
*Add Filler Powder (for Lightweight Fairing Powder) to the mix and blend to an even consistency.*



**STEP 6:**  
*Use a spreader or trowel to work the filler mix into the damaged area and smooth off just proud of the surrounding surface.*



**STEP 7:**  
*An amine blush may form on the Epiglass® surface as it cures, particularly in cold damp conditions. Solvents will not remove this surface stickiness. Instead, wash thoroughly using a Scotch-Brite™ sponge and freshwater before applying anything else. Alternatively, use Peel-ply.*

**STEP 8:**  
*Sand smooth with 120 and 180 grade wet or dry paper.*

**STEP 9:**  
*Finish with Interlux® Primers, Undercoats and Topcoats.*

Again, build up thicker layers by applying small amounts at a time. Don't mix more epoxy than you can use at one time. If the mixture starts to cure in the pot, put it outside your shop on a concrete or metal surface until the mixture has cooled. After the Epiglass has set up on the job, sand it smooth using 120 to 180 grit wet or dry sandpaper, and finish with International primers, undercoats, and topcoats as described in Section 2.

## INSTALLING HARDWARE WITH EPIGLASS

Often on the deck of a boat a part gets moved, or an old piece of gear is removed and a new piece added. The holes in the deck should be tightly sealed to prevent water getting into the deck core and causing rot or degradation. To fill holes in the hull or deck, apply tape over the hole on the underside of the deck. Mix Epiglass in a normal ratio and add glue powder to thicken it. You might also want to add some of the filler additives to colour the application. Put the mixture in a polyethylene bag with one corner cut off (like an icing bag) and squirt it into the hole. If you have more than one hole, use the bag to fill each hole working around the boat. When you have finished put the mixture down outside the workshop until it has set up, and when it is cured dispose of it properly.

### AN EXAMPLE OF A PROJECT USING EPIGLASS®

#### Work Schedule

**Day One (am)** Remove any loose hardware and thoroughly prepare surface. Prepare holes to suit fastenings and drill out  $\frac{3}{4}$  depth with 50% oversized drill for solid decks or bore out core with a bent nail for sandwich decks. Mask off surrounding areas with tape and plastic sheet.

**Day One (pm) Screw Fastening**  
If there is no solid material for a screw fastening to hold to, cast some glue mix into the bottom of the hole and allow to cure.

**Bolt Fastening**  
Seal the back of the hole and fill with glue mix.

**Day Two** Drill pilot hole in the casting, fill hole with glue mix, apply glue mix to the base of the component and fasten down.

When fully cured, re-drill the strengthened area to suit the fastener, apply glue mix to the base of the component and fasten down.

**Day Three** Day for curing before use.

If you are installing deck gear and need to drill holes in a cored deck, you may be exposing the deck core to moisture. The deck core will not rot or degrade (unless from impact) while it is totally sealed between two layers of Fibreglass. It is when holes or cracks let water into the core that rot starts. To make sure that rot cannot start, first drill an oversize hole for the deck gear you are about to install. Fill that hole with Epiglass mixture thickened to a smooth paste and let it set up hard. Now drill the correct sized hole through the hard Epiglass. By installing deck gear and carefully sealing the hole you should never experience problems with the deck core.

If a hole has been created by gear such as a cleat ripping off the deck, you will need to reinforce the hole with fibreglass in the same manner as you would make a repair in a damaged part of the boat. That is, you should grind back the edges, back the hole with polyethylene and wooden blocking, and apply wetted-out Fibreglass to the hole until the deck thickness has been rebuilt. When the repair has dried and been cleaned up, only then can you drill new holes for the equipment.

When installing deck gear, make sure that the equipment has backing plates to spread the load over a wider area and prevent gear from ripping off the deck.

## CREATING THREADED HOLES

To create a threaded hole you first need to drill out the hole as outlined above and fill it with epoxy. Then install a bolt or screw coated with beeswax in the wet epoxy. The beeswax enables the bolt or screw to be removed without damaging the epoxy thread created when the Epiglass hardens.

## WORKING WITH WOOD

Unlike varnish, Epiglass can be used to give wood total protection from rot but it has no UV protection. Four factors that cause wood to rot are moisture, rot spores, darkness, and warmth. Eliminating any one factor eliminates rot. If all the factors are present wood will rot. You can't do much about warmth, but by totally encapsulating a piece of wood in Epiglass resin mix and allowing it to harden completely, rot spores are sealed off from the atmosphere they need to survive and moisture is kept out of the wood. Consequently, the life of the wood is prolonged.

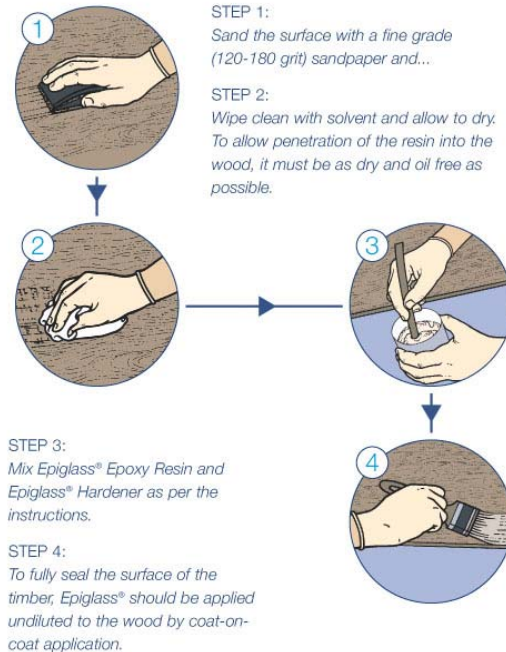
Before coating wood with Epiglass it should be dried to less than 13% moisture content. In some conditions this is hard to do, but in most cases where wood is kept undercover, the moisture content is usually lower than 13% and sealing with Epiglass can be done quickly and easily. Simply prepare the wood surface as outlined above, mix a batch of Epiglass, and brush it on like varnish. You can thicken it slightly with glue powder if you wish. Build up several layers and that's it. Job done. Epiglass is more durable than varnish but it will need over-coating with a varnish or paint to protect it from UV break down (cracking and/or chalking).

## WORKING WITH PREVIOUSLY INSTALLED WOOD

When you are working on a boat restoration, you may have to make new joints or coat a piece of wooden equipment with epoxy. Often old wood contains salt residues and old varnishes that first need to be removed. On most surfaces the job can often be sanded back, but some jobs are slightly more delicate and the old varnish must be removed with a stripper like Interstrip Paint Remover or light sanding. Once the job has been cleared of old varnish, the wood should be dried to the required moisture content (less than 13%) and wiped with solvent to remove salt and other deposits. Typically, the old wood is coated on one side only to allow the wood to 'breathe', but there is often no reason why it cannot be totally encapsulated.

If you are covering a large flat area, such as a deckhouse or hatch, the Epiglass glue mix can be poured onto the job and squeegeed around to get the maximum coverage in the quickest possible time. If you intend to use this technique, make the Epiglass mixture slightly thicker by adding a measure of filler powder to the glue mix.

### APPLICATION OF EPIGLASS® AS A SEALER

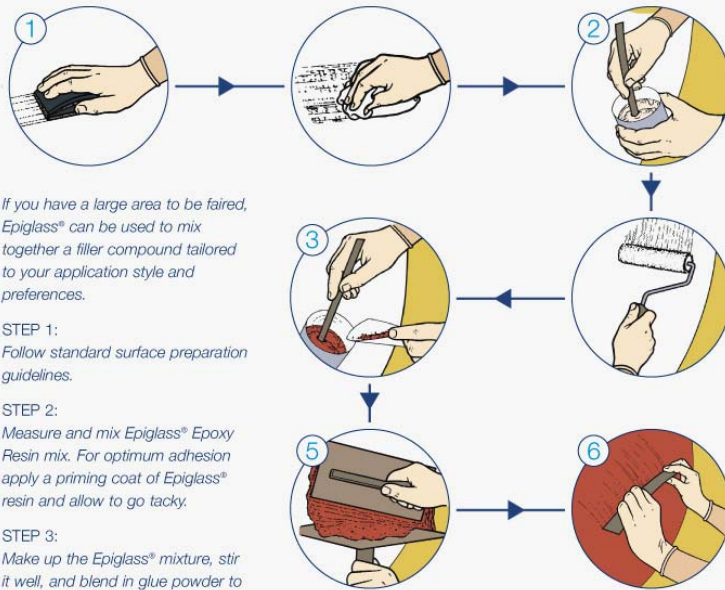


## FAIRING LARGER PROJECTS WITH EPIGLASS

If you have a large area to be faired, prepare the surface by sanding with 80 grit sandpaper. When you have finished sanding, wipe the entire area with solvent. Make up a small amount of Epiglass mixture, stir it well and brush on a thin tack coat to ensure adhesion. When this gets to the tacky stage, make another batch or resin and blend in glue powder to thicken it. Add lightweight fairing powder and blend it in well. Use a trowel or spreader to spread the mixture over the surface. Fair the mixture by using a long flexible batten (battens can be made from thin strips of wood or ½ inch (12 mm) or more PVC piping). For flat surfaces, a blade spreader gives

best results, while PVC pipe is best for compound curves. Getting the mixture as smooth as possible at this stage will save sanding time later. After the mixture is set, sand it back using 120 to 180 grit wet or dry paper and finish the job with International primers, undercoats, and topcoats as described in Section 2.

#### FAIRING WITH EPIGLASS®



*If you have a large area to be faired, Epiglass® can be used to mix together a filler compound tailored to your application style and preferences.*

**STEP 1:**  
Follow standard surface preparation guidelines.

**STEP 2:**  
Measure and mix Epiglass® Epoxy Resin mix. For optimum adhesion apply a priming coat of Epiglass® resin and allow to go tacky.

**STEP 3:**  
Make up the Epiglass® mixture, stir it well, and blend in glue powder to thicken it. Refer to filler addition chart in Section 1.

**STEP 4:**  
Add lightweight fairing powder and blend it in well.

**STEP 5:**  
Use a trowel or spreader to spread the mixture over the surface.

**STEP 6:**  
Use a long flexible batten (battens can be made from thin strips of wood or ½ inch (12 mm) PVC piping to fair the mixture.

**NOTE:** Getting the mixture as smooth as possible at this stage will save sanding time later. A blade spreader will give the cleanest result, but a PVC pipe is very good for compound curves.

**STEP 7:**  
After the mixture is set, sand it back using 120 to 180 grit wet or dry sandpaper.

**STEP 8:**  
Finish the job with primers, undercoats, and topcoats from the Interlux / International professional products range.

## MAJOR PROJECTS

Not only can Epiglass be used to repair smaller jobs, but, by adjusting the rate at which the glue mix cures, a longer working window can be opened and Epiglass can be used on much larger jobs. These jobs can take many forms, from fairing the hull of a large poweryacht to putting a perfect finish on a racing sailboat's keel, to building a carbon fibre spar or simply stiffening a wooden boom. Not only do sailboats benefit, but powerboat hulls can be coated with epoxy, wooden hulls can be sheathed with epoxy and Fibreglass, and completely new boats can be built using Fibreglass or wood with epoxy.

### FAIRING KEELS AND RUDDERS

#### FAIRING A KEEL

**STEP 1:**

*Remove all the original keel fairing to ensure good attachment of new fairing compound.*

**STEP 2:**

*Make keel templates using either thin plywood or stiff cardboard. Mark the keel in sections to ensure that each template is offered up in the appropriate place.*

**STEP 3:**

*Wipe keel with solvent to make sure it is totally clean.*

**STEP 4:**

*Mix epoxy with one measure of Glue Powder (HT 110) and 3 measures of Lightweight Fairing Powder.*

**STEP 5:**

*Trowel mix onto keel and smooth to fair. Don't cover marks at the forward and aft end of the keel yet to ensure that you can offer up the templates at the appropriate place. Offer up templates and check fairing.*

**STEP 6:**

*Repeat steps 4 and 5 until keel is smooth and approximately faired.*

**STEP 7:**

*Let keel dry and sand rough spots to ensure that the keel is faired. Check often with templates.*

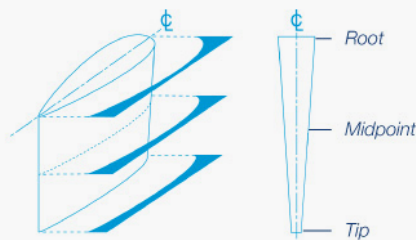
**STEP 8:**

*You may find that steps 4 through 8 need to be repeated several times to get the job perfectly fair. For hydrodynamic efficiency, get the front half of the keel as fair as possible.*

**STEP 9:**

*Finish with Interprotect, Gelshield 200 or Interprime 820.*

TEMPLATE DIAGRAM



Fairing keels and rudders is more exacting than fairing hull sides. To get the optimum performance from any appendage, be it keel or rudder, the section shape needs to be very accurate, especially around the nose and the front one-third where laminar flow is established. To get an accurate section shape you need to find out from the boat's designer what sectional shape was used for this keel. Typically, it is a NACA series 0010 or series 64, although later keels might have a low laminar flow section shape. When you know the section shape, you should make wooden or cardboard templates of the keel sections at three or four places. Use 2 mm or thinner plywood for the templates or very stiff cardboard.) Typically, a designer provides a root, mid, and tip chord section, but if the appendage is five or six feet long, you might ask for intermediate sections so that you do not have long gaps between sections. In general, a section at each 400 to 600 mm is best. Make separate section shapes for the rounded leading edge of the keel that go from the 20% chord on one side to the 20% chord on the other side. This ensures that you get the critical leading edge faired properly. Make a second set of templates for when you get resin mixture on the first set.

You might want to square off the bottom of the keel. A square bottom is reputed to be more effective than a rounded tip, although a tapered tip has the lowest drag. If the keel is bulbed, you should fair the bulb into the keel as per the designer's instructions. Getting under the keel might be a little difficult, but you can usually get your boatyard to lift the boat in slings overnight while

you fair the keel bottom. As most vortices come off the bottom trailing edge of the keel, getting it smooth is very important.

If the keel has bottom paint on it, all the bottom paint must be sandblasted or ground off. After getting the bottom paint off, offer up your templates to see how much fairing material you have to add to the keel. The less material you need to add, the more efficient your keel will be. Make sure the keel or rudder is dry and wipe down with solvent. Sand the area with sand paper dipped in Epiglass Epoxy Resin mix to prevent oxidisation and to provide a good surface for the fairing mixture.

Accurately mix Epiglass Epoxy, adding glue powder and lightweight fairing powder until the mix has the consistency of thick peanut butter. Trowel it into place and spread it well. Use a flexible batten to fair the mixture and offer the template up to check the fairing. If you have to build up a half-inch or more of fairing, do it in two or three layers, rather than a single huge one. If you don't thicken the mixture adequately and try to apply a lot of mix, you will get sags or runs. The only way to eliminate a sag or run is to sand it off and start over.

When the Epiglass Epoxy Resin mixture has set up, it can be sanded using 120 to 180 grit wet and dry sandpaper. While you are sanding, check the fairness of the appendage with your templates to ensure you are not taking off too much mixture. You may find that after the keel has been sanded it still has hollows to be filled. Most do. Simply fill the hollows and sand the surface back until you get a perfect surface. The final step is to seal the surface with Epiglass Epoxy Resin mixed with a little glue powder. Paint first with epoxy sealer and then paint with International bottom paint products.

## **SHEATHING**

You may not realise it but if you have a wood/epoxy boat built today, the chances are that the external surface of the hull has some form of Fibreglass on it. In many cases, wooden hulled boats are sheathed with Kevlar® for impact resistance, while others may have a few layers of woven cloth. The sheathing serves to increase the structural strength of the boat, to protect against marine borers, to ensure that water stays where it belongs, and to protect the hull against impact damage under way.

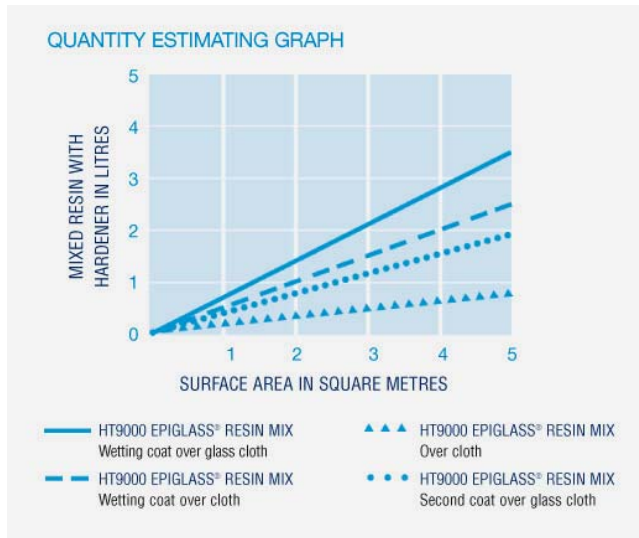
Not only may new boats be sheathed, but older boats can be sheathed too. Suppose you have an older boat that needs pumping every morning. Your choices are to haul the boat out and refasten or re-plank it – that is, if you can find a skilled craftsman and have a bucket full of money – or you can sheath the exterior of the hull with fibreglass to extend the life of the hull. Sheathing a hull is not difficult, but it does take some effort and a little time. Sheathing is not appropriate for hulls with a clinker/ lapstrake construction style, and carvel hulls may have problems too.

Working with the hull upside down is by far the easiest method, but larger boats cannot be turned over and the application techniques will be different. On a boat that is upside down, the Fibreglass can be laid from sheer line to sheer line if the boat's keel has been removed (this method is often used on a sailboat hull), or it can be sheathed from stem to stern (this method is more often used on a powerboat hull). On a boat that is upright, the sheathing must be started at the sheerline and taken to the keel.

Typically, a number of thin layers of woven cloth, such as a 180 grams cloth, are applied when a clear or 'bright' finish is required, but if the Fibreglass sheathing is to be faired and painted over, heavier glass cloth or even carbon and Kevlar® laminates are more likely to be used. Where the hull has lost some structural or watertight integrity by deforming due to rigging loads, a sheathing with carbon fibre might be used to absorb some of the loads on the outer skin. If impact resistance is required, Kevlar® might be used as a sheathing material even though it is difficult to cut and handle.

To sheath a hull the surface must first be prepared. Preparing the hull of an older boat entails removing all the old paint, filler, and varnish, and taking the surface back to bare wood. While the

boat is being sanded back, check the fastenings to make sure they are sound. Any unsound fastenings should be replaced before the hull is sheathed. Depending on the size of the hull, you may be able to complete the sanding part of the job in a day or two. Be careful that you do not dig gouges in the hull while sanding it.



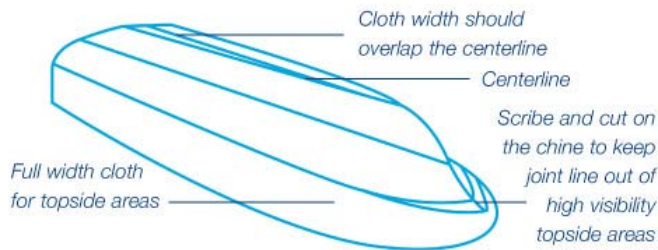
### WORKING ON A BOAT UPSIDE DOWN

When all the old paint and varnish has been removed from the hull or on a new hull when the final sanding has been completed, the hull should be wiped down with solvent and primed with Epiglass Epoxy Resin mix. This sets up the hull to be sheathed. Depending on how large the hull is, you can work in sections or on smaller boats do it all at once. Roll out a section with Epiglass resin mix, thickened slightly with glue powder, and lay Fibreglass over that section. Roll Epiglass through the Fibreglass, adding more resin where needed, but try not to get a resin-rich

laminate. Surplus resin can be removed with a squeegee. When mixing Epiglass, make up batches sufficient for ten to fifteen minutes of work to keep the mixture fresh. Mixing large batches may cause it to set up while it is still in the pot. Each time you make up a new batch of resin, either clean your roller or start with a new one for best results.

When working on a rounded sailboat hull, it is often easiest to work from sheer line to sheer line on a 45 degree angle, and then from sheer line to sheer line on a 45 degree angle at 90 degrees to the first. If a third layer is required, it can be applied longitudinally. A powerboat hull is more often sheathed with Fibreglass running fore and aft.

### SHEATHING WITH CRAFT UPSIDE DOWN



Work down the hull and at least 150 mm around the transom. Try to overlap the sheathing at chines, stem, and transom corners where the hull may get abraded. If you are adding several layers of sheathing, put the joint of the second layer in the middle of the first layer so that there is no area with only resin. Having said

that, try to avoid having a seam in the middle of the topsides where it might be easily seen or require a lot of fairing to hide it.

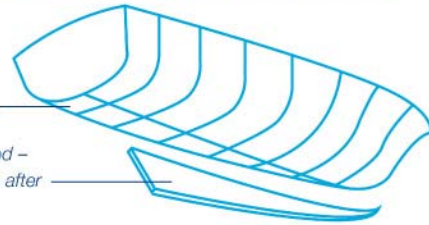
## APPLYING SHEATHING TO A BOAT THAT IS UPRIGHT

If the boat is upside down working longitudinally is easiest and fastest. If the boat is right side up, hanging Fibreglass from the sheerline and rolling it onto the hull is the easiest method. You may have to temporarily staple the sheathing to the hull near the rail to ensure that it stays in place while you roll the remainder of the Fibreglass onto the hull.

### SHEATHING CROSSWAYS WITH CRAFT RIGHT WAY UP

*Cloth widths set out from transom (adjust for cloth width being used)*

*Pre-fitted deadwood – permanently fasten after sheathing*



## SHEATHING

STEP 1: Ensure that the hull surface is free of dirt, dust, and contamination. To make it easy to apply the sheathing, make sure that keels, rubrails, gunwhales, spray rails and other appendages have been removed.

STEP 2: Wipe down the hull with solvent and a clean rag.

STEP 3: Before applying any resin to the hull, cut the cloth to length by laying it on the hull. Fasten this preliminary sizing with tape or staples fastened through strips of wood.

STEP 4: Mix the Epiglass.

STEP 5: Apply the resin to the hull with a 3/8 inch solvent-resistant roller and lay the cloth over the resin. Roll the cloth to allow the resin to penetrate the cloth.

STEP 6: Repeat steps 4 and 5 for each length of Fibreglass cloth.

STEP 7: Try to finish the top side layer under a rub rail or toe rail to ensure that no seam shows.

STEP 8: Allow 5 to 6 hours at 77°F (about 25°C) for the resin to set up.

STEP 9: Scrape off any surface nibs or exposed filaments and start laying a second coat of resin and cloth.

### SHEATHING HINTS

- 1: In cold weather stand the bucket of resin in warm water for 30 minutes before applying it.
- 2: Store resin and hardener out of direct sunlight on hot days.
- 3: On hot days, try to start work before sunlight warms the substrate.
- 4: Make a number of small mixes rather than fewer large mixes.
- 5: Overestimate the time it will take.
- 6: Keep rollers soft by frequently cleaning them.

After it has been sheathed, let the hull cure for a day or so. Then coat it, if you are going to paint over the sheathing, fair the entire hull with Epiglass mixed with fairing powder. Sand everything back and apply Interprime 820. Then apply Interprime 880 above or Gelshield 200 below the DWL and lightly sand back with 360 grit sandpaper when it is dried. Paint the topsides with Toplac or Interspray and the hull bottom with an antifouling paint. Epiglass is compatible with all

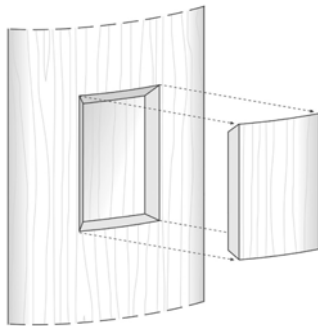
International Professional Range Products and can be used with confidence from bare hull to finished topsides.

## RESTORING, REPAIRING AND STIFFENING SPARS

Increasingly getting new wooden spars made is becoming more and more difficult with only a few independent builders available to make them. Repairing a wooden spar makes sense when the repair material and new wood will cost a lot less than replacement costs and will probably be structurally stronger than the original. Not only can wooden spars be rebuilt with Epiglass, carbon spars can be repaired, too, with a huge saving in cost and time. The repair techniques are fairly straightforward and are explained here.

### REPLACING WORN OR DAMAGED WOOD

If the mast has a damaged section, it can be severely weakened. In the days before epoxy the only solution was to either splice in a large new section or replace the spar. Today the damaged section can be removed and replaced with very little loss in strength. First, cut out damaged timber and prepare a graving piece in the traditional way. (A graving piece is an insert cut to fit the removed material.)



GRAVING PIECE

Epoxy has best strength with a glue line of at least 0.5 mm, but leaving a glue line visible in the spar may be undesirable. Consequently, a little further shaping of the new piece will resolve this issue. (See diagram.) This gives a thick strong glue line that is virtually invisible in the finished piece and more waterproof than the majority of alternative adhesives.

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SECTION THROUGH A MAST



### SEALING AND SHEATHING

Epiglass can protect a wooden spar from the elements better than any ordinary paint system. Seal and sheath as already described and then finish off with either Perfection or Schooner Varnishes. The Epiglass and Perfection combine to give the ultimate protection, while Schooner gives a warm traditional colour and can be re-coated as required with ease. Ensure any amine blush on the surface has been removed before you apply the varnish.

### PROTECTION IN HIGH WEAR AREAS

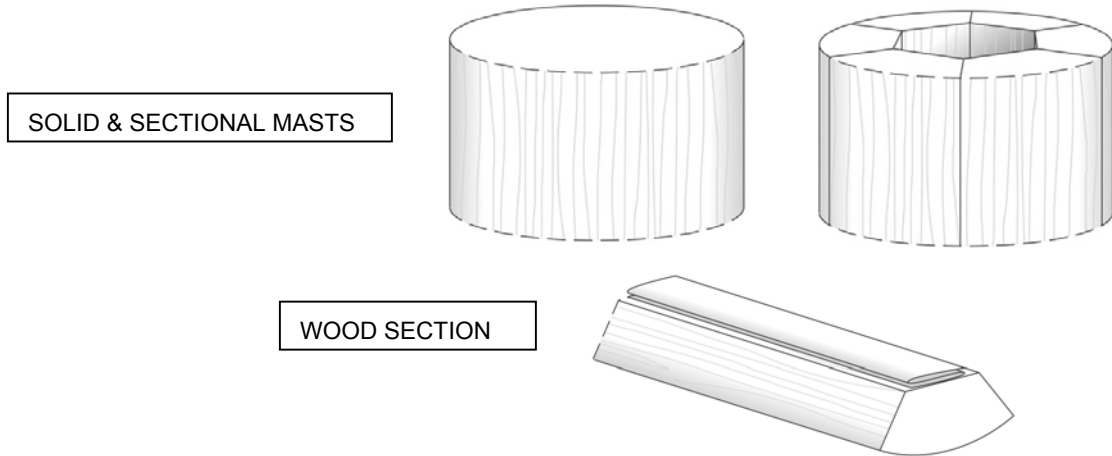
Most gaff rig boats and a few other rigs have a yoke resting against the mast instead of being held by a gooseneck. The yoke or gaff jaws chafe against the mast and quickly wear through most coatings systems. A few layers of glass, Kevlar® or Twaron® cloth can be applied to this area to provide long-term protection. The thickness of glass necessary or the colour of the Kevlar® will not give a clear finished result, so a band of colour or white paint will be necessary to make the job look finished smartly.

NOTE: A reinforcing band also works for composite spars.

## ADDING STIFFNESS

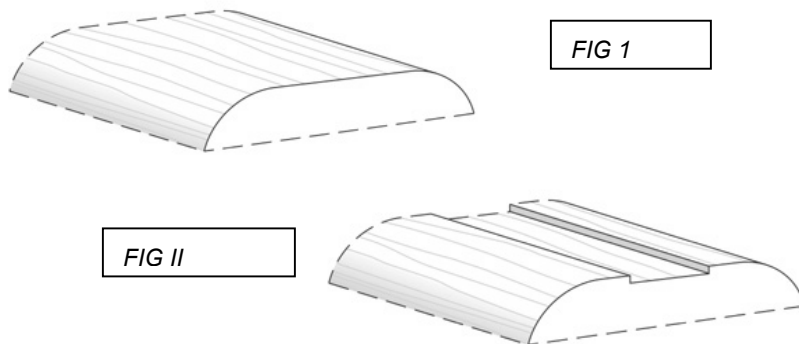
To make a wooden mast stiffer without making it bigger requires a careful approach. If possible, an existing mast needs to be either dismantled or cut in half and epoxied back together.

Typically, a sectional mast is made up of 4, 6, or 8 parts carefully tapered and glued together. While not quite as strong as epoxying carbon fibre to the outside of the spar, strips of unidirectional can be epoxyed to the interior face of the spar to increase its stiffness. The amount to apply depends upon the sectional area of the mast, the thickness of the wood, and the rig loads. You should get a qualified structural mast engineer to calculate this requirement.

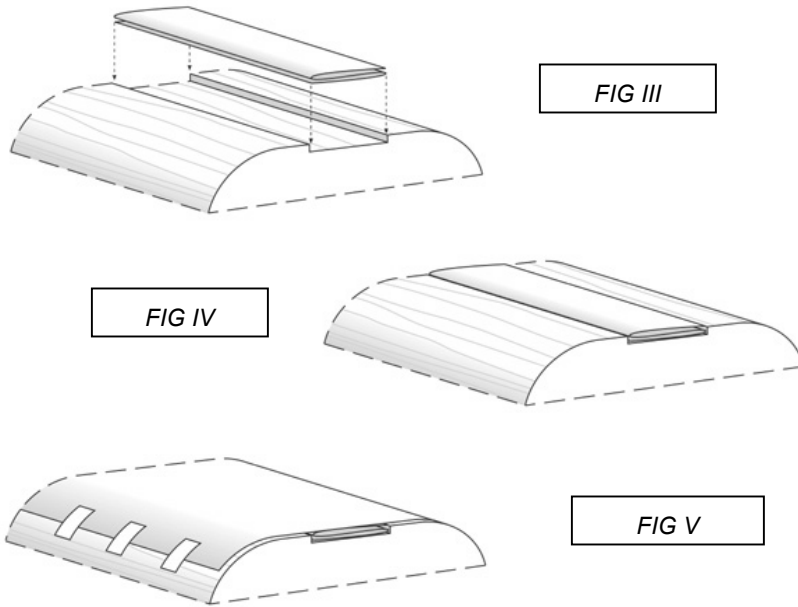


For a new spar the sections can be made up, stiffened separately, and then assembled to form the mast/spar. To give adequate glue line thickness and an invisible joint, use a curved surform file to hollow out the mating faces of the mast section. Once assembled, the whole mast/spar can be sealed or sheathed for a long service life.

On solid spars putting carbon fibre on the interior faces is not possible, and one or more grooves should be routed out down the length of the sides of the mast for increased transverse stiffening (also on the fore and aft faces if longitudinal stiffness is required). *Figs I and II.*



A single wide groove or several narrow grooves should be made to provide a recess into which carbon unidirectional fibres can be set in Epiglass (*Fig III*). Once cured, the carbon can be overlaid with glass tape to provide impact resistance (*Fig IV*). If a wooden finish is required, bond a matching veneer to the glass tape with Epiglass glue mix. Hold this down with a polythene sheet and straps of tape (*Fig V*).



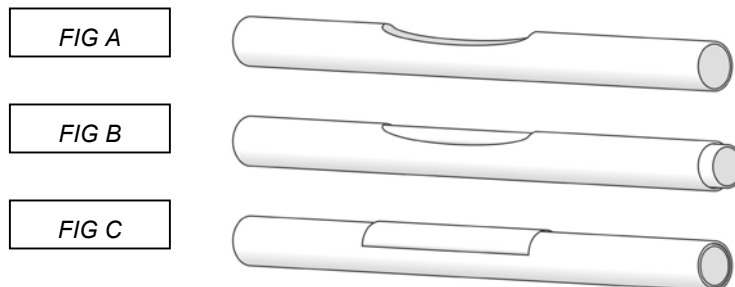
Beware of applying too little carbon over too short a length of the mast. The carbon will be much stiffer than the rest of the mast. If the percentage of the load carried by it is too low, the mast will continue to flex to such an extent that the Epiglass holding the carbon to the mast will pull out the wood fibres at the resin/timber interface and split the mast. A qualified structural mast engineer can specify the quantities and lengths of carbon fibre reinforcement that may be required.

#### REPAIRING COMPOSITE SPARS WITH EPIGLASS

Unlike wood or Aluminium spars, composite spars are made of layers of reinforcement (usually carbon fibre) that are laid up using one of two methods. The first is by wrapping them around a mandrel and applying pressure and heat. The second method is to lay up both halves of the spar in a mold and join the pieces.

If the spar is damaged it is necessary to replace the damaged layers with fresh material that is bonded to the old. Any such repair is likely to be weaker than the original, and some additional reinforcement should be included in the new laminate. If possible, new material should be applied either in a vacuum bag or in an autoclave where both pressure and heat can be exerted.

To make repairs, first grind away damaged material in a series of steps. These steps should replicate the original laminate layers as far as possible. If the damage affects the whole laminate thickness, then the ends of the spar should be opened (*Fig A*). Into the open end of the spar insert an oversized PVC tube that has been split down the length or has a spiral cut (*Fig B*). By cutting the tube, it can be compressed to reduce the diameter and will expand once inside the mast. Before inserting the split tubing, coat it well with mold release wax. Once inserted, the tube becomes a former against which the new laminate can be laid up (*Fig C*).



Cut the new carbon into patch-sized pieces to match the ground back laminates. Using a sheet of polyethelene on a work bench, wet out each patch and apply it to the damaged area. With a brush and roller, roll out any excess air bubbles and apply Peel Ply over the whole repair. If possible, use a vacuum bag to apply pressure to the surface, or wrap polyethelene strips and bind tightly with string. Once the repair has cured, remove the polythene and carefully pull off the Peel Ply. Twist out the PVC tube and apply a coat of Epiglass over the entire damaged area. Sand and paint to match the original spar.

### **MAKING AN ANCHOR LOCKER WATERTIGHT**

Making an anchor locker watertight is a very demanding operation, but the techniques described here can be used to fix any bulkhead-to-hull cracks or separation. The weight of the anchor and chain bouncing up and down in the bow of the boat can strain the seams and joints of the anchor locker in any boat, regardless of the material used in its construction. Often this leads to cracks forming and the locker leaks into the boat rather than draining over the side.

To fix this, the locker walls and floors should be sealed (if they are not metal) and the joints filleted to spread the load. In more serious cases the entire joint may need to be reinforced with Fibreglass tape. For total protection of the locker itself from wear and tear, sheathing with Fibreglass or Kevlar® gives a strong secure finish. Filleting, sealing, and sheathing with Fibreglass have been discussed earlier except for taping the fillet joint. The key to a smooth execution is in the sequence of tasks that comprise the job.

STEP 1: Prepare all surfaces, sand, and wipe with solvent.

STEP 2: Prime the fillet area with Epiglass applied sparingly.

STEP 3: Apply fillet over all the corner joints.

STEP 4: Apply glass tape to fillet. This is applied in the same way as the sheathing operation, with a brush and possibly a roller. To make the job easy and neat, allow the fillet to cure to a gelled stage (B stage). Apply the tape while the fillet is still tacky so that you will not ruin the fillet. By applying the tape now, you avoid the need to sand to obtain a good bond.

STEP 5: Prime and seal the whole locker area with Epiglass.

STEP 6: Apply the reinforcement where required, and work in the resin with a brush and a roller. (Note: Keep drain holes clear by inserting a PVC tube coated with mould release wax.)

STEP 7: Finish off with an epoxy primer such as Gelshield 200. This will give you a hard wearing surface that is easily over-coated in later life.

Steps 2, 3, 4, and 5 may be included or omitted depending on the job.

### **WORKING WITH WOOD**

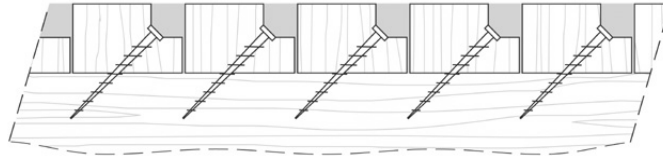
As we mentioned earlier Epiglass can give wood total protection from rot. Wood should be dried to less than 13% moisture content before it is coated, by being brushed with Epiglass just like a slightly thick coat of varnish.

By building up several layers a hard wearing, durable Epiglass surface can be obtained and when the surface is scratched or damaged, it can be sanded it back and recoated with Epiglass.

### **LAYING A DECK ON WOODEN BEAMS**

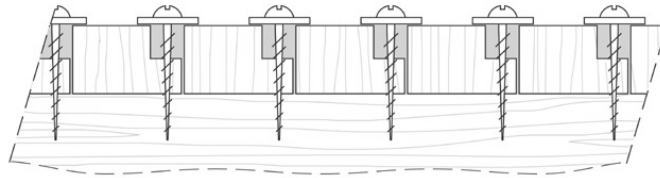
Traditional wooden craft have deck planks laid directly to the transverse beams using a fastening process that required a 45 degree angle through the jointing rebate (rabbit) and then into the beam (see diagram).

#### DECK PANELS

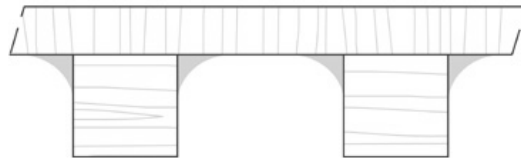


Using epoxy this process can be simplified and the strength and stiffness of the deck improved. The planks are laid directly onto the beam as before, but are glued down to the beam and to each plank another at the same time. This technique reduces the need for an exact fit because the epoxy can be used to fill a gap of up to 2 mm (0.08 inches). While the glue sets, the planks are held in place by screws and metal or wooden tabs.

#### DECK PANELS



The result is a deck less likely to flex and leak. For added rigidity, fillets can be applied to the underside, which may also be sealed with Epiglass prior to painting with primer and/or a finish.



### LAYING A DECK ONTO A SOLID SURFACE

For a more secure deck, marine-grade plywood is often laid first, and teak decking backscrewed to the plywood. To use Epiglass with this method, the approach is slightly different. Preparation of the surface includes a thin priming coat made directly onto the plywood subdeck. Instead of applying glue to the deck beams, an even layer of glue mix should be applied to the entire plywood subdeck surface with a toothed spreader or comb. This spreader can be made from a piece of suitable plastic, such as polypropylene. Many types of spreaders are also available from tile and handyman stores. The teeth of the spreader should be triangular and have a depth spacing of 3 - 4 mm. This gives a glue line of 1.5 - 2 mm.

The standard Epiglass glue mix is suitable, but if you make it a little thicker by adding 50% more glue powder, the application will be easier. Once the glue mix is applied, lay the deck as before, but apply a thin priming coat to the underside of each plank as it is laid. This helps prevent any dry joint areas. Be sure that some surplus glue is squeezed up between the planks. (It can be cleaned off later.) This indicates that the planks are laid firmly onto the deck foundation.

## REPLACING A TRANSOM

Replacing the transom on an ageing powerboat is a two to three-day project. The longest part of the job is the removal of the old transom. The first step is to figure out where to make the cut. If there are no lockers on the inside of the hull, cut the interior laminate and work from the inside out. If there are lockers around or built into the transom you will have to work from the outside of the hull. From the outside, first figure out how much of the boat you will repaint after replacing the transom. If you cut a flange around the transom edges, you will only have to repaint the transom, but it makes the job slightly more difficult and the replacement plywood or foam must be cut into two or three pieces to fit. If you cut directly on the corners of the transom, replacement is easy but you must repaint the entire boat.

On the project boat illustrated here, the transom was cut about 75 mm inside the outer edges of the old transom and the Fibreglass transom laminate was removed in one piece. The old rotted plywood transom was removed by chiseling the delaminated wood away. The transom is left with a Fibreglass laminate with a three inch flange around the edge.



This flange will need grinding back to a tapered wedge shape to allow new laminations to be built up when the transom is replaced. The transom laminate removed from the boat will also need to have a tapered edge ground into it. Grinding it back is a messy job, but one that will make all the difference to the strength of the new Fibreglass joint.

With the Fibreglass tapered it is time to cut new marine grade plywood to fit the space left by the removal of the old wood. Note that if you do not want this problem to reappear use high density (60 pounds or higher) foam instead of marine grade plywood.

Use large pieces of cardboard to make an accurate template of the new foam or wood insert. By offering the template up to the transom you can check it carefully to ensure that the new filler will reach the edges of the hull. If a flange is present as shown on this project, you will be forced to make the plywood in two or more pieces. For example, in the project shown here the transom used two 19 mm pieces of plywood for a total thickness of 36 mm. Both layers were cut into three parts the cuts being as far away from each other as possible.

Before gluing anything, offer all the pieces up to the job to make sure they fit properly. If you have to hammer a piece into place, don't do it until you make the final glued up fit.

## FITTING THE NEW PLYWOOD OR FOAM TRANSOM

It helps to have two or three people at work when the job is to be done. If the daytime temperature is over 60 degrees use a slow hardener to give yourself time to fit everything before it starts to cure.

The order of battle is:

STEP 1: Have one person ready to mix Epiglass and paint the inner faces of the Fibreglass transom laminate and the matching faces of the plywood or foam.

STEP 2: Have a second person ready to make up a stiff Epiglass mix with glue powder and filler powder. This mix should be put into an empty caulking tube and squirted into the corners of the transom. The idea is to fill any voids between the new plywood and the existing transom.

STEP 3: A third person should be ready to put the plywood or foam in place and screw it to the existing Fibreglass laminate (the screws will be removed afterwards).

When you are ready to do the job the person making up the Epiglass mix and filling a caulking tube should start the process. He or she is making the Epiglass mixture, the second person is painting the laminate with an unthickened Epiglass mix. A tip here is to make sure that everyone is wearing coveralls and rubber gloves, it is a messy job and you must work fast to get the job done before the mixture starts to cure.

Put the inner wood layer in place and screw through the inner Fibreglass laminate to hold the plywood firmly to the inner laminate (see illustration). Paint the outer face of the plywood with epoxy and set the next layer of plywood in place. Screw it to the inner layer with screws about every six or eight inches (vertically and horizontally).



The screws should not penetrate the inner Fibreglass laminate. When the plywood or foam is in place and screwed down, paint the outer face of the new plywood and the inner face of the transom laminate with Epiglass mix and screw it to the plywood. Clamp the edges of the transom where possible to ensure that most of the air is squeezed out. You should have a gap about the thickness of a saw blade all around the transom. Leave the entire job to set up in a warm temperature. If you want to vacuum bag the job, now is it the time to do it.

When everything has cured, remove the screws from the outer and inner Fibreglass laminate. Tap the entire laminate gently listening for voids. If you find any, use a syringe to inject more Epiglass mix into the void.

**TIP:** You can inject through the screw holes until the Epiglass mixture oozes out of other holes on the same level. If it comes out of holes lower down, tape the holes over until the mixture has set.

The tapered joint that was created when you ground back the edges of the transom laminate now need to be fibreglassed in place using tape and filler. It makes the joint much smoother if you fill the saw blade sized gap with Epiglass mixed to the consistency of peanut butter, before you apply any fibreglass. Start with a 25 to 50 mm wide tape around the joint, and gradually increase the width of the tape to about 150 mm as you increase the thickness of the laminate.

The final job is to fair the entire laminate to get a smooth transom once more. Don't hurry the fairing part of the project because this is the portion that people will see. Fairing is explained in other parts of this booklet. Once the fairing is complete, use an epoxy primer, rub it down with 400 grit sandpaper and spray on a topcoat to match the existing hull colour.

### **STRENGTHENING AND REPAIRING FIBREGLASS FIBRE FLOORS**

Occasionally, a boat comes into contact with the sea floor with sufficient force that the floors or hull bottom stiffeners become damaged or detached from the hull shell. Alternatively, some sailboats may have their keel configuration altered, requiring new or reinforced keel floors.

Most stiffening beams made from composite or Fibreglass have a low density, low strength core with a Fibreglass shell and possibly an additional capping laminate. To repair damaged floors/stiffeners, locate the damaged section and remove or grind out the broken or cracked laminate. Sand the core with 80 grit sandpaper, and vacuum or brush clean. If the core material is damaged, cut out the affected area and graft in a replacement piece, shaping it to suit the original profile.

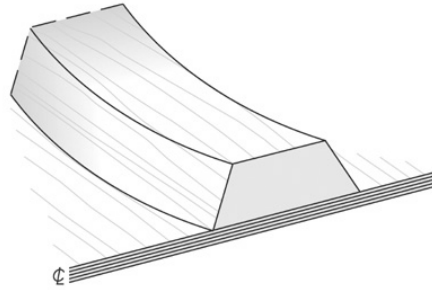


FIG 1

Wipe the job down with solvent and prime the whole area with Epiglass Epoxy Resin mix. Prepare the reinforcement Fibreglass or carbon fibre. The ideal cloth for the stiffener shell is a  $\pm 45^\circ$  biaxial cloth.

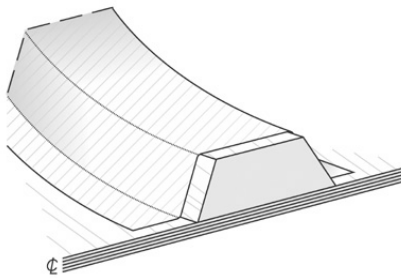


FIG II

This is available in a variety of weights. The heavier cloth will be quicker to apply because fewer layers will be required. With Epiglass you can easily wet-out cloth up to 1200 grams with a brush or a hand roller. Whatever weight you use, you will need to have a minimum of 2 layers if any capping reinforcement is being applied.

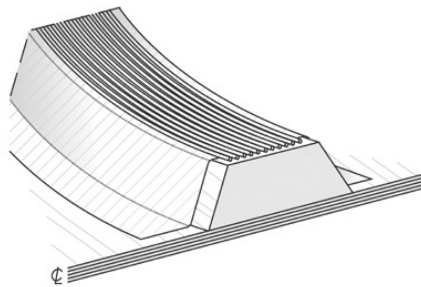


FIG III

Ordinary glass cloth or woven rovings can also be used, but 50% more glass weight is required because of the  $0/90^\circ$  fibre configuration unless you cut diagonal strips from the roll. If the original stiffener is made from a heavy laminate with polyester or vinylester resin and a lot of chopped strand mat (CSM) has been applied to give a thickness, above 5 mm it will be necessary to achieve at least 75% of the thickness with the new laminate. Below 5 mm you need not focus on the thickness but should ensure that a similar weight of glass is used.

ABS, Lloyds, DNV, Bureau Veritas, RINA all have recommendations for the amount of Fibreglass to use, but if the stiffener has failed prematurely or the strength is to be increased, add between 20 - 40% more Fibreglass than the original. Over-stiffening the capping may result in problems, so if you want to prepare for very rough seas or impacts consider either adding more stiffeners or consult a qualified structural engineer. Carbon unidirectional fibre is surprisingly cheap and offers significantly more stiffness for the same laminate weight or reduced weight of laminate for matching Fibreglass stiffness. Strengthening undamaged stiffeners requires only the basic

surface preparation, surface priming with Epiglass, and, while still wet, the application of the capping fibre and a final overlying Fibreglass cloth.

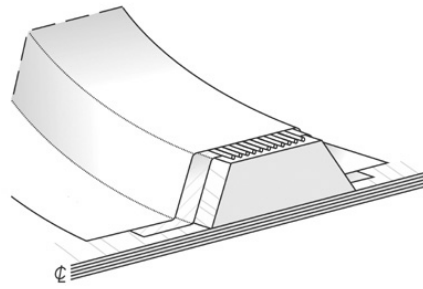


FIG IV



## THE ULTIMATE FINISH

Getting the ultimate finish on a boat takes a little work, but when you start with Epiglass and finish with International you can make the boat look outstanding. Using International products you can build, fair, seal, prime, and topcoat. Only International offers a complete line of finishing products that are compatible throughout the entire range. Here's how to go about getting a superb finish that will enhance a boat's value for years to come.

### GETTING A QUALITY TOPSIDE FINISH ON A WOODEN BOAT

First sand back the hull to get rid of the existing paint. Fill any cracks, dings, or dents with Epiglass mixed with fairing powder after making sure that the damage does not affect the hull's structural integrity. Sand back the filled areas with 120 grit sandpaper. Wipe the entire hull with Thinners No.7 to ensure that it is clean of grease, wax, and impurities. Touch up any areas that are still not quite perfect.

Remember, that the final smooth finish is based on the primer and the fairing job. Any blemishes that appear in the primer or fairing will also appear in the final job. If you want a really good finish, put a lot of effort into getting the fairing perfect and applying primer properly. Sanding back the primer and applying the topcoat are of equal importance.

Make a final sanding with 220 grit sandpaper and wipe down with solvent such as Thinners No.7. Seal plywood with Epiglass before applying Polyurethane Basecoat or Interprime 880. On most other woods apply Interprime 880 directly to wood and sand between coats with 120 grit sandpaper until the surface is translucent. Wipe down carefully with clean rags and apply at least two coats of an International topcoat (dependant on the system used).

For the ultimate clear coat finish combine Epiglass with an International varnish as follows:

STEP 1: Sand the wood along the grain with 220 grit paper.

STEP 2: Wipe down with epoxy solvent to remove sanding residue and any impurities.

STEP 3: Apply 2-3 coats of Epiglass Epoxy Resin mix.

STEP 4: Once the Epiglass has cured to a sandable stage, use 220 - 320 grit sandpaper to achieve an even surface.

STEP 5: Wash down with water & soap to remove sanding residue and any impurities.

STEP 6: Apply International varnish following the instructions for each product.



## CHOOSING THE VARNISH

Product	Appearance	Comment
Interspray 800 Glaze Coat	Clear/Bufferable/Micro finish 2 component	<i>Especially good for achieving a show room finish. 3 - 4 coats will give a buffable finish that also will weather well.</i>
Perfection	Clear/Bright/High gloss 2 component	<i>Hard wearing, excellent chemical and abrasion resistance. Long lasting aesthetic appeal and superb UV protection.</i>
Goldspar Clear	Clear/Satin sheen	<i>Ideal for interior use with its satin sheen.</i>
Schooner	Golden/Warm/High gloss	<i>Traditional tung oil varnish. Easy to repair and re-coat. Rich, golden color and deep gloss.</i>

## GETTING A GREAT FINISH ON A FIBREGLASS BOAT

Prior to any work inspect the gelcoat close up. If it shows signs of a chalky surface or any pin holing, it is best to seal it with Epiglass. If the surface is merely dull or discoloured, this step is optional.

Wash the surface with Yacht Line Super Cleaner. Before the liquid dries, wipe with a clean dry cloth. Sand with 180 grit sand paper to a matte finish. Don't get overenthusiastic with the sanding on a Fibreglass hull, you can go right through the gel coat and into the structural Fibreglass.

Stand back and take a look. At this stage you can go in several directions depending on the amount of fairing that needs to be done. If very little fairing is required, you can simply overcoat with Interprime 820 followed by Interprime 880 Epoxy Finish Primer. If the fairing work is slightly more extensive you can use Interfill 835 Sprayable Fairing followed by Interprime 820 or Interprime 880. Interfill 835 is a sprayable fairing compound which is easy to sand. If you intend over-coating the job within 48 hours, use with Interprime 880 without sanding. If you intend sealing the filler and working on it weeks or months later, use Interprime 820. It sands well but also serves as a holding primer/sealer with long over-coating windows.

Depending on what you decide to do, select the right primer, paint the hull, and sand it back with 320 or 400 grit sandpaper to a nice smooth finish. Remember, the smoother the finish at this point, the better your final job will be. Work it over again if you feel that the finish is not quite good enough.

Apply the topcoat.

## FINISHING A STEEL BOAT

Because of steel's tendency to oxidize or rust, it requires a different preparation than Fibreglass or wood. Before any paint or epoxy can be applied to steel it must be sandblasted or abraded with a rotary sander. This accomplishes two things: it provides a 'key' for the epoxy to adhere to and removes oxidation on the surface of the metal. Before re-oxidisation can occur (within half an hour or so) the surface should be coated with Epiglass Epoxy Resin mix. The residue should be left to cure. This step is probably the most important part of the entire process. If the Epiglass resin mix does not get a good bond, there is a possibility that the finish could crack or craze.

Once the surface is coated, and dried it should be faired in the same manner as any Fibreglass surface. If the welding is done well and little fairing is required, you can use Interfill 835. In regards to priming use Interprime 820. See the note in the Fibreglass section.

On a newly built boat this sandblasting, coating and fairing process is easy, but on an existing boat the fairing may be in good condition. If so, the hull should be patched (if needed) and any

repairs made, faired, and over-coated with Interprime 820 followed by Interprime 880 Epoxy Finish Primer.

### **MAKING ALUMINIUM LOOK GOOD**

Aluminium has a layer of oxidation on the surface that must be removed to get good adhesion. To get the best adhesion the surface should be sanded with 80 grit sandpaper dipped in resin leaving the residue on the surface to cure. Once the resin has cured, you can build up the fairing surfaces as for steel or Fibreglass. If the fairing is in good condition and the boat has been sanded, simply coat with Epiglass and build up the surface as for steel or Fibreglass.

# 3

## 3. Boatbuilding

All over the world, many boats are built using epoxy resins. The Epiglass Epoxy Resin System offers greater tensile strength and the material's cure time can be changed within limits to suit the local conditions. It is a material with no known limits on the time it will last, and a material that can be used by amateurs and professionals alike. Its properties can be improved by curing it under heat and pressure, and once set up it will never become liquid again. It can be used with wood, Fibreglass, carbon or other high-tensile fibres and excels as a boat building material.

### COMPOSITE CONSTRUCTION

Epiglass can be used to laminate with Fibreglass, carbon, Kevlar® and Twaron® reinforcing fibres. It has extremely good wetting out capabilities, is extremely strong when cured, protects against osmotic blistering, and dries without leaving the waxy film that polyester resins often do. It also has good secondary bonding capabilities that polyester resins often have problems with.

#### THE BASICS

Fibreglass is made by drawing molten glass through very fine holes to form filaments. Filaments are then formed into tows or yarns, and the yarns may be woven into cloths, made into chop strand mats, or any of the other multitude of cloths, weaves and fabrics that Fibreglass can be obtained in today.

Fibreglass is not rigid on its own. In virtually every cloth, yarn or weave it simply collapses over the object it is placed on. When building a boat the Fibreglass is placed in a mold and then coated with resin. The fibres must be held together with some form of glue in order to become effective. The three major types of 'glues' or resins in the marine business are polyester, vinylester, and epoxy. Of the three, epoxy is by far the strongest.

#### POLYESTER AND VINYLESTER RESINS

The major resin used in boat building is polyester resin, but the use of polyester has declined since osmotic blisters were discovered on older boats. When polyester became a problem many boat builders switched to an epoxy or vinylester external barrier coat. Some builders now use epoxy or vinylester throughout the laminate, while others switch back to polyester after the barrier coat is in place.

The basic chemical used in polyester laminating resin is orthophthalic acid, making the resin an orthophthalic laminating resin. Another type of polyester resin uses isophthalic acid and is known as an isophthalic resin. A third kind of polyester uses dicyclopentadiene or DCPD to speed up the cure rate. The acids react with other chemicals in the mix to form long chain polymers. These resins work well because they shrink very little, coat the Fibreglass effectively and once set up, they last a long time.

Unlike epoxy, polyester resin is comprised of the resin, the catalyst, and the accelerator. Usually the accelerator comes ready mixed with the resin and the catalyst is added. By adding the catalyst to the resin (at this stage the resin is about the consistency of maple syrup and peroxide is a thin, watery liquid.) and mixing the two components, some heat is given off and the mixture sets up into a solid lump, never again to become liquid. Also unlike epoxies, the speed of cure can be adjusted by varying the amount of accelerator in the mixture. Epoxies need to be mixed in

strict proportions for best results. Polyesters generally use styrene as the solvent for the polyester and can be identified by their characteristic styrene odor.

Vinylester is a vinyl-based polyester with higher interlaminar and flexural properties than polyester [flexural is a combination of compressive, tensile, and shear properties. Interlaminar is important for laminates without chopped strand in between the cloth layers]. Methyl-ethyl-ketone peroxide (MEKP) is used as the initiator of the polymer chain reaction in vinylester and polyester. Vinylester resins are stronger, provide better adhesion, and have less shrinkage than polyester, but they are also more expensive.

## **FIBREGLASS GLOSSARY**

### **E GLASS**

'E' glass is the most basic of the Fibreglass family. It was originally developed as electrical insulation and was first used to build boats in the late 1950s. Both its cost and its strength are quite low compared with the latest materials. It is used by most state-of-the-art production boat builders.

### **S GLASS**

As the use of 'E' glass spread, aircraft builders demanded more strength and lighter weight. 'S' glass was developed to meet these requirements. But 'S' glass is very expensive, so a slightly less expensive high-strength version 'S2' glass was developed for boat builders needing slightly higher-performance materials.

### **GRAPHITE**

Graphite fibre, more commonly known as carbon fibre, is probably the most well-known high-strength fibre. Originally developed for high-speed turbine blades, it is now common in boats. It is a high-strength, high-stiffness, reasonably lightweight material used to carry loads in areas of high stress where several layers of Fibreglass would normally be required.

### **KEVLAR®**

Kevlar® is an aramid fibre made by Dupont. It is very strong in tension but not as strong as graphite or glass in compression. Typically, Kevlar® is used on boat hulls to absorb impacts, in the same way that bullet-proof vests absorb bullet impacts.

### **TWARON®**

Twaron® is made by Akzo Nobel and is a high-modulus, light-weight aramid fibre with good energy absorption and good fatigue properties. It can be used as an impact absorbing layer and has been used to build performance catamarans and Round-the-World racing yachts.

## **FIBREGLASS STYLES**

Fibreglass comes in many shapes and forms. Chopped strand, woven cloths, and woven rovings are the most well-known styles. But for higher strength the cloth needs to be straight. In this case, a non-woven stitched fabric may be the answer. These fabrics are available in bi-, tri- and quadraxial configurations.

## **FIBRE ORIENTATION**

The orientation of the fibres in a reinforcement is relative to the length of the reinforcement. Typically, fibres are run at 0, 30, 45, 60, or 90 degrees to the centreline of a boat.

## **LAMINATING METHODS**

### **AUTOCLAVING**

After a mast or boat part has been laid up, it might be put in an oven where high temperature and pressure are applied to cure the laminate. An autoclave is a vessel that has both pressure and heating capability. By exposing the laminate to pressure and heat, voids and VOCs (volatile organic compounds) are forced out of it and its strength properties are considerably enhanced.

### **HAND LAYUP**

Most boats are built using the hand layup method, in that each length of Fibreglass pre-preg or other material is hand laid in a mold.

### **PRE-PREG**

A resin-impregnated cloth, mat, or filament that can be laid on a boat without adding additional resin or epoxy. After laminating the laminate is cured by vacuum bagging or autoclaving.

### **RESIN TRANSFER MOLDING**

Resin transfer molding is a relatively recent technique originally developed to reduce the number of VOCs getting into the air. There are several methods available, the most popular one being SCRIMP. In all the techniques, the laminate is laid up dry and a bag rather like a vacuum bag is placed over the mold containing the dry laminate. A vacuum up to 60psi / 4 bar is generated and the resin valves are opened. The resin is sucked into the dry laminate. The entire laminate is then cured under pressure.

### **VEC**

Virtual Engineered Composites is a new and expensive method of building a large number of boats developed by Genmar Holdings, Inc. It uses an inner and an outer mold floating in a tank of warm water. The Fibreglass is laid into the mold and resin injected under pressure. The system uses computer monitoring with over 500 nodes to ensure that quality is identical on every boat that is built using that tooling. VOC emissions are less than 3% of a conventional open molding process.

### **VACUUM BAGGING**

After a laminate has been laid up wet it is cured under a plastic airtight cloth that is sucked tightly onto the laminate. The pressure exerted is not a total vacuum, but it is often 0.8 or 0.9 bar. Vacuum bagging is used to reduce the number of voids in the laminate and to compact the laminate to get better strength. The pressures achieved when vacuum bagging are usually not as high as those used in an autoclave.

## **USING EPIGLASS EPOXY AS A LAMINATING RESIN**

Epoxy can be used as a laminating resin. It has lower viscosity than many similar resins and wets out very easily. With the addition of fillers the viscosity of Epiglass can be adjusted to suit the job.

When Epiglass is used as a laminating resin, a general user can expect to achieve a resin to Fibreglass ratio of about 60 to 40 while a specialist should be able to attain a 40 to 60 ratio. Some high-tech builders use additional pressure and heat to get a high-strength lightweight laminate and can get a ratio with about 35% resin and 65% composite reinforcement.

When a hull is laminated, the first step is to coat the mold with mold release wax or release agent to enable the finished hull to be easily removed. An exterior layer of resin about 500-1000 microns thick is applied over the mold release wax to form the outer skin of the hull. (On polyester boats this layer is referred to as the gel coat and while it was originally a polyester resin, it is more likely to be an epoxy or vinylester resin today.) With Polyester resins, a layer of chopped strand mat is placed on the gel coat to reduce 'print-through' and provide an even

backing. Print-through occurs when the resin shrinks and the weave of a Fibreglass cloth shows through the gel coat. A high tech laminate may eliminate the chopped strand and rely on a thick layer of epoxy or paint to cover print through. Once the outer layers have been set in the mold, the remainder of the laminate is laid in place and wetted out layer by layer.

When Fibreglass boats were first built they were almost universally made of layers of Fibreglass bonded with polyester resin. When osmosis turned up in boat hulls, most production builders introduced a vinylester or epoxy barrier coat. Some went the whole hog and switched over to using vinylester or epoxy throughout the laminate. Along with change in resins and epoxies came changes in Fibreglass materials. Biaxial and triaxial cloths replaced chopped strand and woven rovings. Graphite and Kevlar® cloths became part of a composite laminate. In other boats, cored hulls were used instead of a single-skin laminate. Since that time, the state of the art for racing boat hulls has become graphite (carbon-fibre) with epoxy resin, while cruising boats still use Fibreglass and vinylester or polyester. More esoteric boats might have a laminate of graphite, Kevlar® and S-glass laminated using pre-preg epoxy laminates and be autoclaved.

Laminates may be laid up wet, they may be pre-preg, they may be laid up dry and epoxy resin forced into them using a resin injection system known as VARTM or Vacuum Assisted Resin Transfer Molding (The most popular one is SCRIMP® which stands for Seaman Composite Resin Infusion Molding Process), or they may be vacuum bagged and autoclaved (heated and cured under pressure). A boatbuilder may favour any of the above methods. One leading edge builder uses epoxy in an in-house impregnating machine. That way the builder controls exactly how much epoxy is in the laminate.

On smaller boats the entire laminate may be laid up wet-on-wet – that is, a wet or impregnated cloth is laid on another wet cloth – and post cured in an oven. But ovens and autoclaves are expensive and are usually only used for small boats or parts.

A typical leading edge laminate on a high-tech boat might have a 35% epoxy to fibre ratio and may use sophisticated techniques such as B-staged pre-preg cured in an autoclave using 100+ degree post cure and 4 - 6 atmospheres. The builder can also vary the thickness of the epoxy layer. For example, many builders make the outer layer thicker than inner layers for increased strength and abrasion protection. Inner layers usually have less epoxy resin and a higher resin/glass ratio. One builder comments that if you are going to use high-performance carbon fibre, you should use high performance epoxies to get a complete high-performance composite.



*Hull 113, a 57' Spencer Yacht*

To show how far boats using high-tech laminates have come, maxi-sized sailboats (about 24 metres overall) in the 1970s weighed in around 27,000 to 31,000 kgs, with some as heavy as 45,000 kgs. In the '80s their weight was down around 22,000 kgs and in the 90s lightweight maxi-sleds are being built weighing 13,600 kgs.

Epiglass fits into this picture because it is a high quality epoxy resin which has a cure time that can be adjusted to suit the time available to laminate the boat. For example, you don't want to have the layer next to the gel coat completely cured before you lay up the next layer. If the project is fairly large this is precisely what might happen, but with the variable cure time of Epiglass, the builder can adjust the rate at which the epoxy kicks off to enable a second or third laminate to be laid up before the first laminate has set.

For smaller projects and components the slow cure hardener may allow for vacuum bagging and RTM (Resin Transfer Molding) techniques to be employed.

## USING CORE MATERIALS

Core materials can also be incorporated into a laminate to improve its strength. Think of using a core material as similar to building an 'I' beam. The core material represents the vertical portion

of the I and the exterior laminates represent the top and bottom of the I. The core holds the exterior laminates apart. The further the laminates are apart, the stiffer the I-beam or laminate is.

### RESIN RATIOS

Use these formulations to establish what weight of glass has been used in the laminate you are repairing or replacing:

#### FOR CSM LAMINATES: Fiber Resin Ratio = 1:2.33

$$\text{Fiber content} = \frac{1}{3.33} \times \text{Total areal weight}$$

eg: A laminate sample 10 x 10cm that weighs 40 grams:

$$\text{Fiber content weight} = \frac{40}{3.33} = 12 \text{ grams}$$

$$\text{Area} = 10 \times 10 = 100\text{cm}^2$$

$$\text{Total areal weight of reinforcement} = \frac{12\text{g} \times 10,000\text{cm}^2}{100\text{cm}^2} = 1,200\text{g} \text{ or } 1.2\text{kg/m}^2$$

$$\text{Formula} = \frac{\left\{ \frac{\text{Sample weight in grams}}{3.33} \right\} \times 10,000}{\text{sample area in cm}^2}$$

#### FOR CLOTH LAMINATES: Fiber Resin Ratio = 1:1

$$\text{Fiber content} = \frac{1}{2} \times \text{Total areal weight}$$

$$\text{Formula} = \frac{\text{Sample weight in grams} \times 10,000}{\text{Sample area in cm}^2}$$

A cored hull is made by laying the exterior laminate up in the mold and while it is still wet, laying the core material over it. Foam cores should be bonded in a slurry of Epiglass glue mix. To increase the strength of the laminate it is usually vacuum-bagged to eliminate voids. Generally, the core material should be fairly high density, but if a low-density core is used, it should be primed with an Epiglass glue mix before being applied to the job. The vacuum-bagged job is left to cure before the exterior laminate is applied and vacuum-bagged into place. If foam cores are cut or grooved to increase flexibility, care must be taken to ensure the gaps are filled with Epiglass mixed with lightweight fairing compound, as air gaps will lead to early failure of the panel.

## WOOD CONSTRUCTION

The days of building wooden boats using planks carefully shaped and fitted into the hull are long gone. The vast majority of builders now built a wooden hull using either strip planks or diagonally laid planks or a combination of the two. Often a layer of Fibreglass will be laminated over the outside of the hull to provide abrasion and impact resistance. In this type of construction the 'glue' used is epoxy. It encapsulates each piece of wood and seals it against moisture and rot.

Another method of building a wooden boat is to build it using marine grade plywood. Typically this method is used for small skiffs and dinghies, although it has been used for larger sailing sharpies and some fairly high-performance powerboats.

### STRIP PLANKING: METHODS AND TECHNIQUES

To build a new wooden boat the builder first makes sections representing the shape of the hull. These sections are set vertically on a foundation (or strongback depending on what part of the world you are building the boat). Often the major bulkheads are set up in between the sections and in some cases premade furniture is set in place before the hull shell is installed. No matter what parts of the interior are included, the outboard edges of the sections need to be tapered to suit the curvature of the hull.

Once the sections (and bulkheads or furniture) have been tapered the outer skin of the hull is usually laid up by placing strips of wooden planks anywhere between 10 mm and 50 mm thick, and 12 mm to 35 to 50 mm wide longitudinally down the hull. These strip planks are coated with Epiglass along one edge and on the furniture or bulkheads. Each section, which will be stripped out later is protected with a strip of polyethelene so that the epoxy will not adhere to it. Many builders start planking in the middle of the hull and work toward the keel and to the sheer line inserting tapered planks to fill the increased hull girth in the middle of the vessel. Other builders start at the sheer and work toward the keel installing shorter, tapered planks near the keel. The planks are often temporarily stapled (through a double or triple thickness of polythene sheet) to hold them in place while the epoxy dries and to make it easy to remove them after the Epiglass has cured. Other builders use bronze staples and leave them in place after the glue has cured. Leaving the staples in place makes it harder to sand and fair the strip planking before covering it with diagonally laid wood or Fibreglass. In general, permanent fastenings such as nails or staples are only left in place in bulkheads or furniture that will remain inside the boat after the boat is built.

Typical woods used in strip planked construction might be Western Red Cedar, Port Orford Cedar, White Pine, Mahogany, or other woods with a reasonably long life and ease of gluing. The wood is virtually encapsulated in epoxy, and is usually impermeable to moisture, however, poorly made strip planked boats have been known to rot, so it important to have the wood at less than 13% moisture content, totally encapsulate it, and make sure it is protected from abrasion both inside and outside the hull.

To protect against abrasion on the outside of the strip planked hull a builder might place two or three layers of Fibreglass cloth. In effect, sheathing the entire hull. If fibreglass is not desired on the outside, two or more layers of wood about 100 mm wide and 3 mm thick might be laid over the strip planking. If wood is used, generally, it is laid at a 45 degree diagonal from sheer line to sheer line with the diagonals crossing at 90 degrees. A third layer with the grain longitudinally oriented gives a good cosmetic result if the boat is to be finished with varnish or topside paint.

When the hull is finished it is turned over and the sections stripped out and discarded. The main bulkheads are left in place and form the foundation for the interior joinery. The deck may be built separately, but is usually built directly onto the hull using conventional deck beams with plywood coated with Epiglass and screwed to the deck beams. Teak deck planking can be fastened and

epoxied to the plywood deck to give an attractive finish. The entire structure forms a strong waterproof, rot resistant, monocoque shell that can be finished with a number of International painting systems.

This method of construction gives a strong, lightweight hull, is easy to fair and can be finished with a layer or two of clear epoxy. If a painted hull is desired, the entire hull can be faired using Epiglass and primed with Interprime 880 and finished with an International topcoat.

## BUILDING WITH PLYWOOD

Building a boat out of plywood is relatively easy provided that the design has been made using developed sections – that is, sections that allow the plywood to bend in one direction only. In the BC (before computer) days, developing a hull for plywood was a difficult job done by only a few designers. Today, however, a computer can produce a hull specifically shaped for use with plywood extremely quickly. The beauty of binding plywood edges together with Epiglass is that a reasonably thick mixture fills all the voids and gives a smooth finish.

For smaller craft that use a wood thickness of less than 6 mm the most common method is Stitch-and-Glue. To use this style of construction the two sides of the plywood chine are held together with plastic ties, copper wire or even heavy twine. At this stage, the bindings are all that holds the plywood together and the hull is fairly flexible. For a larger craft up to about 8 metres, the hull should be set up on its bulkheads or forms to enable it to hold its shape.

Using a thick Epiglass mixture a fillet is made on the inside of the chine and left to set up. Depending on the builder the ties may be stripped out or covered with a fibreglass fillet and left in place. On larger craft, fibreglass tape is often applied inside the hull over the fillet to give increased rigidity, however, it is easier to strip out the plastic ties or copper wire before applying fibreglass tape to the chine. Outside the hull, the ties are usually stripped out to allow the fibreglass to lay flat on the chine. But in areas where the wood is heavily bent, you may have to apply short lengths of tape between the ties to hold the wood together before removing them.

When the Epiglass is cured, the ties are removed and the entire chine taped outside. With the hull formed, all the ties are removed, the outside is faired using Epiglass fairing mix and sanded back ready to be finished as explained in Section 2.



Larger craft over 9 metres are usually built with 'chine logs' – that is, wooden formers at each chine, at the stem, and at the transom corners.

Having a chine log gives two advantages. First, there is something to screw the plywood to, and second the wood of the chine log helps to protect the end grain of the plywood. Plywood panels are coated with Epiglass and screwed to the chine log and the entire chine is covered with Fibreglass tape and fixed in place using Epiglass. Once the hull has been assembled it is faired.

When using Epiglass, it is good practice to keep the work area clean, scrape off or remove an epoxy drips or runs before the glue sets up, and to use the minimum amount of epoxy to glue tape down or to make a fillet. When taping, masking the surrounding area will help to prevent epoxy sticking to other parts of the hull and causing extensive cleanup. The less sanding and cleanup work you need to do after the Epiglass is set, makes your work much easier. Sanding Epiglass or any epoxy that has cured is hard work especially on the inside of a chine.

At the end of the day make sure that all containers of curing epoxy are disposed of in a way that the heat they emit during curing will not ignite other waste. Clean tools and rollers before epoxy has time to set up and make sure that flammable supplies and other materials are stored well away from the job.



*Hull 113, a 57' Spencer Yacht*

# 4

## 4. Osmosis/Gelcoat Blistering

One of the most dreaded parts of boat ownership is finding that the Fibreglass hull has developed blisters. You can protect against blistering and also treat blisters with several methods. The most drastic cure is to peel the entire outer skin below the waterline off the hull and recoat the boat with an epoxy-based laminate. A less drastic cure is to grind out the blisters or bubbles, and fair and fill what is left. However, such an approach can allow blisters to develop in untouched areas of the hull.

### EPIGLASS AND OSMOSIS

Epiglass is an effective barrier coat against osmotic blistering when it is applied after the original gel coat has been removed. Grinding old Fibreglass away is a job best carried out using a gelcoat peeler (robotic rotary planning machines that peel a precisely calibrated layer of the hull away). The machine can be calibrated to thousandths of an inch or millimetre. There are also hand-held hydraulic and electric planers that may be used. The peelers leave a relatively smooth surface behind ready for a new laminate and top layer of Epiglass Epoxy Resin. In other boatyards, the Fibreglass is sand blasted off the hull (or blasted with walnut shells and other media), but this method tends to leave an uneven surface and can cause damage to the underlying Fibreglass substrate from the blasting media. It can also contaminate the underlying Fibreglass, requiring further sanding to remove contaminants.

Cored hulls pose a particular problem for sandblasting in that the outer Fibreglass layer is often quite thin and it is easy to blast right through it. When this happens, damage to the core often occurs and the core needs to be replaced. However, experience shows that blistered cored hulls often have a saturated core which needs to be exposed to air to dry and may also need replacing anyway.

### WHAT ARE HULL BLISTERS AND HOW ARE THEY CAUSED?

Understanding what causes hull blistering is a large part of the cure. The process starts when the boat is built. The hull mold is polished with mold release wax and a layer of gelcoat sprayed into it. The gel coat is supposed to be impervious to water, but in reality no polymeric materials are totally impervious to water vapour.

Two types of polyester resins (orthophthalic and isophthalic) are used in the construction of boats, although isophthalic is the most common resin. Also in the gel coat are thixotropic agents and often colour pigments. Ideally, the gel coat thickness should be 0.5 mm - 0.6 mm and a wet film thickness gauge may be used to measure its thickness.

On older boats quality control of gel coats laminates was not particularly high and when the gel coat was sprayed into the hull, the sprayer often did not apply a uniform thickness layer of gel coat throughout the mold. Another problem was that the gel coat was sprayed with air-powered equipment rather than the airless equipment used today. These problems, taken together with temperature variations when spraying resulted in gelcoats that contained voids and were less protective than they should be.

When a boat spends a year or two in the water without being hauled for the winter, as often happens with boats in warm climates, seawater has the opportunity to penetrate through the gel

coat where it reacts with the polyester resin. Polyester is made by a process that combines two compounds and removes water, and the accelerator and catalyst, which are present in the resin matrix but not chemically bonded in, are dissolved by water to produce a highly concentrated solution that attracts further moisture.

When water is present within the laminate this process goes into reverse. One of the products of this reversal is an acid, which attacks the polyester, producing a chemical reaction and the telltale gel coat blisters. The only way to eliminate the possibility of blistering is to make the outer gel coat totally impervious to water. At this time most builders use either vinylester resin or epoxy as the external barrier to water penetration because it is most impervious to water.

## REPAIRING HULL BLISTERS

Treating a blistered hull has four key steps; removing the blisters, re-laminating to replace laminate that has been peeled or ground off, re-fairing to restore the original hull and repainting to the finish desired.

The first step in repairing blisters is to determine the extent of the blister damage. Once this is known the decision as to whether to remove the entire surface or coat the underwater portion with Epiglass Epoxy can be made. Typically, if you see a single blister, the entire hull needs work. A blister shows that water has been present in the hull for a long time and bubbles are starting to form. The moisture level in the hull should be measured to ascertain how much work needs to be done. If blisters have yet to form, but a moisture metre indicates that the laminate contains moisture, it should be peeled and recoated. Only if you have achieved the low moisture level should an epoxy barrier coat be applied.

### OSMOSIS REPAIR STEP-BY-STEP

**STEP 1:**

*Peel or sandblast the bottom of the boat*

**STEP 2:**

*Rinse the hull repeatedly with fresh water.*

**STEP 3:**

*Dry the peeled hull thoroughly.*



**STEP 4:**

*Sand or plane out bumps and any ridges left by the peeling process. If the hull has large hollows, fill them after sanding and cleaning.*

**STEP 5:**

*Wash and let dry.*

**STEP 6:**

*Apply a coat of Epiglass® to the entire hull.*



Once the hull has been peeled, the hull must be dried. This can often take a few weeks. A moisture metre will determine moisture left in the hull. Once the hull is dried, the usual process is to relaminate the hull bottom using one or two layers of woven Fibreglass as determined by a boat designer or naval architect. Woven Fibreglass has a higher glass content than chopped strand and is easier to apply to the flat or slightly rounded surfaces of a boat. It is best to use a fairly heavy fabric to minimize the number of layers and save time and effort. Lighter fabrics can be applied in areas of sharp turns such as around the transom, around a skeg, near the forefoot, and at the turn of the bilge. Vacuum-bagging and SCRIMPing a new laminate has been tried, but because it is difficult to obtain a good seal because air can bleed through from the other side of the laminate, neither method has worked well.

Installing a new Fibreglass laminate is done by applying wetted-out cloth to the hull, squeegeeing it in place and then rolling to get rid of air bubbles and voids. (See Sheathing a Hull in Section 2.) The cloth may be applied either vertically or horizontally (longitudinally), with the vertical method being favoured. More applicators are required if the cloth is to be applied horizontally down the hull. In general, sailboats are done by hanging cloth vertically, while powerboats, with their long flat sides, are often done horizontally.

To apply a barrier coat, the hull bottom should be completely cleaned of antifouling paint and a coating of Epiglass applied. Fill as required with Epiglass fairing mix or Interfill 830. Prime with Gelshield Plus or Gelshield 200, and paint the hull with a normal antifouling paint. Research done by International shows that boats protected with Gelshield 200 realise a higher resale price that is about eight times the cost of applying Gelshield 200.

## **FAIRING A RACING BOTTOM?**

At this point you should decide how smooth you want the bottom of the hull. A racing bottom is a lot smoother than the bottom of a cruising boat. We'll go through the process of putting a smooth racing bottom on the hull, with the understanding that the cruising sailor can stop almost anywhere along the way.

To get the best racing bottom the hull should be very, very fair and smooth.

STEP 1: Remove all the paint on the boat. (If you've ground off a lot of the paint to repair blisters, remove the remaining paint.)

STEP 2: Put a long batten (about 2 metres long), made from a piece of 10 to 20 mm plastic pipe or 18 x 50 mm along the bottom of the hull. Use thinner pipe or batten transversely across the hull and thicker pipe or batten longitudinally. Mark any hollows on the hull.

STEP 3: Wipe the hollow areas with Thinners No.7 or YTA910 and make up a fairly thick mix of Epiglass, glue powder, and filler powder. (You can also use Interfill 830.)

STEP 4: Spread the mix into the hollow area and use a batten to get it smooth and fair.

STEP 5: Leave it to set up. When it is set up, sand the area back using a 'long board.' A long board is a sanding board that is just over 1 metre long and up to about 3 metres long depending on the size of the boat, and 75 to 150 mm wide. A long board can be easily made in the yard as required. Use this board with 80 to 100 grit sandpaper working in a fore and aft direction to get the hull bottom smooth.

NOTE: Use a batten often to check the fairness of the hull bottom.
--

STEP 6: Keep going back over the hull until all the hollows are filled and faired as described above.

STEP 7: When the hull is faired and smooth, make keel templates as described in Section 2 and get the keel perfectly fair.

STEP 8: Repeat the process for the rudder.

STEP 9: Apply an epoxy sealer and paint the hull.

## **REPAINTING BELOW THE WATERLINE**

When the entire hull, keel, and rudder are faired perfectly, the underwater portion of the boat should be protected with Epiglass, Gelshield 200, Interprotect or Interprime 820. Using a two-part epoxy coating system reduces water absorption through the hull and protects the underwater metal parts of the boat. It also promotes adhesion of any subsequent coating, e.g: antifouling.


STEP 1: Clean the hull surface with Yacht Line Super Cleaner.

STEP 2: Mix as per the instructions on the can of the chosen epoxy primer.

STEP 3: Apply to the hull as per the instructions. For multiple applications ensure over-coating times are followed.

STEP 4: Apply antifouling. Epiglass and Interprime 820 require a tie-coat before antifouling can be applied. Interprotect and Gelshield 200 are both suitable for this. For more information visit <http://www.yachtpaint.com/>.

The first step in doing a great paint job is to make a full project plan that details the area to be painted. This plan should include surface preparation, priming, any filling, undercoating and finishing. Make sure that adequate time has been allowed for each job. You should also check with your local paint supplier to ensure that any special paint specs are met. In other words, if you decide that the second paint coat is to be applied a day after the first coat and the manufacturer's specs say that it should be applied within six or eight hours, you might need to put in a long day to get the job done right. Getting a great paint job is in the details. Without a solid plan, good preparation, careful workmanship, and material compatibility, even the best painters can fail.



## APPLYING ANTIFOULING PAINT

Applying antifouling paint to a hull newly coated with Epiglass is fairly straightforward. After the epoxy surface is fully cured it should be scrubbed down with a stiff brush and soapy water, rinsed thoroughly with lots of fresh water and then wet sanded with 80 grit sandpaper. The surface is then sealed with a 250 micron thickness of Interprotect or Gelshield 200. When this is all done, the hull can now be painted with the desired International antifouling paint. International has a large range of antifouling paints for racing, cruising, sail or powerboats, refer to the International compatibility chart for compatible paints.

Because there are so many types of bottom paint it is worth reviewing the details.

### SELF-POLISHING COPOLYMERS



SPC technology antifouling works because the film contains a patented technology called an 'SPC Copolymer'. This copolymer reacts with saltwater in a controlled way. As a result, the chemical reactions control and sustain the release of biocides throughout the lifetime of the antifouling without decline. This chemical reaction will take place at the same rate whether you boat is underway or sitting at the dock. This type of technology has previously only been available in tin-based copolymer coatings, which are banned in the EU since 1<sup>st</sup> Jan, 2003. This new, patented International technology is available for professional application to boats of all sizes. Micron® 66 will last for 2 years and beyond. It is not recommended for use in fresh water.

For Self-Polishing Copolymers ask for **Micron® 66**.

### POLISHING ANTIFOULING



This type of antifouling is partially soluble and therefore as water passes across the coated hull, its action steadily reduces the thickness of the antifouling at a regulated rate. This results in a layer of fresh biocides on the surface that are constantly exposed to the water and the fouling throughout the season.

For this reason, this type of antifouling has the capability to perform in the areas of highest challenge. The reducing thickness of the film has other advantages. The minimal build up of the coating at the end of the season reduces the maintenance and preparation needed when it is time to apply the next layer. Micron Extra will last up to 2 years.

Polishing antifouling is available in Micron Extra, Micron Optima and Uni Pro.

## SLOW POLISHING



The latest, slow polishing, TBT-free antifouling from International is Trilux 33. With a slow polishing rate it is very suitable for faster, active crafts as it won't wear away as quickly as traditional polishing antifouling. Boosted with Biolux technology, it has an optimised biocide release system which lasts up to 18 months. Trilux 33 is the ideal choice for aluminium hulls and is available in bright colours.

## HARD ANTIFOULINGS

The technical term for these types of antifouling paints is 'contact leaching'. The paint dries to a porous film that is parted with biocides, which leach out on contact with water to prevent fouling growth. This leaching is chemically designed to release biocide throughout the season, but the amount will steadily decrease until there is not enough biocide coming out of the paint film to maintain fouling protection. Once the biocide is exhausted, the hard paint film remains on the boat. Hard antifouling does not retain their antifouling ability out of the water and cannot be hauled and re-launched without repainting. One of the main benefits of this type of antifouling is its resistance to abrasion and rubbing. This makes it ideal for fast powerboats, racing sailboats or boats where the owners have the bottoms scrubbed regularly. Most hard antifouling paints can be wet sanded and burnished prior to launch to reduce drag and improve hull speed.

For Hard Antifouling ask for VC® 17m or Trilux.

# 5

## 5. Further Information

### EPOXY TERMINOLOGIES: AN EXPLANATION

#### PROPERTY DEFINITIONS

**POT LIFE:** The length of time before the liquid nature of a mix changes to a solidifying gel. Usually shorter than the working time.

**VISCOSITY:** Property of a fluid which resists change in the shape of its elements during flow.

**TENSILE STRENGTH:** The ability a material possesses of resisting deformation by the application of a tensile (stretching) force or load.



**TENSILE MODULUS:** Measurement of the amount of stretch a material can take in relation to the ability to resist stress. e.g.: Rubber has a low modulus, steel has a high modulus.

**COMPRESSIVE STRENGTH:** Maximum compressive load which a material is capable of resisting before breaking.



**COMPRESSIVE MODULUS:** The measure of elasticity in a compressed state. A low modulus material would be more likely to deform before breaking.

**SHEAR:** The tendency produced by loads to deform or fracture a member by sliding one section against another.



**FLEXURAL STRENGTH:** The ability of a material to resist bending. (Combination of Compressive, Tensile and Shear Strength) the stress needed to break the epoxy is measured. A higher number denotes a stronger material.



**FLEXURAL MODULUS:** Measurement of stress vs. strain. A high flexural modulus would equate to a stiffer material.

**SHORE D HARDNESS:** Numerical measurement of cured epoxy hardness. A metal point is forced into the cured epoxy to measure resistance. A higher number denotes a harder surface.



**ELONGATION AT BREAK:** Percentage of increase in length of epoxy as failure under tension.

**INTERLAMINAR SHEAR STRENGTH:** The ability of the resin to hold two adjacent layers together under lateral loads.



**SPECIFIC GRAVITY:** Comparison of density of material with that of water. eg: Water has a specific gravity of 1. Something with half the density of water = 0.5.

## TECHNICAL DATA

COMPONENT PROPERTIES	HT9000	Hardener		
		HT9001 – Fast	HT9002 – Std	HT9003 – Slow
Mix ratio (by weight)	100	22	21	21
Mix ratio (by volume)	100	25	25	25
Color (Gardner)	1 – water white	5 – light amber	5 – light amber	5 – light amber
Mixed color (Gardner)		2 – pale straw	2 – pale straw	2 – pale straw
Component density (g/cm <sup>3</sup> )	1.14	1.01	0.96	0.96
Mixed density (g/cm <sup>3</sup> )		1.12	1.11	1.11
Viscosity @ 25°C (75°F) (cP)	850	100	100	100
Shelf life (months)	24	24	24	24
Hazard definition	Xi, N	C	C	C
Cure to max strength (days)		5	7	7
Minimum usage temp (°C)		10	15	25

CURED SYSTEMS PROPERTIES	Room temperature cure 28 days @ 21°C			Post curing 24 hours @ 21°C + 16 hours @ 50°C		
	HT9001	HT9002	HT9003	HT9001	HT9002	HT9003
Tg DMTA (Peak Tan) (°C)	59	52	52	63	65	62
Est.HDT (°C)	54	49	49	56*	66.7*	60.7*
Shore D Hardness	85	85	85	85	85	85
Barcol Hardness				26*	25.8*	23*
Moisture Absorption (mg)				31.5*	27.1*	22.9*
Cast Compressive Str. (MPa)	109	104	108	106	104	108
Cured Density (g/cm <sup>3</sup> )	1.1	1.1	1.1	1.1	1.1	1.1
Wood Bond Strength (MPa)	4.65	4.65	4.34			
Cast Flexural Strength (MPa)				109	102	103
Cast Flexural Modulus (GPa)				2.8	2.7	2.7
Cast Tensile Strength (MPa)				53.2*	71.0*	69.2*
Cast Tensile Modulus (GPa)				3.5*	3.5*	3.6*
Laminate Compressive Strength (MPa)				190*	216*	212*
Laminate Compressive Modulus (GPa)				16.6*	17.9*	18.6*
Laminate ILSS (MPa)				25.9*	30.1*	27.1*
Elongation to break (%)				6.5*	5.9*	3.3*

\* Lloyds Test Data after 16 hrs @ 40°C (104°F)

## EPIGLASS® POT LIFE

	Fast Hardener HT9001	Standard Hardener HT9002	Slow Hardener HT9003
Pot Life @ 77°F (25°C)	14 minutes	30 minutes	55 minutes
Application Temp.	10°C	15°C	25°C

## WORKING PROPERTIES vs TEMPERATURE

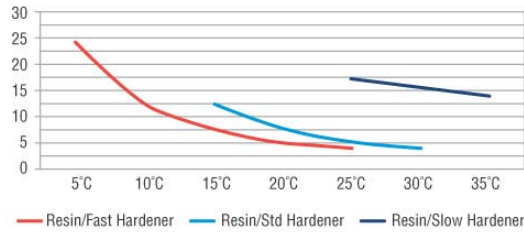
	Resin/Fast – HT9001					Resin/Standard – HT9002					Resin/Slow – HT9003				
	5°C <sup>1</sup>	10°C	15°C	20°C	25°C	10°C <sup>2</sup>	15°C	20°C	25°C	30°C	15°C <sup>3</sup>	20°C	25°C	30°C	35°C
Gel time – 100g mix in water (mins)	74	39	25	17	14	138	72	40	24	17	245	128	75	4.3	26
Thin film working time – initial gel – tack-off (hrs)	6	3.75	2.5	1.8	1.5				2				4	3.3	3
Thin film working time – final gel – overcoat (hrs)	11	6.5	4	2.75	2.25				3.5				7	5	4
Sandable time (hrs)**	64	22	18	15	12										
Demold/clamp time (hrs:mins)	24	12	8	5	4		12	8	5	4			17	16	14

<sup>1</sup> Will cure down to 5°C but best applied at temperatures of 10°C and up.

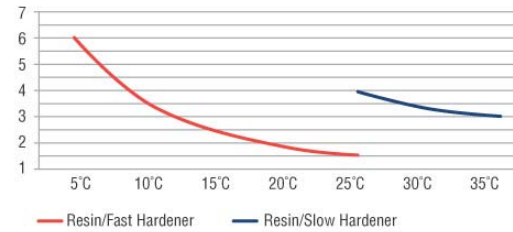
<sup>2</sup> Best applied at temperatures of 15°C and up.

<sup>3</sup> Best applied at temperatures of 25°C and up. \*\* After removal of any surface by-product

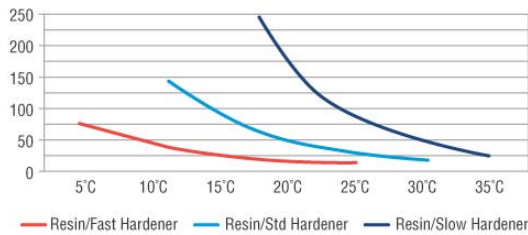
DE-MOLD/CLAMP TIME (HRS)



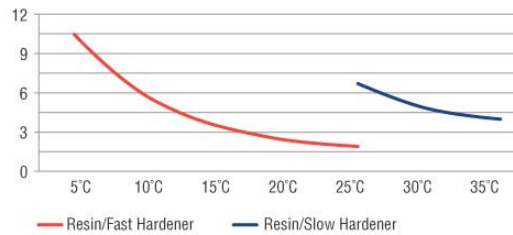
THIN FILM CURE – INITIAL GEL (HRS)



GEL TIME (MINS)



THIN FILM CURE – FINAL GEL (HRS)



## ESTIMATING QUANTITIES REQUIRED

### 1. LAMINATING RESINS

$$\text{Resin/Hardener Mix required (g)} = \frac{A \times n \times W_F \times \text{R.C.}}{(1 - \text{R.C.})} \times 1.5^*$$

A = Area of laminate (sq m)     $W_F$  = Fibre weight of each ply (g/sq m)  
 n = Number of plies    R.C. = Resin content by weight

Typical R.C.'s for hand layup manufacturing are:

Glass - 0.46  
 Carbon - 0.55  
 Aramid - 0.61

### 2. GELCOATS AND COATINGS

SOLVENT FREE:

$$\text{Resin/Hardener Mix required (kg)} = \frac{A \times t \times \rho_m}{1,000} \times 1.5$$

SOLVENT BASED:

$$\text{Resin/Hardener Mix required (kg)} = \frac{A \times t \times \rho_m}{10 \times \text{S.C.}} \times 1.5$$

A = Area of laminate (sq m)     $\rho_m$  = Density of cured resin/hardener mix (g/cm<sup>3</sup>)  
 t = Total finished thickness required (µm)    S.C. = Solids content of mix (%)

## LAMINATE FORMULAE

### 1. FIBRE VOLUME FRACTION FROM DENSITIES

$$FVF = \frac{(\rho_C - \rho_m)}{(\rho_F - \rho_m)} \quad (\text{assuming zero void content})$$

### 2. FIBRE VOLUME FRACTION FROM FIBRE WEIGHT FRACTION

$$FVF = \frac{1}{\left\{ 1 + \frac{\rho_F}{\rho_m} \left( \frac{1}{FWF} - 1 \right) \right\}}$$

### 3. FIBRE WEIGHT FRACTION FROM FIBRE VOLUME FRACTION

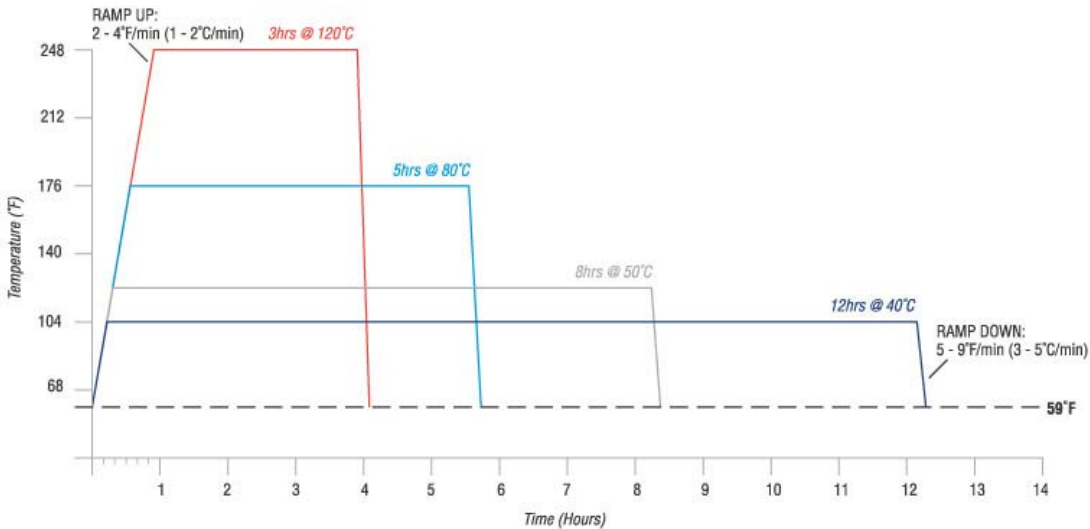
$$FWF = \frac{\rho_F \times FVF}{\left\{ \rho_m + \left( (\rho_F - \rho_m) \times FVF \right) \right\}}$$

### 4. CURED PLY THICKNESS FROM PLY WEIGHT

$$CPT \text{ (mm)} = \frac{W_F}{\rho_F + FVF \times 1,000}$$

FVF = Fibre Volume Fraction     $\rho_m$  = Density of cured resin/hardener mix (g/cm<sup>3</sup>)  
 FWF = Fibre Weight Fraction     $\rho_F$  = Density of Fibres (g/cm<sup>3</sup>)  
 $\rho_C$  = Density of Composite (g/cm<sup>3</sup>)     $W_F$  = Fibre Area Weight of each Ply (g/sq m)

## POST-CURE CYCLE



## HEALTH & SAFETY

Like many boat building materials working with epoxies can be hazardous to your health. Epoxies are a blend of chemicals and as with any chemical, poor handling, misuse, and poor disposal can cause problems. There are some strong chemicals present that should be respected by the user. Always read the health and safety information displayed on the labels and safety datasheets. Always use the recommended personal protection equipment (PPE).

### BEFORE YOU START

Any epoxy is a fairly nasty stuff if you get it on your skin. In extreme cases it can sensitise your skin to such an extent that you may break out in a rash as soon as somebody opens a can of epoxy on the other side of the room. You should always use a barrier cream and disposable latex gloves when using epoxy. Avoid direct skin contact with resin and hardener and wash with lots of soap and water after using epoxy. Make sure you wear long sleeved clothes and that your working clothes are washed regularly. If possible wear coveralls that do not trap sweat, as this allows your pores to open and absorb more chemicals. Change gloves frequently during the day's work, again to avoid any chemicals being absorbed.

Even though many professionals may do it, International does not recommend washing your skin with a solvent. Solvents strip the skin of its natural protective oils increasing the chance of dermatitis and other skin disorders. Use lots of soap and water and wash up before eating, drinking and smoking, before using the bathroom, and as soon as the job is finished.

### WORKING WITH EPOXIES

Protect your eyes with safety goggles and avoid breathing the vapours. If you are not working in a well-ventilated area, wear a respirator. Some epoxies contain VOC (volatile organic compounds) and phenols that can make you sick. If you are doing any sanding wear a respirator to ensure that you do not breath sanding dust. If you get any epoxy in your eyes, International recommends flushing them for at least 15 minutes with running water.

As soon as you have used a resin, hardener, extender or solvent, replace the lid to prevent fumes and fillers from spreading. If you spill any chemical clean it up immediately, by soaking with sawdust, or absorbent material. Dispose of all waste properly.

When mixing fillers and powders with epoxy resin, wear a dust mask or respirator. Fillers such as microballoons or filler powder easily become airborne and may be inhaled. A respirator will give you the best protection, but failing that use a dust mask.

When working with epoxies, keep all materials in closed containers and avoid spillage or leakage. Vacuum up spills of any fillers. If you try to accelerate a cure using an electric heater, make sure the heater has the appropriate safety controls, cannot get too hot, is not placed too near flammable materials, and that there is adequate ventilation available. Exhaust systems should vent outside the workshop or vessel. Ensure also that the heater is not a combustion type such as a propane space heater. Not only will there be an increased fire risk, but the heat will contain extra moisture that may cause a surface by-product to form.

### CLEAN UP

Wash tools with acetone or YTA910. Don't leave unused mixtures in pots or cups. Heat is given off when epoxy sets up and if the mixture sets up in a cup it can emit a lot of smoke. There have also been occasions where a curing mixture has been tossed into a trash can and ignited the

can's contents, burning down the workshop. Put pots of un-hardened mixtures on the ground outside the workshop until they are completely cooled and set hard, then throw away with normal rubbish.

## **ACCIDENTS**


If any chemical gets in contact with your skin, remove it as soon possible by wiping the area with an absorbent material. Then wash the area thoroughly with soap and water. Bostick's hand cleaner towels or Goop will remove resins, but you should wash up with plenty of soap and water.

TIP: Normal table vinegar has also been proved to be effective in removing epoxy residues.

If you get chemicals in your eyes, wash with a mild alkaline solution, flush with running water for at least fifteen minutes, and seek medical help immediately. If you swallow resin or hardener, drink plenty of water and get medical help immediately. Always refer to the MSDS for the correct treatment if a person has been exposed to chemicals.

## **MANUFACTURER'S SAFETY DATA SHEETS**

If you have any doubts about the toxicity of the materials that you are working with, you can obtain a Material Safety Data Sheet from the manufacturer. MSDS's are required for all epoxies and tell you what toxic materials are in the resin and hardener.



## FREQUENTLY ASKED QUESTIONS

### **1. How can I be sure I've used the correct amount of base and hardener?**

Only use the specially calibrated dispensing pumps available from International – don't use other manufacturers dispensing aids as they may be calibrated to dispense a different mix ratio.

### **2. How do I decide which hardener best suits my needs?**

Ensure that the hardener you choose is best suited to the climatic conditions. For warm environments select a slow hardener, in cooler climates make sure you use a faster hardener.

### **3. When mixing the base and hardener the mix started to bubble and smoke, and within a minute I couldn't use it. How do I avoid this?**

Re-evaluate the hardener you are using – is it suitable for the climatic conditions? You are probably using a fast hardener in a warm room, by using a slower hardener, mixing smaller quantities or working in a cooler environment you can prolong the pot life.

### **4. How will temperature fluctuations throughout the curing cycle effect Epiglass?**

Check the temperature during the curing cycle as well as when you mix and apply Epiglass. Using products on winter afternoons and allowing to cure overnight in the garden shed will result in slow cures as temperatures drop rapidly, and will also slow down the recovery cure once temperatures begin to rise.

### **5. How do I avoid a 'soft cure' of my Epiglass mix?**

Insufficient curing agent will usually slow the epoxy reaction down and lead to softer cures, which never really harden up. A slight excess of between 5 and 15% may not be obvious as the epoxy may cure hard and firm. Too much hardener however, may lead to softer cures, as the excess hardener becomes in effect a plasticizer for the cured mass. Avoid this by using the correct mix ratios of base to curing agent (4:1 by volume).

### **6. Could Epiglass cause yellowing in my topcoat?**

Not if used correctly, with the correct amount of base to hardener. However, addition of excess hardener could lead to this problem. Increased moisture and solvent sensitivity can lead to blistering of paint films and possible yellowing of topcoats as the excess curing agent permeates out of the coating. Once on the surface they will yellow or discolour in the sunlight. This is avoided by using the correct mix ratios.

### **7. How can I tell the difference between amine blush and uncured resin?**

Due to the chemical make-up of Epiglass HT9000 hardeners, an amine blush may be seen after curing, which many people often mistake as uncured resin. To tell the difference between amine blush and uncured resin check the cure after a day or so with a fingernail. It should be difficult and/or impossible to dent. Amine blush can be removed with fresh water, or water with a drop of detergent added. Sand the surface, and then continue with the system.

**8. Can I add a tint to Epiglass?**

Universal type tinters are formulated for use in both solvent and water-based products, and contain a type of solvent that will act as a plasticizer, heavily retard the cure and may stay trapped in the film. As this may lead to soft cures, it is not advisable to add tints to Epiglass.

**9. Can I use Epiglass with teak, or other oily woods?**

Yes, as long as the surface is thoroughly cleaned and de-greased, and gluing occurs as soon as possible after de-greasing.

**10. My boat encounters a harsh UV challenge, how can I optimise UV protection when using Epiglass?**

Although Epiglass is a clear coating it does not contain UV protection filters found in other International products. To maximize UV protection, apply a coat of varnish, such as Interspray 800 Glazecoat, Perfection or Schooner, over the top of fully cured Epiglass. A two-component varnish provides the ultimate in UV protection and also durability, helping protect your hull from scratches and minor abrasions.

**11. How long do epoxies really take to cure?**

Room temperature cured epoxies can take up to a month to fully cure. Even at this point they may not be fully cured due to the presence of low levels of both epoxy and amine materials still not cross-linked.

Heat curing will advance the cure to the best that can be achieved, and typically 16 hours at 40°C (104°F) is reputed to cure epoxies to the maximum level that they would be expected to cure at room temperature.

Post curing will also even out the cure of various areas cured at different times of the year. Post curing at higher temperatures may or may not improve the actual cure of room temperature cured epoxies depending on their exact formulations, but will usually help to make the epoxy somewhat tougher as usually its degree of stiffness is decreased slightly as more heat is used to cross link it.

**12. Following a minor accident, I now have a 9-inch wide hole right through the hull (Fibreglass), just above the waterline on starboard side. How can I repair this?**

Begin by grinding away all the loose Fibreglass inside and outside the hole. You will probably end up with ground away area about 15 inches wide. Put a piece of wood covered with polyethelene against the outside of the hull, Make sure the polyethelene is stretch tight and is against the hull. Cut a piece of Fibreglass cloth or use a piece of Stichmat (18 ounce woven roving backed with 1 ½ ounce chopped strand) equal to the hole size plus about two inches. Lay this Fibreglass on another piece of polyethelene covered wood and wet it out thoroughly with Epiglass mix, (make sure you wear rubber gloves.) Wipe the inside of the hull with solvent. Peel the Fibreglass off the polyethelene covered wood and lay it against the inside of the hull. Use a Fibreglass roller to roll the Fibreglass into and around the hole.

Let it cure to the tacky stage. Cut a second piece of Fibreglass about an inch or two larger than the first piece and wet it out. When the first layer is tacky, lay the second layer on top and roll it out. Build up the layers until you have about half the original Fibreglass thickness and let the job cure completely. When it is cured, go outside the hull and remove the polythene-covered wood.

Make identical Fibreglass patches and laminate them in place until you have built up the laminate to the same or slightly more thickness than the original laminate. Let it cure.

You will have to grind or sand away Fibreglass strings, and drips until you have a smooth surface. On this surface make a mixture of Epiglass and add fairing powder until it is about the consistency of peanut butter. Trowel this mix over the area fairing it as you go. You should now have a nice smooth finish on the exterior of the hull. Let it set and allow at least 48 hours for the Epiglass to harden. Sand it smooth and apply a primer coat, let that dry and apply selected paint system.



## **EPIGLASS FOR NON-MARINE USE**

Outside the boatyard, Epiglass can be used for a myriad of projects. It has been used for home and office repairs, for example, the repair of rotted sills and walls in older homes. Because it protects against many boring insects it can be used to protect vulnerable materials with none of the chemical bleed often found with preservative coated wood. Epiglass can also be used to protect wood that will be exposed to water. By fully encapsulating the wood, it will be protected from water absorption.

Epiglass can be used to glue furniture joints together on both new and older furniture with damaged joints. It can be used to preserve and protect furniture or larger projects when used like a varnish and top coated with Schooner or Perfection. Epiglass is also suitable for a wide variety of modelling and craft uses.

In short, Epiglass can be used around the interior of the home and workshop because it does not contain VOCs, and is relatively benign. It can be sanded, although protection should be worn against sanding dust, and it can be applied by brush or roller.

If you use Epiglass for an unusual purpose we'd love to hear about it. Contact your local International office to tell us about it.

## EPIGLASS RANGE LIST

### EPOXY RESIN

HT9000 Resin (YAA900) 200LT, 20LT,  
3.8LT KIT (FAST AND STANDARD)  
1.2KG KIT (FAST ONLY)

### FAST HARDENER

*Formulated for use in colder climates or  
where users require a faster curing system.*

HT9001 Curing Agent (YAA908) 5LT

### STANDARD HARDENER

*The most widely used hardener, formulated  
for most conditions.*

HT9002 Curing Agent (YAA904) 20LT, 5LT.

### SLOW HARDENER

*Formulated for use in warmer climates or  
where users require a longer curing system.*

HT9003 Curing Agent (YAA907) 5LT

### GLUE POWDER

*The extender produces a high strength  
epoxy glue when mixed with the Epiglass  
epoxy resin.*

HT110/QT Glue Powder 50GM Container

### WOOD FIBRE

*A white cellulose fibre designed for adding  
to glue mixes when bonding wood and  
especially for fillet bonding.*

HT220 Wood Fibres 175GM Container

### PUMPS

Used for dispensing Epiglass at a 4:1 ratio.

HT80 Boatyard pack (YXA080) 20LT resin  
and 5LT curing agent.

HT55 (YXA053) for 3.8LT KITS 3LT resin  
and 750ml curing agent.

# Quick Reference Guide

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