SECTION IX - AREAS OF EPOXY USE

In the Introduction we stated that this is not a book about boat construction and repair. While that is true, we believe that the ways of using epoxy described in Section VII will have more meaning if the prospective user can relate the techniques of boat construction and repair. There are a number of boatbuilding books that go into greater depth than we will here.

These books go in and out of print fairly frequently and new ones are always coming along. In addition to the local library the reader should consult current magazines oriented in this direction.

SECTION IX A - WOODEN BOAT CONSTRUCTION

Sheet Plywood

Plywood is a very versatile material widely used in wood boat construction. It is dimensionally stable and needs only to be epoxy coated to protect it from moisture to become an almost ideal boatbuilding material. Several construction techniques are used to fabricate boats from plywood.

It is not necessary to use marine grade plywood in boatbuilding. Marine plywood is basically exterior plywood with a lower void content. Several years ago the plywood association that sets specifications started degrading marine plywood by allowing a higher void content. We believe that the extra cost for fir marine plywood over A-B exterior is not justified today.

Fir plywood boats that see continuous outdoor exposure should be sheathed on the exterior surfaces. Almost all fir plywood is rotary cut and exposed exterior surfaces will eventually check if unreinforced epoxy coatings are used. Sliced veneer plywood has almost no tendency to check. However, we know of no source of sliced fir plywood so plan to put a light layer of cloth on all exterior fir plywood surfaces. Sliced veneer mahogany plywood is readily available in many coastal areas. This plywood is considerably more expensive than fir. Builders using this for small boats rarely fiberglass the surface. Large boats are commonly fiberglassed if only because repair is far more costly if the epoxy coating is breached in impact. Better to build in the protection during production.

Frame, Stringer, Planking Construction

Plywood was probably first used in this type of construction which came along even before epoxy and polyester resins were developed. This is a simple and straightforward method of boatbuilding.

The builder makes the frames from a set of drawings or table of offsets. Some of the frames may be temporary while others stay as bulkheads in the finished boat. The frames are mounted bottom up on a horizontal ladder-like structure called a strongback. Here the rungs are attached to the rails precisely at ninety degrees to the centerline. Strongbacks are precisely leveled so that plumb bobs may be used to aid in attaching the frames to the rungs. Usually an overhead taut wire will represent the centerline in space. The frames are mounted on the rungs of the strongback so that centerlines and reference lines align precisely. Temporary bracing is often used until the stringers are added.

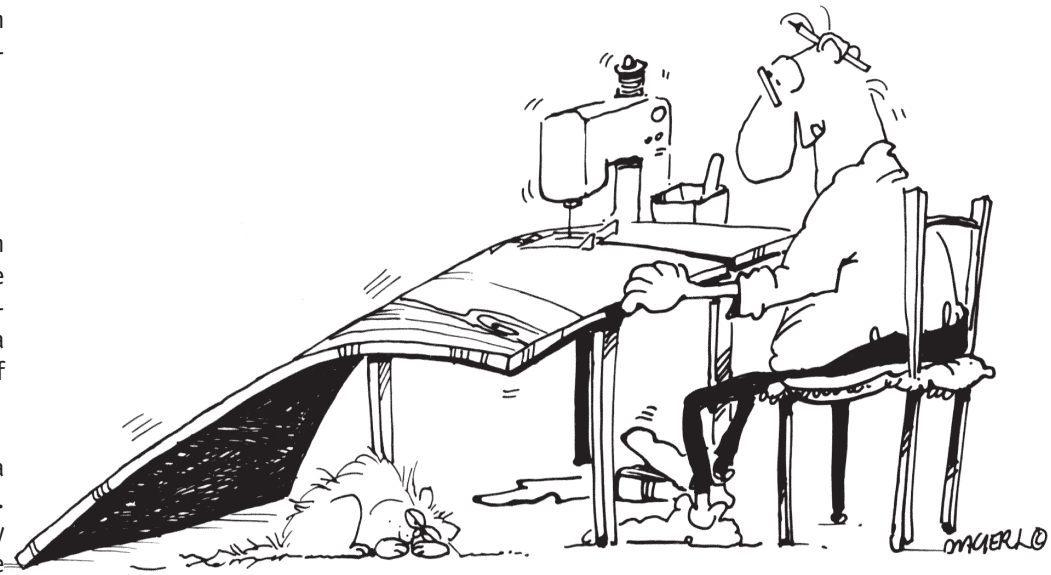
After this notches may be cut into the frames to mount the stringers, which are epoxy glued into place. Once the epoxy has cured the temporary bracing is removed as the frames and stringers are quite rigid. Plywood is fitted and glued to the frame/stringer structure. After this the strongback is superfluous.

The plywood is epoxy coated, faired, and fiberglassed. All the unit operations of epoxy use have been employed so far. There are a number of tricks that can make the epoxy work go easier. For example, the plywood frames could have been coated and sanded even prior to cutting from 4x8 sheets. Plywood planking should have been coated and sanded on the inside before the planking is attached. Some designs use molded chines rather than chine logs. Here, biaxial tape would be ideal to attach adjacent planking.

It is important to remember that there is no one right way to do most anything (except for correct mix ratios!) when boatbuilding. Build it in your head first and you'll think of a lot of short cuts that work.

Stitch & Glue Construction

In a way this uses plywood in hull construction in almost the reverse order of the frame, stringer, planking building method. Here the panels are cut to the correct shape and wired together with soft copper wire through small holes cut in adjoining planking edges. Sometimes a frame or two are used to facilitate in the bending and joining of the panels.



Once wired together the joints are glued by applying large epoxy fillets to the inside edges. The wire is removed and the outside edges are taped with glass cloth and epoxy. Several bulkheads are added and stringers may be glued to the interior panels to increase stiffness.

This construction method, also called sewn seam construction, lends itself very well to small boat construction where the internal structure of frames and stringers are not necessary. Lately several large production boats (56 feet) have been built on the West Coast using this method. The commercial builder of one of these made his own plywood on a 10 by 60 foot vacuum table. Interestingly, many huge fiberglass boats are partially constructed using this method (bows and sterns are still made in a standard fiberglass mold).

Some designing skill is required to take a three dimensional concept and reduce it to a two dimensional drawing that can be laid out on plywood so that edges meet when the panels are cut and sewn together. The first time builder should purchase plans rather than suffer the frustration involved in ruining several sheets of plywood "trying to get it right." The classified sections of the boatbuilding magazines carry ads for these plans. Often, there are also ads for kits where the panels are already cut.

Epoxy coating and perhaps even fiberglassing the panels prior to assembly will save lots of time in this construction method. Learning to make the "no sand" interior fillets described is a must. Removing the copper wire can be tricky. Some builders fillet right over it and then cut it off flush on the outside.

Here it becomes part of the boat. We heard of one builder who hooked the wire up to a car battery for a second or two and then pulled the red-hot wire out with a pair of pliers. We like the idea of making small fillets using Quick Cure 5 and wood flour, or alternately using SilverTip EZ-Fillet wood flour putty every six inches along the inside seam. After a few minutes the wires can easily be removed and the regular fillet applied. Talk to your plans designer and see what he recommends.

Glued Lapstrake Construction

Many people believe that traditional lapstrake construction makes the most beautiful boat of all. They long for a more modern method that produces a light, strong boat without the maintenance problems of the traditional lapstrake boat. Several builder/designers have developed techniques for doing this out of plywood.

Basically, plywood is cut to the proper shape and one edge of each plank is beveled. These planks are attached to temporary mold frames and permanently attached to the stem and transom. The boat is usually built upside down with the very bottom planks applied first. Successive planks are laid on these with about a half-inch overlap. The laps are epoxy glued. Planking continues in this fashion to the gunnels.

The result is a lightweight, stiff boat. The stiffness comes from the doubling at the laps combined with the bent planks. So far, only small boats have been built using this method. A chief aesthetic advantage of this style is that it allows for more roundness in the finished hull than other plywood methods. A possible disadvantage is that it is more tedious than sewn seam construction.

We can't conceive of building a boat in this method without epoxy coating and fiberglassing the plywood panels prior to cutting the planks. The boat would be impossible to fiberglass once assembled. Doing it first means that except for the cut plywood edges the boat is essentially "epoxied" before it is even assembled. We'd seal these after assembly and use fillets to round them into the adjacent planks.

There are several books available on glued lap construction. Check in the various boating magazines to find them. Buy a good design. As much as in stitch and glue construction, cutting and beveling the planks is critical to achieving good results.

Strip Plank Construction

Strip planking has been used to construct boats with lengths from eight feet (prams) to huge power and sailboats. The most common strip planked boats built today are canoes in the fifteen to eighteen foot range. Strip planking readily allows the builder to make compound curved hulls even in shorter lengths.

Strip planking is simply the edge gluing of long strips over temporary mold frames. Most often these are male mold frames although some advantage is possible using female mold frames. The strips are cut somewhat longer than the boat so that they are long enough to be bent around the curve of the mold. Larger boats use scarfed strips to achieve the proper length. Western red cedar is

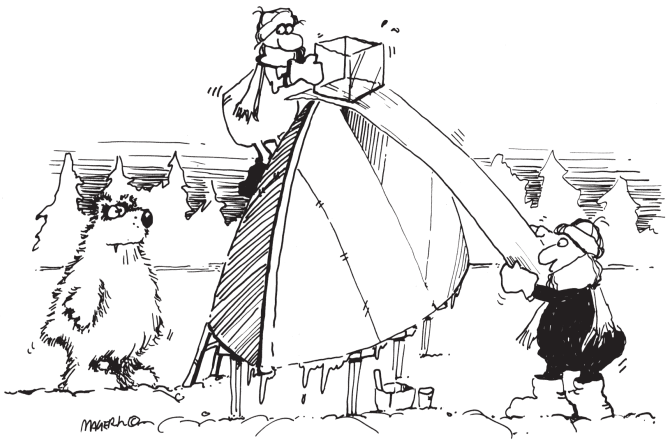
often used to build canoes and smaller boats. It is lightweight and attractive lending itself well to bright finished hulls. Redwood, Alaskan yellow cedar, Sitka spruce, and fir are also used.

Several companies are now marketing veneer faced end grain balsa strips. This material shows promise for boats over twenty feet. It is lighter than solid material for a given thickness. It is also weaker and much more expensive. Because it is weaker more exotic fiberglass fabrics must be used to build strength. This further adds to the cost of using this material and adds enough additional weight to largely offset its lower density when used for smaller boats. In larger boats where lightweight is the ultimate goal and the money is there to buy it, balsa strip is worth considering.

In a way the smaller strip planked boats may be thought of as wood cored fiberglass composite boats, as the sheathing is structural. Here the strips are thin and edge contact area is low enough that the strips need the structural reinforcement of cloth on the inside as well as the outside. As boats get larger strip thickness and glue surface area increase. The overall strength coming from the glued edges begins to predominate and the structural importance of the sheathing becomes less important. Still, most builders of large strip plank boats use a healthy layer of reinforcing material on the outside of the hull. Some large strip planked boats use a double layer of diagonal veneer planking (see section on cold molding). Except for scarfing and edge gluing not much epoxy is used in strip planking until the hull is completed. One neat trick when canoe building is to use Quick Cure to glue the butt ends to the side strips when closing the "football". The outside of a strip-planked boat is faired and fiberglassed before taking the hull off a male mold. In female molding the inside may be fiberglassed and ribs molded in place prior to demolding the hull. Since the sheathing is an important structural part of strip plank boats the designer's recommendations should be followed when selecting sheathing materials.

Cold Molding

The term "Cold Molding" was coined to differentiate the process from hot molding. In hot molding layers of veneer are glued together under heat and pressure. Plywood is hot molded. In cold molding some pressure is used at least to keep the veneer in contact but heat is not generally used. Boat hulls have been built using the cold molding process long before the advent of epoxy resin adhesives. The development of modern epoxy resins has made cold molding into a viable building technique for the professional one-off builder as well as the serious amateur.



Cold molding is the process where strips of veneer are laid diagonally to the hull's centerline over a male mold or plug. Three or more layers are used with each layer at ninety degrees to the one below it. The net result is a large piece of plywood in the shape of a boat hull.

The length of the strips is sufficient to reach from the keel to the sheer with the thickness and width largely determined by the size of the boat. Many materials have been used for cold molding including veneer, plywood, and door skins. Western red cedar, fir, spruce, Alaskan yellow cedar, mahogany, and redwood have all been used to build successful boat hulls.

Epoxy resin is the preferred adhesive because of its great gap filling properties. Veneer is often stapled either permanently or with removable staples. Because the "clamping pressure" varies over the surface small gaps result in areas away from the staple. Thickened epoxy like SilverTip GelMagic fills these gaps to make a solid structure. Some builders prefer to use vacuum bagging techniques to clamp the veneer until the epoxy cures.

Vacuum bagging is a very simple process that uses atmospheric pressure to achieve clamping forces. Essentially, a "bag" is created by using the part to be clamped as one side with a polyethylene film as the other. The two sides are joined with some type of mastic sealant and the air in the bag is removed with a vacuum pump. In order to work properly the veneer must be molded on some type of mold that is impervious to air. The bag must totally cover the veneer (which may be stapled at the ends to hold it into place until the bag is evacuated) and be affixed to the mold surface. Obviously, a more elaborate mold must be constructed for vacuum bagging a cold molded boat.

In the past several years many techniques have been developed that allow hull panels to be cold molded using vacuum bag techniques. The hull panels are cut to shape, butted together and joined along the keel line using sewn seam methods. Two of these techniques, Constant Camber and Cylinder Molding, are especially suited for making long narrow hulls of the types used for catamarans and trimarans.

Cold molded boats are epoxy faired and fiberglassed before removing them from the mold. Once removed they are epoxy coated on the inside and frames and bulkheads are added.

Just as some strip planked boats have several layers of veneer cold molded to the outside, some cold molded boats are built by permanently attaching the veneer to a latticework of frames and stringers. Some carvel planked and caulked boat hulls have been preserved using cold molding techniques. The careful reader will have noted that it is possible to combine elements of several building techniques to produce a strong hull.

SECTION IX B - WOODEN BOAT RESTORATION AND REPAIR

Often our technical service people take a telephone call where the question "I bought this old wooden boat and I was wondering if your product can be used to restore it?" The caller often hopes that slathering on a coat of System Three epoxy will turn the boat into a beautiful modern wooden boat. More often than not we end up dashing his hopes for a quick fix simply because there isn't one.

Modern wooden boat construction takes small pieces of wood in some form and uses epoxy resin to laminate the pieces into one large piece in the shape of a boat hull. This so called monocoque (single piece) structure is very different from traditional wooden boat construction wherein the various pieces are mechanically attached to each other in such a way that movement is allowed. Indeed, it is the movement caused by the swelling of wood by water that keeps these boats leak proof.

Jim Brown of trimaran fame uses the analogy that a traditionally built boat is like a woven basket where a modern wood/epoxy boat is like a bowl. To be watertight the basket must be allowed to swell a little when wet so that the strands press against each other. For the bowl to remain watertight it must be sealed to keep water out - the very antithesis of the basket. Therein lies the problem with slathering epoxy on a traditionally built wooden craft. To do it you must first dry the hull, which causes shrinking of the wood planking. At this point it is no longer watertight. Epoxy coating the planking will prevent it from absorbing water and swelling. It will remain leaky.

While it is possible to stuff thickened epoxy into the opened seams of the dry hull, fiberglass the outside and produce a leak proof hull the results are apt to be temporary as the planking will pick up moisture elsewhere and swell probably cracking the fiberglass. Dry wood picks up moisture and swells producing forces that greatly exceed the strength of epoxy resins.

If the boat owner is aware of the risks and is prepared to sink a lot of labor into the project some traditionally built boats can be brought into a modern monocoque condition. The key to success is devising a way that will eliminate or reduce the movement of the various wood members permanently. The problem is that no one possesses the crystal ball that predicts such success. The following will give a rough outline of the techniques involved. Be advised that there are no guarantees and the situation may deteriorate rather than improve.

Plywood Boats:

These pose no problem in restoration as they are essentially built as modern plywood boats. Dry the hull thoroughly. Remove all coatings and take the boat back down to bare plywood replacing any rotten plywood. Make sure that the frames are in good shape and replace any that aren't either by sistering in new frames or building new frames and installing them. Epoxy coat the bare plywood and fill depressions, screw holes, staple holes, etc. With System Three epoxy and microballoons. Sand fair. Lay down fiberglass cloth and reinforce the chines, bow, corners, etc. Finish as described in this book. If possible, the inside should be taken down to bare plywood and epoxy coated. Remove any oil or grease that would interfere with epoxy adhesion.

Carvel Planked and Caulked:

The important thing here is that the planking has got to be immobilized against both mechanical movement and moisture swelling.

Remove all caulking by using a router or saw blade. Dry the hull thoroughly and remove all outer coatings down to bare wood. Remove any damaged planks and replace. Make sure that the frames are in good shape and replace any that aren't either by sistering in new frames or building new frames and installing them. Refasten any loose planks. Fill the seams with thickened epoxy or glue in wedge shaped battens if the gaps are wide. Fair the hull using System Three epoxy and microballoons.

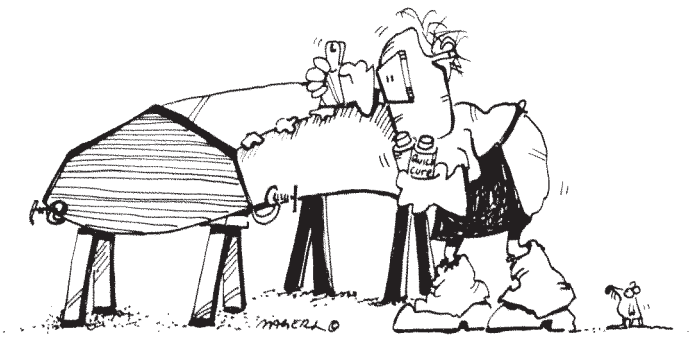
At this point a crucial decision must be made. The planking must be sheathed with an outer layer that is structural. We believe that the best way is to use a double diagonal layer of veneer at 45 degrees to the planking. The veneer is then finished as a new hull. An alternative way is to use a structural fabric and orient the fibers so that they lie perpendicular to the planking. As added insurance the inside of the hull planking should be taken down to bare wood and epoxy coated. This may not be possible without gutting the boat. If you go this far put nice generous fillets in the corners formed by the frames and planks.

Glued Planking:

Restoring these boats is quite similar to carvel planked boats except there is no caulking to remove. Make sure the hull is dry, the planks well fastened to the frames and each other regluing the planking where required. Follow the outline above.

Traditional Lapstrake:

We do not recommend restoring this construction method with epoxy resin. Restore boats built of traditional lapstrake construction using original techniques.



SECTION IX C - COMPOSITE CORED CONSTRUCTION

Many high tech one-off custom boats are built with epoxy resin and exotic fabrics such as Kevlar and Carbon Fiber laminated onto cores of vinyl foam, balsa, or thermoplastic honeycomb. Phase Two epoxy is System Three Resins' preferred material for this type of construction. These boats are built on male or in female molds in a variety of ways.

The chief structural difference between this and more common wooden boat construction is that in wooden boat construction the wood acts as the "core" and is structural. The fiberglass/epoxy skins protect the wood against the elements rather than strengthen the wood core to any great extent. In composite cored construction the opposite is true. The skins carry most of the structural load and the core, by separating the skins, provides stiffness and enables the builder to produce a very strong, lightweight hull. This not so obvious difference dictates very different requirements for the matrix resin used. A resin well suited for a wooden boat will not be good for a composite cored hull. Those who tout their products for both types of construction are robbing Peter to pay Paul and penalizing builders of both types of boats in the process.

Almost all serious racing sailboats and powerboats are composite cored. The materials used to build these boats are expensive. Generally, the lighter the hull the more it costs. Lightness comes at a high price if strength is also a requirement. The reason for the extreme push towards lightness is that with limited horsepower (sail area or engine size) a lighter hull will move faster.

Proper design and engineering of these boats is essential if they are to be lightweight and still hold together. Because the materials used in composite cored construction are exotic and expensive a proper shop with the right environmental control is a must. These hulls are almost always postcured. That is, after the laminate hardens the entire hull is raised to an elevated temperature for several hours to finish curing the matrix resin. Phase Two epoxy requires this post cure to achieve it's ultimate properties and it is folly to use a product like Phase Two unless it will be post cured.

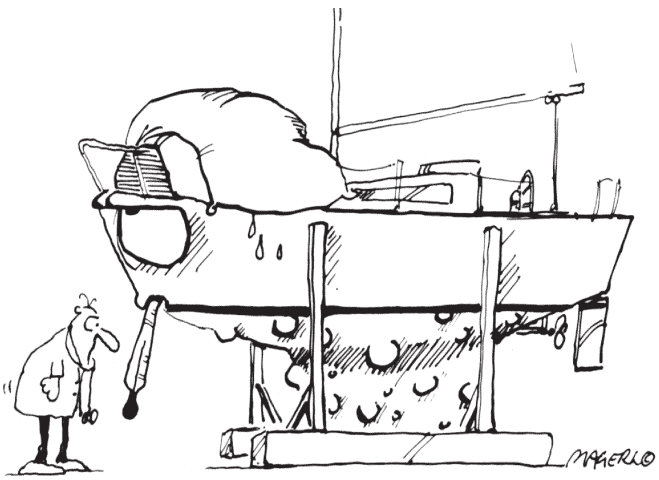
If you are interested in learning more about composite cored construction ask for System Three Resins' publications "Two Phase Epoxy Systems for Composite Cored Construction" and "Using Phase Two Epoxy Resin".

SECTION IX D - FIBERGLASS BOAT REPAIR

Epoxy resins are increasingly being used to repair polyester/ fiberglass boats both above and below the waterline. The usage techniques are identical to those used in wooden boat building and described in Section VI of this book. The only real difference when using wood and epoxy is that wood is porous, at least for the first coat. Fairing and hole filling on a fiberglass hull is no different than doing the same thing on epoxy-coated wood. The same materials and tools are used.

The greatest use of System Three epoxy for fiberglass hull repair is gel coat blister repairs below the waterline. The product is used for many above waterline repairs as well. Polyester gel coats generally are not used as finishes on epoxy repairs. However, it will bond to System Three Resins' SB-112 epoxy system. We recommend the use of this product where the repair will be finished with polyester gel coat.

Above Waterline Repairs:



The first thing before attempting to do any repair is to assess the problem. It is not possible to know how to fix something until you know why and how it broke. Professional repair yards understand this while many boat owners do not. Spend some time understanding the problem.

If, for example, a boat owner discovers that some fiberglassed in wood engine stringers are rotting; it will be necessary to pull the engine to affect a repair. Do this and then poke around to see the extent of damage. Don't get out a grinder and start hacking away at the fiberglass in an effort to remove the cancer that affects your boat. In many cases fiberglass boat repairs using epoxy resin can utilize the existing structure to make a speedy repair. The very top of the fiberglass can be carefully removed and the rotten wood scraped out. A new piece the same size can be fitted, epoxy coated and glued in place using the fiberglass that was bonded onto the sides of the removed wood. The fiberglass top is then epoxy glued on the new wood and, presto! the new engine mounts are ready to go without a lot of realignment problems.

Think the problem through before mucking things up! Each problem and boat has it's own peculiarities. Study the problem on your boat and use the principles of epoxy use described in this book. If you need more knowledge there are a number of books on fiberglass boat repair. You are probably not going to find that your boat fits any of the textbook examples in the repair books so you'll have to make up your own recipe for success. It is doubtful that a can of some glop sold by some marine store will do the job. Study the problem, plot out the solution step-by-step, make a dry run in your head to see if you've missed anything, order the materials, get everything ready and go. This is the way the professional repair people do the new, unfamiliar repairs and you can too!

Gel Coat Blister Repairs.

Much has been written about this increasingly common problem in polyester resin fiberglass boats. It is beyond the scope of The Epoxy Book to go into the "why" of the problem. System Three epoxy is highly rated by one consumer boat repair magazine for this purpose.

Many people and boatyards use our product in the repair of gel coat blisters. This section describes the method of repair. We do not claim that this is either the only method or the best method available. Our only claim is that the method described herein is being used and the track record has been generally good. There have, however, been a few failures using our products just as there have been using others' products and methods. This section has not been written as an inducement to sell our product for this purpose. Blister repair, being an inexact science, is one where you "pays your money and takes your chances." Please read the special warranty at the end of this section before deciding to use our products for gel coat blister repair.

We caution that gel coat blister repair is a dirty labor-intensive job. This is why the price the yard quoted may seem so high. Compared to the labor cost the materials are cheap. Unless you have more time on your hands than money in your pocket, you might want to accept the yard's offer and have them do it. Or, you might have the yard do the gel coat removal and you do the rest with some occasional hired help. If you do plan to do the job yourself, make sure your haulout yard knows what you plan to do and allows it.

STEP 1: Clean Hull – Remove Bottom Paint.

Remove all marine growth, scum, barnacles, etc. Your yard may do this upon haulout by hydro blasting or steam cleaning. It may be necessary to use a scraper to get the barnacles off.

If your boat lacks a boot top stripe you'll want to develop a technique for marking the top of the bottom paint line. Running masking tape above the line on the topsides is a good method. It will become frayed when sanding and you'll want to replace it for Step 7. Making small grease pencil marks right above the tape on the topsides every foot or so will serve as a guide for the new tape. These are easily removed with soap and water or paint thinner when the project is finished.

When the hull is dry you've got to make a decision whether you are going to remove the gel coat or merely abrade it by sanding and opening the blisters as discussed below. The decision will largely hinge on the extent of blistering. Removal offers the greatest chance of a complete cure but it also requires great labor to bring the hull back to its original fair condition. Merely sanding but not removing gel coat eliminates a lot of the fairing problems but may

miss some of the small blisters. They may show up on next haulout and you'll have to patch them then.

Sandblasting is the easiest, fastest and most widely available way to remove the gel coat. Several newer methods that work like a power plane or joiner have been developed but the equipment is expensive and not yet widely available. It is worth paying a professional to remove gel coat. Your yard may know of someone who does this. Be sure to check with your yard to see if they even allow sandblasting. Some do and some don't. If sandblasting, be careful to remove only the gel coat and any damaged mat. Digging into the hull with the sandblaster will weaken it as it removes structural fabric.

A 1500 to 2500 rpm sander polisher with an eight-inch foam backed pad is the best way to sand gel coat. Be advised that this is dirty, strenuous and tedious work. You can do it yourself but will get very tired and may spend as much money in time and materials as you'd have paid to have someone come in and sand it for you. Hulls with gel coat removed dry faster than those with the gel coat intact.

Bottom paints contain toxic materials. Avoid breathing dust or getting dust in cuts or open sores. Always wear suitable dust masks. Wash contaminated clothing separately from other clothing.

STEP 2: Open Blisters -Remove Damaged Fiberglass.

If you have elected to remove the gel coat you have already completed this task. Skip on to Step 3. If you have only sanded the gel coat and do not plan to remove it, read on.

Now is the time to open the blisters and clean them out. Use the point of a utility knife to puncture each blister. Insert the knife and with a twisting action, cut out the damaged gel coat and fiberglass. Remove all the "rotten" material. Keep cutting until you get it all out. Don't worry about cutting good fiberglass. It is highly resistant to cutting. Use the knife to get rid of all undercuts, as they will make filling more difficult.

Other tools may be used also. Small rotary files attached to electric drills have been successfully used. The idea, whatever you use, is to open up the blisters and remove damaged gel coat and fiberglass. Blisters generally contain acidic water under pressure. The water may contain dissolved material, which could cause eye irritationor damage. Wear safety goggles and stand back out of the line of fire.

STEP 3: Wash and Dry Boat and Blisters.

Wash the boat thoroughly from the boot top stripe down with fresh water to remove all traces of salt, blister fluid, sanding dust and other dissolved material. Rinse the hull well. Be sure to squirt the water into the exposed blisters to remove any contaminants in the blister. Let the boat drain and air dry for several hours. Look and see if any purple-brown colored vinegar smelling liquid is oozing out of opened blisters. This is blister fluid. If it is, then dig out those blisters even more and rewash. Repeat this step as necessary.

The next step, drying the hull, is the single most critical operation to affect a cure that lasts. It is of paramount importance that the hull be as dry as possible. Start by emptying the bilge of standing water. In 80°F weather at 40 percent relative humidity the average blistered hull will take three weeks to dry to a steady low level. You may not be able to achieve these conditions without "skirting" the boat and using heat and a dehumidifier. If you plan to do it this way we recommend reading "A Manual for the Repair of Fiberglass Boats Suffering from Osmotic Blistering" by Richard and Roger McLean.

Some people have suggested that the hull drying process can be accomplished by vacuum bagging. We have studied the results of this process and talked with those who have done it. While there is some initial drop in hull moisture content, this method will not properly dry a hull even at safe elevated temperatures. We cannot recommend this method of hull drying.

If you live in an area where boats are hauled in the winter do Steps 1, 2, and 3 in the fall and when the weather starts to warm in the spring, skirt the boat and finish the drying.

STEP 4: Fill the Blisters.

When the hull laminate has completely dried you should roll on a sealer coat of mixed Clear Coat epoxy resin/hardener. Work the mixed resin into each cavity to wet out any damaged fiberglass. Allow it to soak in for an hour or two. Then mix up some System Three epoxy and make a tilling putty by the addition of microballoons and silica thickener. This material makes a non-sagging putty which will replace the material you removed in Step 2. Try to perform this step on the shady side of the hull if possible as you will have longer working time.

Initially, mix small batches until you get the hang of working with QuikFair or an epoxy/microballoon mixture. You can always mix more but once mixed you've got to use it within a short period of time or it will go off in the pot. Fill each blister from the bottom (otherwise you will trap air) using a putty knife or similar tool. Fill flush with the gel coat surface with a slight overfill which will be sanded down later. Finally, use the edge of the putty knife to scrape off any excess around the perimeter of the hole. Get it now before it cures or you will have to sand it off later.

Fill all the blisters and allow to cure at least overnight if the temperature is above 60°F or two nights if the temperature is below 60°F before proceeding to step 5.

If you have had the hull sandblasted then you may not have blister pockets to fill. Your job is to begin fairing. Before beginning, roll on a coat of mixed Clear Coat resin to seal the exposed fiberglass surface. Allow several hours to cure before fairing. The idea in fairing is to restore the surface to the gel coat level prior to removal. You will do this with the same with QuikFair or the microballoon mixture but use a broad knife or similar tool to apply it. In effect you will be plastering the hull with the epoxy microballoon mixture and sanding it to get it fair. A careful job applying the "mud" will save hours of sanding later.

STEP 5: Sand the Hull.

Use 60 grit aluminum oxide paper and sand the filled cavities fair with the surrounding hull. Blocks or sanding pads help avoid sanding the cured putty below the surrounding hull surface. The putty will sand faster than the fiberglass. Refill any concave holes or exposed air bubbles with the putty blend. Allow to cure and resand.

If you removed the gel coat and puttied the entire hull bottom you will now sand it fair. This is best done by two people using a long board. This is just a long sanding block with paper glued to it. The flat part of a straight 2x4 about 3 feet long works well. You may find that the sanding will reveal low spots that require additional microballoon mix. Fill them, resand and continue in this fashion until the entire hull is without ridges, bumps or hollows.

STEP 6: Prepare the Hull for Epoxy Coating.

After the cavities have all been filled and the hull is fair it is necessary to prepare the hull for epoxy coating. It is this coating that will help prevent the hull from blistering in the future as the epoxy coating is much more resistant to water penetration than the polyester resins used to build your hull.

Begin by sanding the entire hull to be epoxy coated with 60-grit paper if you have not sanded it in the filling/fairing process. You may hand sand it or use a vibrating sander. Rotary high-speed sanders should only be used if you are confident about your ability to use them. They are heavy and cut fast and you may end up gouging the hull. Sand the hull until there is no gloss left - sand right up to the old bottom paint line. Avoid breathing the dust.

After the hull has been thoroughly sanded wash it with water to remove the sanding dust. Really get in there and scrub it with a clean brush to remove all traces of sanding dust. Rinse and allow it to dry well - at least overnight.

STEP 7: Coating the Hull with Epoxy.

You will need System Three epoxy resin and hardener, disposable gloves, graduated cups, stir sticks, yellow foam roller covers, roller frame, disposable brushes and a 9" roller paint tray for this step. Use only the roller covers supplied by us. They are designed for our product.

The idea here is to get on a minimum of four coats of epoxy without the runs and sags that will require a lot of sanding later. It is this coating that provides the barrier that help prevent the future intrusion of water into the hull.
First run masking tape around the boat so that the bottom edge of the tape is right at the top of the old bottom paint line. This will help prevent rolling epoxy on the topsides or boot top stripe.

Put on the gloves and mix up about six ounces of resin/hardener. Pour the thoroughly mixed material into the roller pan and "paint" the hull using the yellow foam roller covers. Put on as thick a coating as possible but not so much that it will run and sag. Experience will teach you how much you can get away with. Better to spend the time putting on an extra coat if the previous coats have been a little thin rather than sanding out runs later. If you see a run developing go back and roll it out. The resin/hardener mix contains no solvent so you won't leave marks if you do this. Brush out any air bubbles with a foam brush using light strokes. Just use enough pressure to break the bubbles and not disturb the uncured epoxy.

Remove the masking tape right after you finish the first coat. Do it before it cures or else it will be difficult to remove later. Wear gloves since the masking tape will be wet with epoxy.

Retape then apply the next coat as soon as the previous coat is set enough so the combination of the two coats will not run and sag. This is about 2 to 3 hours with fast hardener on a 60°F day. Less on a warmer day, longer with slower hardener. You may wait up to 72 hours between coats without sanding as long as the hull does not become contaminated in the meantime.

Put the succeeding coats on the hull right up to the top of the first coat. By catching the light right you'll be able to see where the first coat ended and the new coat starts.

If you wait longer than 72 hours between coats you'll have to give the epoxy a light sanding to give the new coat some "tooth" to tie into the previous coat. Prior to this time the coats will bond chemically to each other.

Allow the last coat to cure overnight before proceeding to the next step - even longer if the temperature is below 60°F during the cure cycle.

STEP 8: Sanding for Bottom Paint.

Hose and sponge the hull with water to remove any oily surface film on the cured epoxy. This is a water-soluble film and will be thicker if you applied the coating in humid weather. It is a by-product of the epoxy curing reaction. Solvents do not remove this film.

Sand the cured epoxy with 80-grit paper to smooth any runs and kill the gloss. A sanding block helps to prevent over sanding when removing cured runs. Be careful not to sand through the epoxy coating and re-expose the gel coat thus losing the epoxy protection. If you desire an even smoother bottom you may want to use finer grades of wet and dry paper. If the sandpaper clogs excessively then the epoxy coating has not sufficiently cured. Wait another day. Wet sanding helps prevent paper clogging and keeps the dust down. Use wet or dry sandpaper and dip it into a bucket of water occasionally.

After sanding, wash the dust off with a sponge and water. Allow the hull to dry. Wipe with acetone, MEK, or the solvent recommended by the bottom paint maker for preparation to applying this paint.

Do not be seduced into believing that bottom paint can be applied to partially cured System Three epoxy. Some would have you believe that this avoids final sanding of the last epoxy coating. If you do this you may find that the bottom paint along with the last coat of epoxy will start to fall off in several months.

STEP 9: Applying the Bottom Paint.

Follow the manufacturer's recommendation when applying bottom paint to the epoxy-coated hull. Most bottom paints will adhere well to the sanded epoxy coated hull with no primer. Keep in mind, however, that bottom paints are formulated for polyester gel coat hulls and some may not work well on epoxy coatings. You should do a small test patch on your hull to make sure that the bottom paint dries properly and adheres well to the epoxy coating.

Estimating Amounts

Figure 0.2 gallons of mixed resin and hardener per coat per 100 square feet of hull surface (500 sq. ft. per gallon per coat) to be coated for the barrier coat. Thus, a 30-foot sailboat with 175 square feet of under water surface will require about 1 3/4 gallon of mixed resin/hardener for the barrier coat. The amount necessary for the filling/fairing will depend greatly upon each boat.

Materials List

The following materials are available from System Three Resins and will be necessary for the completion of a blister repair job.

Epoxy Resin and Hardener	Filler Materials
Measuring Cups	Mixing Sticks
Mixing Pots	Disposable Gloves
Disposable Brushes	Foam Brushes
Roller Covers	Roller Frames
Roller Tray	Squeegees
Masking Tape	Dust Masks
Utility Knife	Sandpaper
Safety Goggles	

In addition to these materials you will need hoses, buckets scrub brushes, clean rags, paper towels, putty knives, a ladder, sanding tools, etc.

SPECIAL WARRANTY FOR GEL COAT BLISTER REPAIR

Because the construction of your hull and the repair of the gel coat blisters are beyond the control of System Three Resins, no representations or warranties are made or implied that future gel coat blistering will be prevented using the techniques and materials described in this booklet. System Three Resins shall not be responsible for incidental or consequential damage as a result of using its materials or the techniques described herein. System Three Resins' sole liability shall be the replacement of defective materials or the refund of the purchase price of these materials.

SECTION IX E - OTHER AREAS OF EPOXY USE

System Three Resins' products have been used in many areas besides boatbuilding and repair. These areas include concrete repair, radar dome fabrication, piano repair, guitar making, art deco projects, jewelry making, pottery repair, golf club repair, outdoor sign production, home and professionally built hot tubs and spas, aircraft manufacture, tooling, electrical potting, home restoration, rock polishing, and sports equipment manufacture to name a few.

At best we are experts on epoxy resin product formulating and students of boat building and repair. If you have an oddball use give it a try. If you call and ask us this is probably the answer you will get. At best we can only give you our honest opinion and maybe tell you why we think it might not work. But don't take our word for it. Give it a try. Just like on a boat, you're the captain of your project.