SECTION VII - TECHNIQUES OF EPOXY USE

Epoxy resins are used and applied following one of four basic techniques. These are coating, fiberglassing, gluing, and filleting/fairing. Furthermore, the techniques are pretty much the same whether they involve new wooden boat construction, the repair of fiberglass boats, furniture building, bar top coating or dry rot repair.

What might seem to be other techniques are usually just variations or combinations of the above. Many of our epoxy users discover new variations. We will discuss a number of these variations and the "tricks" that will make the epoxy work go easier and faster. We don't know everything and are constantly learning something new. We invite you to learn along with us. If you come up with a variation that we don't mention, model it first to see if it will work. Do this prior to using your whole project as a test. For example, we are often asked if System Three epoxy will stick to stained wood. Most of the time it will regardless of the stain used. However, the only way to be really sure is to conduct your own little test.

Suppose that you are staining a piece of fir that will later be coated with epoxy and have another piece laminated to it. First, stain a scrap piece of the same wood; allow it to dry well (several days). Laminate on two pieces of 3 or 4-inch wide fiberglass tape about five inches long. Leave a "tail" that can be grasped later with a pair of pliers by running the tape a couple of inches up on a plastic squeegee. Let the epoxy cure a day or two. Remove the squeegee and grab the tail with the pliers. Try to peel the tape off the substrate. If the tape tears where the tail starts, leaving the balance of the tape bonded to the surface, then the bond is good. If the whole thing pops off intact then the bond is bad and the stain is interfering with the bond strength. Better find a new stain and repeat the test.

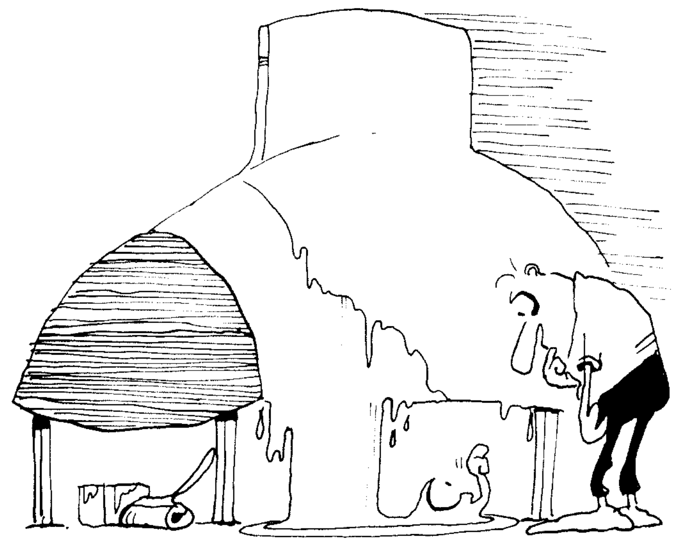
This same procedure can be modified to test the ability of the epoxy to bond exotic woods. If the failure occurs in the wood when two pieces are glued rather than in the glue line then it is safe to assume that the epoxy works on that kind of wood.

In order to simplify the following discussion of the four main areas of use for our epoxy systems we are going to confine the discussion to using our SilverTip Series products with wood. Where appropriate we will mention the use of our other epoxy systems. We feel that if you can understand and use the following techniques then you will be able to do most kinds of epoxy work regardless of the nature of your project.

SECTION VII A - COATING WITH EPOXY RESIN

Wood is often coated with epoxy to dimensionally stabilize it and provide a barrier which helps to prevent the passage of moisture. SilverTip Laminating Epoxy has a certain amount of flexibility and tough resilience built into the formulation. Because of this, a plywood panel could be coated on the bench, then bent into place without danger of the epoxy cracking. When working flat you're not fighting gravity and the coated panel is easily sanded on the bench using a disc sander and foam pad. The sanded panels are then installed and are ready for painting. Coating a 4'x8' sheet of fir plywood will illustrate this method:

Mix the SilverTip resin and hardener in the correct ratio, referring to Appendix D to estimate the amount you'll need. Pour this mix on the plywood in a stream of "S" curves starting at one end and finishing at the other, making four or five curves along the eight foot length. Spread the epoxy back and forth with a squeegee into the dry areas, trying to get as even a coating as possible without being too fussy. Use a dry foam roller to even out the coating. When this first coat is cured to at least a soft set tack free stage it can be recoated. Subsequent coatings applied at any time between this soft set stage and 72 hours do not need to be sanded and will chemically bond.



Subsequent coatings may still bond well after 72 hours without sanding but the proposition gets riskier. An amine cured epoxy surface is quite alkaline and can react with any acidic material such as moist carbon dioxide or silicates. Further epoxy coats may not bond well to some of these reaction products. Sanding, in addition to providing some "tooth" for mechanical bonding, also cleans since it exposes new, uncontaminated surface. If in doubt, sand enough to kill most of the gloss.

Working on non-horizontal surfaces is similar except that the mixed resin is poured into a roller pan and applied with a foam roller. To control runs and sags use several thin coats rather than a few thick coats. As with coating the flat panel, just wait until one coat has reached the soft set stage before applying the next.

In boat building use at least two coats for interior wood surfaces and three in areas that may be constantly wet, such as bilges. Darkroom sinks should have at least three coats on the wet side and two on the back. White epoxy paste pigment is a nice addition to an epoxy coating where appropriate. Unlike paint it will not flake off.

Several tricks can be used to improve the appearance of the finished film. Bubbles that persist in the coating can be broken with a foam brush by lightly dragging it across the surface. Quickly and lightly fanning the uncured surface with a propane torch will accomplish this with greater speed. Avoid overheating an area as this could cause the epoxy film to pull away from the surface creating craters. Overheating will also cause the expansion of any air in the pores of the wood and may result in an epoxy coating full of bubbles.

Sometimes a coating will try to crater. This is most common with recoated surfaces that have been sanded, but may happen on other surfaces as well. While the cause of cratering is quite complex, the solution is pretty simple. Immediately after coating a surface look at it from an angle, sweeping your eyes over the whole surface. Craters will usually form within ten minutes after first applying the coating. Take the heel of the foam roller and really grind it in the area that has cratered. This wets out the dry spots in the crater center. Then, re-roll the area treated to even out the coating.

After 24 to 48 hours (depending upon temperature and hardener used) the coating will be cured enough to sand. When using general-purpose resin first wipe the surface with a damp sponge to remove any water-soluble amine carbonate surface film prior to sanding. It is not necessary to wipe SilverTip Laminating and Coating resin prior to sanding. At this stage of cure the epoxy coating can usually be sanded with a disc sander or random orbital sander. Machine sanding can generate quite a bit of heat, especially when the sandpaper gets dull or clogged, causing gumming of the sanding dust. Keep the sander moving and apply only light pressure. This keeps the heat down. If clogging still happens you'll have to either hand sand, scrape as described below, wet sand or allow another day for the cure to proceed.

Scraping is an alternative to sanding that actually produces a better finish. This shaves off a thin film of epoxy leaving a surface that looks like it was sanded with 600 grit paper. Small parts can be scraped using a single edged razor held vertically. Several companies make wood scrapers for working on larger surfaces. Keep them sharp and be careful not to cut yourself.
Any residual sanding dust should be removed by blowing or brushing it off prior to recoating. The final bit may be removed with a damp rag. Don't use acetone, other solvents or tack rags. They may leave an unbondable surface coating on the sanded epoxy surface.

Try to work at a constant or falling temperature when coating new wood. When the temperature is rising, air trapped beneath the uncured epoxy may expand and cause small bubbles to form in the coating. Avoid working in direct sunlight on new wood for this reason. If you must work in sunlight, coat the wood as the sun is going down. The wood will be cooling and air bubbles should not form. Cover any outdoor work to help prevent dew from forming on the uncured epoxy surface.

Some very porous woods are quite persistent at forming air bubbles. A trick we have used is to heat the whole surface to a temperature at least 40°F higher than room temperature. Use a hot air gun or place the wood in the sunlight for a while. Stop heating and immediately coat the surface. The epoxy will thin on the warm surface and at the same time start to cool it. The air in small pores will begin to contract pulling the thinned epoxy in to them. Any air that does rise will be going through thinned epoxy and have an easier time of it. In lieu of this you may be able to apply a thin epoxy coating, allow it to soak in and then squeegee and discard any remaining on the surface. Once cured the coated wood now acts as a non-porous surface and rising air bubbles should pose no further problems.

Clear Coat epoxy can also be used for coating wood. Like SilverTip Laminating Epoxy it leaves no amine blush on the surface. It is a much thinner material and, while an argument could be made that this is good for the first coat, it takes over twice as many coats to achieve the film thickness and hence moisture barrier protection of SilverTip or our general purpose epoxy.

SilverTip Laminating Epoxy is an excellent base for varnish. The application of multiple coats of varnish and sanding between coats can be eliminated with two coats of SilverTip with NO sanding between coats. The final epoxy coat is sanded to provide a base, and then one or two coats of varnish are applied. The result appears to have the depth of ten or more coats of varnish and is much more durable. Revarnishing is much easier because the old varnish is just removed down to the epoxy coating. SilverTip Laminating Epoxy may be thinned with up to ten percent lacquer thinner to improve brushing. The use of solvents will retard the cure time somewhat so don't use any more than needed. Add just enough thinner to allow the epoxy to brush easily. Never add solvents to epoxy for gluing or fiberglassing.

Clear Coat epoxy is also used as a base for varnish but has several differences from SilverTip Laminating Epoxy in this application. First, it is thinner and can be easily brushed without adding solvents. Second, it is much slower affording longer working time but at the expense of a longer cure time. Third, it soaks into wood much better. Like SilverTip Laminating Epoxy it does not need to be sanded if recoated within two or three days. Unlike SilverTip Laminating Epoxy it takes over twice as many coats to achieve equal thickness.

Clear Coat epoxy may water spot if water stands on it even though it has been cured for a long time. This is a phenomenon unique to the raw materials used in the Clear Coat hardener. Sanded Clear Coat epoxy will not water spot as the offending surface layer has been removed. SilverTip Laminating Epoxy develops water spot resistance within 24 hours of application.

Epoxy coatings should be sanded before varnishing or painting. These materials stick to the epoxy by mechanical means and must have some "tooth" in order to bond well. Never apply solvent-based coatings to partially cured epoxy. Read the Painting Section before painting or varnishing an epoxy coating.

Materials Required for Coating:

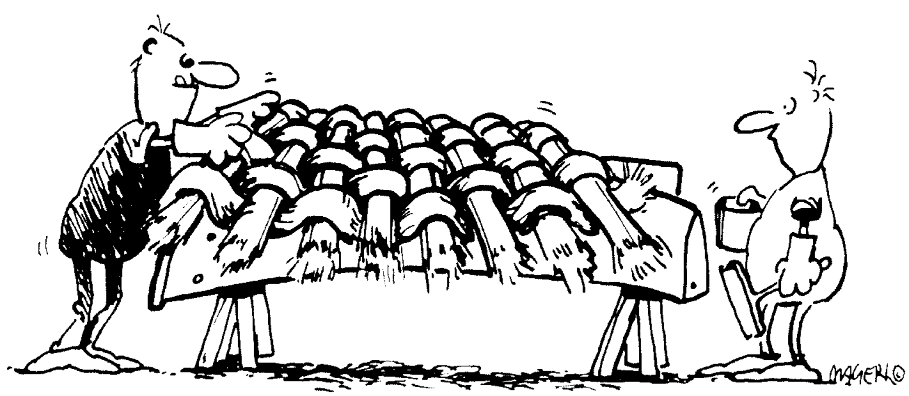
SilverTip Laminating Epoxy (Resin and Hardener)
Foam roller covers/frames
Measuring device
Plastic squeegees
Protective gloves
Brushes, foam and bristle

SECTION VII B - FIBERGLASSING WITH EPOXY RESIN

Outside surfaces of boat hulls are usually epoxy/fiberglassed to create a thicker, stronger epoxy coating. This provides higher abrasion, impact and moisture resistance. In the case of most wooden boats the purpose of reinforcing cloth is to strengthen the epoxy coating, not to reinforce the hull. Chines, keels, bow and transom corners are structurally reinforced with fiberglass tape and epoxy. Fiberglass tape has been judiciously used to great advantage by woodworkers to strengthen unseen edges of complex miter/bevel joints in panels.

Some small, dry-sailed boat hulls made from plywood other than fir don't need cloth. Several coats of epoxy alone are usually all that is needed, though seams should be fiberglassed for structural reasons. Rotary cut fir plywood should always be fiberglassed on outside exposed surfaces or the plywood may check and crack the epoxy coating.

Epoxy resins have all but replaced polyester resins for the fiberglassing of wood. Polyester is a poor adhesive, delaminating when moisture gets between the fiberglass substrate and the wood.



Because the fiberglass is structural to the epoxy coating rather than the boat hull, it's possible to use a lightweight cloth. Six-ounce cloth is sufficient for most surfaces and can be doubled in high wear and impact areas. Don't use cloth that is too heavy for the intended service, you'll use a lot more epoxy and have a heavier boat, gaining little else. Tests show no appreciable difference in peel strength between the two most popular finishes of fiberglass cloth, Volan and Silane. Four and six ounce cloths are nearly invisible when wet out with SilverTip Laminating Epoxy. Heavier weight fiberglass shows the weave pattern under certain lighting conditions.

Avoid using fiberglass mat with epoxy resins. The binder that holds the mat together is dissolved by the styrene in polyester resins. Epoxies don't use styrene as a diluent, making it almost impossible to properly wet out the mat. Woven roving is wet out well by epoxy but we know of no reason to use it in building a wooden boat. Clear Coat epoxy due to lower viscosity and higher solvating power will wet out fiberglass cloth faster than other systems.

Regardless of the type of the cloth or resin system used, fiberglassing is done essentially the same way. There is no need to be intimidated by fiberglassing, what you are really doing is gluing the cloth to the surface with a minimum amount of resin. Use just enough epoxy to wet out the cloth, you'll fill the weave of the cloth later. Work on as horizontal a surface as possible. Fiberglassing is much easier if you are not fighting gravity.

The first step to doing a good fiberglass job is to pre-coat the wood to avoid the problem of having unsealed wood soak up too much epoxy, starving the wood/glass bond. Pre-coating doesn't use any more epoxy than the more difficult one step method (for experienced fiberglassers only!) and helps to assure that maximum peel strength is achieved. After the first coat cures fill any holes with SilverTip QuikFair or an epoxy /microballoon mixture to provide a smooth base for the cloth. Sand off high spots and burrs or knock them down with a Surform or body file. Clean the surface with compressed air or brush off and wipe with a clean damp rag to remove any remaining traces of dust. Don't use acetone or similar solvents for this. Much acetone sold today is reclaimed and may have impurities that interfere with secondary bonding by leaving a film of residue on the surface. Avoid the use of tack cloths as they may transfer some of the waxy material on them to the epoxy surface causing secondary bonding problems. Next lay the fiberglass out on the pre-coated, tack free surface, smoothing it out and doing any rough trimming. Masking tape may be necessary to hold the cloth in place if the surface has any slope.

Mix no more than 15 fluid ounces of resin and hardener. Work with small batches until you get the hang of it. Start at one end and pour the resin out over an area equal to about 1 square foot per fluid ounce (15 ounces does a 3 x 5 foot area). Pour in "S" curves as described in the coating section (on steep surfaces apply the epoxy with a roller cover and roller tray), spreading lightly into the dry areas with a squeegee (we like the rubber Thalco squeegee for laying down cloth). Let the resin wet the cloth out. Don't try to "force" it through the weave with the squeegee. Notice how the cloth disappears as it wets out.

When this first area has been covered and the cloth has disappeared, take the squeegee and use reasonable pressure to squeeze the excess resin away from the wet cloth. Work it down into the dry cloth area only if the surface will be painted. If you intended to clear finish the part you should discard the frothy squeegeed resin as it may not expel all the microfoam before curing. You can wipe the squeegee edge on a cup or can to remove the resin. Squeegeeing removes excess resin and entrained air, sticking the cloth down right next to the wood surface. The squeegeed cloth should now have a semi-dry look with the weave pattern showing; the cloth itself will be invisible.

Keep on going, section by section, until you are finished. If you are working on a very large area use a dry roller cover on the previous three or four sections to give a final smoothing. On smaller boats the roller cover can be used after the entire hull has been fiberglassed.

Let the epoxy resin cure to the "green" stage where it is pliable but no longer tacky unless pressed really hard. Now is the time to trim the excess cloth. Trim by running a single edged razor blade around where the glass overhangs the edge. Press down any glass that lifted from the surface while trimming.

The selvage edges of the fiberglass have to be feathered before being covered by another piece of cloth. Wait another hour or so and do the feathering with a Surform. Do it while it is in the right state of cure. Too early and the wet fiberglass will lift, too late and it will be too hard to cut. The alternative is to wait a day or so until it is hard enough to sand.

It is not always possible to have a selvage edge on the cloth. Rather than have a cut edge fraying allover the place, which can only be cleaned up by a lot of sanding later, here's a trick that produces a very neat edge. Run a piece of 2" masking tape so that the inner edge of the tape is where you want to stop the glass. Lay down the cloth so that it runs at least an inch past the outer edge of the tape. Wet out the glass past the inner edge and about halfway across the tape. When the cure reaches the green state run a single edge razor blade right down the inner edge of the tape. Pull off the tape and presto; you have a nice edge right where you cut the fiberglass. If a little of the cloth lifts, press it back down.

The weave of the cloth can be filled once the resin has reached the green state of cure. Don't try to sand the weave smooth, fill it with epoxy. Apply fill coats the same as discussed in the preceding section on coating. Several coats may be necessary before the weave is filled. If you plan to paint the surface you may fill the cloth weave with SilverTip QuikFair in one coat using a squeegee. Don't use any filler on surfaces that are to be clear finished.

When the weave has been filled the surface should be sanded to prepare it for painting or varnishing. Sand the epoxy, not the fiberglass. Be sure to wear a respirator or dust mask while sanding. You'll probably get the fiberglass itch. Take a cool shower after this step and put on clean clothes to minimize the irritation. If you do get the fiberglass itch, don't worry; it goes away after a few hours.

Applying fiberglass overhead is at best a difficult, messy job. Anyone who has tried it once has no desire to repeat the experience and will do everything possible to try to turn the work over or at least fiberglass on a slant. If this is not possible then here are several suggestions for accomplishing this job:

If you are working on a relatively small area, wet the surface with mixed resin/hardener and lay a rough-cut piece of cloth into the resin. Surface tension will hold it into place without sagging if not too much resin is used. Using a squeegee overhead is a feat no one has yet mastered. Use foam rollers. Once the epoxy has cured you finish the overhead area in the usual manner.

Glassing large overhead areas calls for a different technique and a helper or two. Most successful jobs are done by rolling on a coating, then allowing it to cure to a tacky state. The cloth is then rolled out as smoothly as possible into the tacky coating. This is where you'll probably need more than one person. Get the wrinkles out as you go along, you won't be able to slide them out because the tackiness of the coating will hold the cloth in place. Once you've got the cloth where you want it press it into the tacky undercoat with a dry foam roller. Then wet it out using the roller cover and a roller pan. Use just enough epoxy to wet out the cloth. When cured finish in the usual way.

Corners and edges often require several layers of cloth. Giving thought to a "glassing pattern" will allow doubling at edges without going through extra steps. Corners are most easily "patched". Cut circles of different diameters from cloth scraps. Wet down, dabbing at it with an epoxy soaked brush. Lay down the next larger circle over this wetting it with more epoxy, if necessary. Continue the process until finished. Each larger circle will fray the cut edges of the smaller circle under it. This process is self-feathering. Use the masking tape trick for the last circle and the job will require little sanding to look nice.

Heavy structural seams are best done using biaxial tape. Biaxial means that the fibers run at 45 degrees to the way the tape comes off the rolls. When run along a seam ALL the fibers run across the seam at 45 degrees. In regular plain woven tape half the fibers run parallel to the seam and add nothing to the strength.

Biaxial tape is heavy at 24 ounces per square yard and it won't be clear like lighter tape when wet out with epoxy so don't use it for clear finished seams. Rather than feather edge biaxial tape by sanding we prefer to fair the edges using SilverTip QuikFair after sanding off the high spots.

In summary, fiberglassing is a three-step process:

1. Seal the wood to prevent starving the wood/cloth joint. Do filling and fairing on the sealed wood.

2. Stick the cloth down leaving a minimum amount of resin in the cloth.

3. Fill the weave any time after the wet cloth has reached the "green stage" and is stuck to the substrate.

Materials Required for Fiberglassing:

SilverTip Laminating Epoxy and hardener
Roller covers and frame
Fiberglass cloth
Thalco (rubber) squeegee
Measuring device
Protective gloves, dust mask
SilverTip QuikFair
Trimming knife
Surform (Stanley Tool Works)
Sandpaper

SECTION SECTION VII C - MODIFYING EPOXY WITH FILLERS

Epoxies formulated for coating and fiberglassing are too thin to serve as gap-filling adhesives. They can be modified by the addition of thixotropes to form non-sagging pastes very useful as gap filling glues. These pastes can be further modified with the addition of microballoons to form putties for fairing and hole filling. Wood flour can be used to make filleting putty for stitch-and-glue boat construction. All these solid dusty additives are called fillers. Fillers change the flow and density characteristics of the epoxy system. Each filler changes the liquid resin and hardener in ways that make epoxy useful for other applications besides coating or fiberglassing.

You will need to learn how to use fillers if you intend to use our general-purpose epoxy. You can avoid using fillers if you choose to use products from the SilverTip Series. SilverTip GelMagic, SilverTip EZ-Fillet, SilverTip QuikFair, and SilverTip MetlWeld have already been modified and optimized for their particular end uses. You simply measure and mix these products and do not have to bother with fillers. So, if you are using any of the SilverTip Series products, skip this and move on to the next section.

Fillers fall into four general classes: thixotropic agents, bulking agents, fibrous fillers, and pigments. There is some overlapping as to function of certain fillers. For example, plastic minifibers are both fibrous and act also as a thixotropic agent.

Silica thickener (Cab-O-Sil or Aerosil), plastic minifibers and wood flour are thixotropic agents. They turn the epoxy into a thixotropic fluid. These fluids flow under shear stress but do not readily flow once the stress is removed. Ketchup and latex house paints are examples of thixotropic fluids. Adding these agents to the mixed resin and hardener produces a fluid that will easily flow under the spreading stress of a putty knife. Once the stress is removed the thickened epoxy retains its shape. In short, these fillers make the epoxy non-sagging and are added specifically to make gap-filling adhesives.

Phenolic microballoons, quartz microspheres, and wood flour are bulking agents. They "bulk out" the epoxy making a lightweight putty like mix. Although all these thicken the epoxy, only wood flour will also make it thixotropic. Attempting to add sufficient microballoons or microspheres to make a non-sagging fairing putty will result in one that spreads poorly as it becomes dry. These materials should be used along with a thixotropic agent. Silica thickener is the best choice because it produces the smoothest compound.

Chopped glass strands, milled glass fibers, and plastic minifibers are fibrous materials that can be incorporated into structural filleting putties to improve tensile strength, and are listed above in descending order of tensile strength improvement.

White paste pigment (titanium dioxide) and graphite powder are generally used as pigments. Graphite powder added at high loading levels (25%) to coatings, which are then sanded, produce a "slick" racing finish due to the lubricating qualities of the graphite. Graphite is a conductive material and could cause electrolysis problems under the right circumstances. Since it is the most "noble" of all conductors you should avoid direct contact with other metals under wet conditions. Adding white paste pigment produces a white resin coating that is useful where a light color is desired and painting is difficult. Pigments aren't meant to serve as substitutes for paint in areas exposed to strong sunlight. White paste pigment can be added to the final fill coat when fiberglassing, allowing this coat to serve as a base coat for finish painting.

Our other pigments are pure dry colorants ground into epoxy resin to produce an epoxy paste pigment. Since they are dispersed into epoxy resin they may be added to the resin side of our epoxy systems to produce stable pigmented resin. The volume of the pigmented resin is used to determine the hardener necessary. These pigments are transparent when used in tiny amounts in an epoxy and can be said to act as dyes. In larger amounts they are opaque. Our pigments come in white, black, brown, yellow, red, green and blue and may be blended with each other to produce various hues. They should be used in epoxy systems only and never used in our paints.

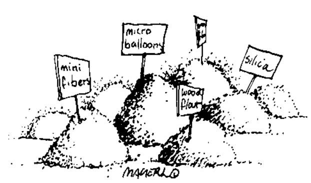
These fillers, pigments and additives may be used with any of our epoxy systems except for SilverTip Laminating Epoxy, which was designed as a coating and fiberglassing resin only. Higher filler loading levels are possible with Clear Coat epoxy because it is much lower in viscosity than our other systems.

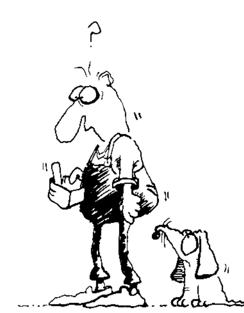
Fillers change the mechanical properties of the cured resin. For all practical purposes the builder can ignore these changes. Thixotropic agents have the least effect since they are used in the smallest amounts to produce the desired result. Bulking agents reduce tensile strength in proportion to the amount added. Some will initially increase compressive strength. With increasing amounts of additives, though, compressive strengths will decrease.

Many combinations of filler materials are possible and we have not tested them all. If you have an idea that a certain combination might do something special for you then check it out. Little pieces of scrap plywood are good for this. Think up some destructive tests that will simulate the stresses the material will see in service. Check to see where the failure occurs. If the wood breaks then your combination should work well with wood, at least.

The correct sequence for the addition of filler materials:

1. Correctly measure and mix resin/hardener.
2. Add fiber fillers, if any, and mix well.
3. Add bulking agents, if any, and mix well.
4. Add thixotropic agent and mix well.





SECTION VII D - BONDING WITH EPOXY

The mixed viscosity of coating and fiberglassing epoxies is not high enough to make good gap filling adhesives. Thixotropic agents like silica thickener (Cab-O-Sil, Aerosil), plastic minifibers, and wood flour are used to thicken the epoxy and change the flow characteristics. These fillers will turn the epoxy from translucent to opaque depending on the type and amount used. Silica thickener and plastic minifibers make the epoxy whitish while wood flour turns it reddish-brown. Silica thickener makes a smooth material while epoxy thickened with plastic minifibers or wood flour will be coarse. Microballoons and microspheres should not be used in adhesive formulations as they reduce tensile strength.

Making an epoxy glue joint is quite simple. It is even simpler if SilverTip GelMagic is being used since SilverTip GelMagic "self-thickens" to become a gap filling adhesive. T-88 is thick enough straight out of the bottle to be used as a gap filling glue. Assuming that our general-purpose epoxy is being used first properly measure and mix the resin and hardener, then coat both mating surfaces with this unfilled epoxy to wet them out. It is not necessary to let this coat cure. Next, add the thixotropic agent to the balance of the mixed resin/hardener blend and spread this thickened resin on either of the two surfaces. When using SilverTip GelMagic simply measure and mix the two parts and spread on both surfaces. Then close up the joint. There are some tricks and things to keep in mind.

First, remember that the ultimate strength of any glue joint is a function of the glue surface area. The more surface area, the stronger the joint. This is the reason that scarf joints are made at a minimum 8:1 slope. Fillets increase glue surface area and are used to relieve stress concentrations that build at right angle corners. Stringers, for example, should have fillets where they butt onto the boat hull planking.

Second, make sure that the surfaces being glued are clean, free of grease, oil, wax, and other contaminants that could act as release agents. If the surface is coated with cured epoxy, sand before gluing and wipe the dust off. Prior to sanding wipe away any oil or grease with a clean rag and suitable solvent. Remove paint rather than trying to glue onto a painted surface. Epoxy resins stick well to sanded paint but the overall bond strength will be no better than the paint to substrate bond.

Third, do not over-clamp. Epoxy resins require only contact pressure. Over-clamping can squeeze most of the adhesive out of the glue joint and the epoxy that is left is absorbed into the wood starving the joint. A glue-starved joint is very weak. Use only enough pressure to hold the joint immobile and keep the two surfaces in contact until the epoxy has set overnight at normal temperatures. Nails, screws, clamps, rubber bands, or staples can all be utilized.. Clamp just hard enough to close up the joint.

Fourth, remember that epoxy resins continue to cure and build strength for several days after they solidify. Joints that will be under immediate stress once they are unclamped need more cure time before the clamps are removed. Overnight cures are usually sufficient for most non-stressed joints. In cold weather the time could stretch out to several days. A common cause of epoxy joint failures is excessive stress before the epoxy has reached sufficient strength. This might occur when a scarf joint is bent too soon. Fifth, protect the finished glue joint from weather degradation. Wood that is allowed to weather will cycle through moisture content extremes. Wood expands as the moisture content increases. This expansion can set up enormous stress concentrations across a glue joint due to uneven rates of expansion on either side of the glue line. These stress concentrations can exceed the strength of any glue, including epoxy resins, causing failure. Protect the joint by epoxy coating all surfaces of the glued wood. This will stop moisture cycling and prevent failure because of weathering. This is not a problem for wood glued with epoxy that will not be subject to deep moisture cycling – indoors, for example.

Most woods can be successfully bonded with epoxy. Teak is not difficult to bond but the bond may fail if allowed to cycle moisture. When epoxy gluing a teak on plywood boat deck, the teak should be less than 3/16" thick. The expansion joints should be of a flexible material like the two part polysulfide rubber mastics. Don't use black-pigmented epoxy between teak boards that will be subjected to strong sunlight or weathering – the epoxy will crack.

SilverTip GelMagic and our general-purpose epoxy are specifically designed for use as an adhesive for wood-to-wood bonds. Both will bond well to sanded polyester and vinyl ester resins. For metal bonding we recommend using SilverTip MetlWeld, our specially designed adhesive for bonding metal and other difficult to bond materials.
Metal to metal bonding success depends upon the type of metals bonded, the surface preparation, and the intended service temperature. Bonds between different metals may degrade over time due to differential thermal expansion, which sets up shear stress that leads to interfacial failure. Potential structural bonding of metals should be thoroughly evaluated before proceeding. We recommend the use of mechanical fasteners for critical applications.

Metal to wood bonding for non-structural applications may be done successfully with epoxy providing that the metal is clean and bright. Don't pot stainless steel bolts in any epoxy resin if the application will be around water. Stainless steel works only in the presence of sufficient oxygen. The epoxy will deprive it of oxygen causing crevice corrosion in the presence of an electrolyte like seawater. Stainless steel fastener failure occurs where the bolt emerges from the epoxy resin.

Bonding to metal alone such as fairings on lead keels will work well with epoxy so long as the lead is bright and free of oxidation. Since lead readily tarnishes there may be benefit from immediately coating the bright lead with SilverTip MetlWeld before fairing with SilverTip QuikFair to fair the keel. The SilverTip MetlWeld provides an almost absolute bond to the lead and SilverTip QuikFair easily bonds to tacky or cured and scuffed SilverTip MetlWeld.

Thermoplastic materials like vinyl plastics or ABS bond reasonably well with epoxy resins. You will get the best results if you first sand the plastic with coarse paper. Before bonding flame treat these plastics by passing the flame of a propane torch across the surface without scorching or melting the surface.

Epoxy will not bond to polyethylene, polypropylene, or Teflon. It bonds well to neoprene and polyurethane rubbers.

There are too many materials and combinations to cover every possibility. Model any questionable materials that you want to bond. Glue some scraps and test them. Try accelerated aging and retest them. If they survive an hour in 160°F water they will probably last for quite a while.

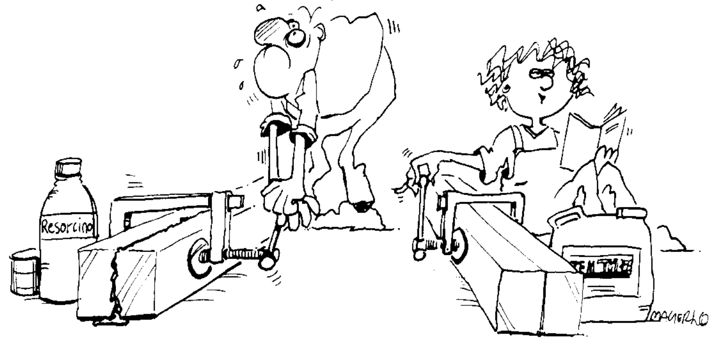
Quick Cure is our 1:1 "five-minute" epoxy. Items glued with Quick Cure can be stressed in as little as 15 minutes. It is very handy to have in the shop simply for this reason. Builders often find that "missed screw hole" when ready to lay down the fiberglass cloth. Mix a little Quick Cure; add some wood flour and you've got an instant putty to fill the hole. Quick Cure can also be used in combination with slower epoxies as a "spot welder" where clamping is all but impossible.

Coat the pieces to be bonded with SilverTip GelMagic, except leave several silver dollar size bare areas. Mix some Quick Cure and apply to the bare areas. Push the pieces to be bonded together with enough pressure to cause some "ooze out". Hold in place for about five minutes until the Quick Cure hardens. Now the Quick Cure will hold the pieces together while the SilverTip GelMagic sets.

Unlike our other epoxy systems Quick Cure (like all similar epoxy products) is water resistant, not water proof. It is fine for intermittent water contact but should not be exposed below the waterline on a boat, for example.

Materials Required for Bonding:

Epoxy Resin and Hardener
Brushes, spreading tools
Silica thickener
Sandpaper



SECTION VII E
FILLETING, FAIRING, AND MOLDING WITH EPOXY RESIN

The SilverTip Series contains two putty materials: SilverTip EZ-Fillet, a wood-flour filled putty, and SilverTip QuikFair, a microballoon filled putty. Neither involve user added fillers and powders. As described elsewhere these have other advantages beyond simply eliminating the use of obnoxious, dusty powders. We suggest that most epoxy users will be better off using these rather than whipping up a batch of "homebrew" epoxy putties. Once mixed SilverTip EZ-Fillet and SilverTip QuikFair are used as described below.

For those who choose to homebrew putties we offer the following: Our general purpose epoxy can be mixed with phenolic microballoons (purple), quartz microspheres (white), or wood flour (brown) to make a putty-like material that is used for making cosmetic or structural filleting, fairing, or molding compounds. The use of these materials with the right portions of silica thickener makes a smoother compound than the fillers alone can produce. The amount of these fillers is best determined by experimentation taking into account the desired results, temperature and viscosity of the epoxy being used. For previously stated reasons we neither recommend nor support the use of SilverTip Laminating Epoxy resin with fillers or thickeners.

Filleting is the process of adding an epoxy putty to concave angled corners for cosmetic and structural reasons. Cosmetic fillets are generally "low density" being made by the addition of microballoons, which "bulk out" the epoxy. Structural fillets are "high density" and are thickened with silica thickener, plastic thickener, or wood flour. These fillets sometimes contain glass fiber. Thixotropic agents make the mix non-sagging when sufficient amounts are used. Microballoons and microspheres do thicken the epoxy, but when used in proper loadings do not prevent sagging, and need the addition of a thixotropic agent like silica thickener.

Cosmetic fillets are applied by putting an excess of material along the length of the corner with a putty knife or caulking tube. Be careful not to force big air bubbles into the fillet when putting the putty into the corner. A rounded tool is used to shape the putty by drawing it along the fillet. The sides of the tool should touch both sides of the corner and the radius of the tool is determined by how rounded the finished fillet will be. Almost any material can be used to make a filleting tool. Plywood paddles work well, are easy to make and are inexpensive. The excess putty will be forced out on either side of the tool where it is scraped off with a putty knife.

Once the fillet has cured it may be sanded. A round edged sanding block with coarse (50 to 60 grit) paper works best. Knock off the high spots with the sandpaper and then come back and fill in the low spots with an additional batch of putty. This is much easier than sanding the whole fillet down to a common level. Blow or brush off the sanding dust (wear a dust mask!) Make up some more filleting compound and use a broad putty knife to fill the low spots resting the blade against the fillet parallel its axis. Allow the putty to cure and do a final sanding.

Before microballoons are painted they should be sealed with epoxy or else the paint goes into the tiny hollows in the broken balloons and the finish will appear ragged. Brush or roll on a coat of epoxy on the sanded balloons. Use either Clear Coat or SilverTip Laminating Epoxy thinned with about 10% denatured alcohol or lacquer thinner to make it easier to apply. Treat this cured sealer coat as any other epoxy coating before finishing.

Structural fillets increase the glue joint surface area relieving stress concentration zones that occur at angled corners. They are usually made at the same time that the piece creating the corner is attached. For example, when sheet plywood is glued onto a stringer the excess glue that oozes out can be used to form the fillet. A gloved finger makes a good filleting tool, as these fillets don't need to be large. Once the glue begins to cure it can be smoothed by rubbing with a solvent saturated rag. Wear solvent resistant gloves when doing this.

Large structural fillets are generally made in a separate operation in a manner similar to making cosmetic fillets. The addition of either milled glass fibers or chopped glass strands, improves the tensile strength of structural fillets.

Proper epoxy fillets don't need to be covered with fiberglass cloth. Apply cosmetic fillets after the fiberglassing is finished. This makes fiberglassing easier as the edges of the cloth can be run into the corners; left ragged, and then later is covered by the fillet.

Fillets in stitch-and-glue boat construction are usually fiberglassed. The easiest way to do this is to fiberglass the fillet when it is in a semi-stiff state so that it can still be pushed around with an epoxy-saturated brush. This saves having to sand the fillet after it has cured.

Fairing is the operation of filling the low spots on a boat hull or auto body to the level of the high spots, eliminating waviness and hollows. Use SilverTip SilverTip QuikFair for this or make your own. The compound used is identical to that of the cosmetic fillet and the operation is similar except that large flat areas are involved. Large wallpaper broad knives, stiff boards with taped edges, squeegees, and similar tools are useful for fairing. Once the putty has cured it is sanded with long sanding blocks to a level fair with the surrounding area. On very large areas low spots may appear during sanding that will need a second fairing. After final sanding the fairing compound should be sealed with epoxy prior to painting.

Molding with epoxy compounds is a very useful technique that can be used to build winch pads, lifeline stanchion, pulpit pads, etc. A high-density compound like SilverTip EZ-Fillet should be used here. The idea is to make a pad on the hull or deck of the proper size and shape to mount the hardware. An example can best illustrate the technique. A six-inch diameter pad is needed to mount a winch. A plywood circle six inches across is cut and transparent cellophane tape is stuck all over it, to act as a release agent. SilverTip EZ-Fillet or a stiff structural putty of epoxy, milled glass fiber and Silica thickener is made and liberally applied to the taped plywood. The plywood is then located at the proper place on the cabin top and the puttied plywood is pushed down onto the deck. The plane of the plywood face is adjusted so that the winch will have the proper sheet lead angle. Tapping the plywood forces the excess putty out. When the plywood has been properly positioned, the excess compound is removed with a putty knife. The molded pad is allowed to cure and the plywood blank can then be knocked off with a hammer. Any voids are then filled with more compound and the pad edges are filleted with SilverTip QuikFair to fair them in with the cabin top.

Materials Required for Fairing, Filleting:

Epoxy Resin and Hardener (SilverTip QuikFair, SilverTip EZ-Fillet)
Spreaders
Microballoons /Microspheres
Sandpaper
Silica Thickener
Fibers