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EPOXYWORKS®

BUILDING, RESTORATION & REPAIR with EPOXY

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EPOXYWORKS®

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Drumming in Circles

By Tom Pawlak

A variety of drums made by Technical Advisor Tom Pawlak.

In 1991, during testimony before the United States Senate Special Committee on Aging, Grateful Dead drummer Mickey Hart stated:

"Typically, people gather to drum in drum 'circles' with others from the surrounding community. The drum circle offers equality because there is no head or tail. It includes people of all ages. The main objective is to share rhythm and get in tune with each other and themselves. To form a group consciousness. To entrain and resonate. By entrainment, I mean that a new voice, a collective voice, emerges from the group as they drum together."

I recently joined a group of mostly old guys who meet a couple of weekends a year to experience nature and the great outdoors. We all come from a diverse cut in society yet we all get along very well. One reason is we all love nature but another reason, I believe, is when we first gather and just before we leave a couple days later, we sit in a circle and we drum together for 10-15 minutes. It is a simple but effective primal group ritual that allows us to release hard wired anxieties and help clear our minds. I can't explain why it works—it just does. Apparently others feel the same way because drumming circles are gaining popularity in many communities around the world.

New members, participating for the first time, often arrive without drums because they don't own drums or because they haven't found anyone willing to loan them one. More likely they are like me and don't want to ask friends for a drum because they would have to admit what they need it for.

Many of the guys I drum with have their own drums. Some built theirs at home from kits purchased on line while others attended weekend workshops to build their drums from scratch with expert guidance. Some of the guys also purchased drums made by someone else. The drum shells are mostly made from wood but some are made of metal and a few are fired ceramic. Nearly all of them are covered with animal skins that have been stretched by lashing cords and other means. Each drum is a statement in itself about the person who built it.

I'm a composites guy who loves to build things. I thought if I made my own drum it could be unique. Over a period of months I kept thinking about what a drum would sound like if it were made with a carbon fiber skin, a Kevlar® composite skin or even a fiberglass composite skin.

One of the benefits of working on Gougeon Brothers' tech staff is we have a number of old cored composite panels left over from panel stiffness testing. Some of the 2'x2'x1" panels are undamaged and have been on the shelf for 15-20 years. I began experimenting with how different composite skins sound by cutting away the middle of the composite skin on the back side of the panel and removing the core in the center of the panel. That way the smooth molded side skin was left unsupported by core in the middle of the panel. This allowed me to hear what the skin sounded like when struck by my hand. I discovered if the composite skin was more than .040" to .050" thick it did not sound anything like a normal drum. It did not resonate well—at least not for my taste. But I discovered if the composite skin was thinner, it actually sounded great and looked pretty interesting at the same time. Success achieved from these experiments gave me the confidence to build the strip planked composite drum that is featured in this article.

If you are intrigued by the idea of building your own composite drum, here's one way of building a unique and unconventional drum:

Locate a smooth shiny solid surface like plate glass or shiny Formica® laminate to act as a mold that is slightly larger than the top of the drum shell that you have in mind.

Apply several coats of mold release wax to the mold (PARTALL Paste #2 works well for this) so the composite drum skin can be removed after cure.

Apply a thick coat of WEST SYSTEM 105 Resin/207 Special Clear Epoxy and lay a light layer of 2 to 4-oz. fiberglass cloth into it. Allow the epoxy to soak into the fiberglass for a minute or so then wet out any remaining dry fiberglass areas with more epoxy.


Cut form to size


Rip wood strips to cover the form


Mark vertical lines for alignment and attach accent pieces


Dry fit then coat the strips and tube with unthickened epoxy

Lay a piece of dry carbon fiber, Kevlar®, woven or biaxial fiberglass fabric into the epoxy while allowing the epoxy to soak through the fabric. Apply more 105/207 as needed to finish wetting out the fabric. Apply another layer of the same 2-4-oz. fiberglass as used initially over the carbon fiber, draw off excess epoxy with a plastic spreader or squeegee then cover it with release fabric to compress the fibers. If you don't have release fabric, just allow the epoxy to cure.

Allow the laminate to cure and leave it attached to glass mold until after you are able to glue the drum shell to the composite skin.

Building the Drum Shell

Locate a mold or former for the drum.

An 8" diameter cardboard shipping tube caught my eye as a simple form onto which I could glue wood strip planks. I could cover it with shiny Cellophane tape and edge glue the wood strips together, pull it off and apply fiberglass inside and out or I could take the easy way out and glue the wood strips to the rigid cardboard tube so fiberglass would not be needed at all. I took the easy way out given that keeping the drum shell light was not important.

Fabricate wood strips

I found a nice variety of ½", ¾" and 1" thick wood scraps with varying color that I took to the table saw and ripped into ¼" thick strips.

An 8" diameter tube has a circumference of about 25" so I would need enough wood strips to cover the shipping tube.

Create accent strips

I decided to rip the darkest wood strips down to ¼"x¼" for use as accent strips.

Once my strips were ripped, I tried several different patterns for orienting the strips. The Jatoba wood strips were a bit wider and a bit more colorful than the other woods so I used them in the center of my repeating pattern.

Dry fit the pieces

I stood the cardboard tube on end and verified that the tube was cut square with a framing square. I sanded the end slightly a couple times to make it perfectly square.

I marked the circumference of the tube into eight equally spaced segments. From each segment mark, I used a combination square to draw the equal spaced lines that were perpendicular to the length of the tube.

These lines were used to locate the first accent wood strips that were glued on with G-5 Five minute Epoxy.

I used a few heavy rubber bands around the tube to hold my wood strips in place while the epoxy cured.

The rest of the wood strips were dry fitted in between the glued in divider strips. I adjusted the width of the strips slightly with a sanding block and a low angle block plane so they all fit nicely against the tube with rubber band pressure. The strips were numbered so they could be removed and glued into place later. Working with the separate segments would allow me to turn this into eight separate gluing sessions, if needed, which took some of the stress out of attempting to glue them all at once.

Unthickened 105 Resin/206 Slow Hardener was initially applied to the cardboard tube and to the wood strips with a disposable glue brush.

Epoxy thickened with 406 Colloidal Silica and colored with 502 Black Pigment was applied to the cardboard tube with a fine notched trowel just prior to pressing the wood strips in place. The glue squeeze out was more than enough to fill the slight gap between strips.

It took about 35 minutes to apply the epoxy and press all of the strips in place. Initially I just worked with one rubber band to hold the strips in place then after the last strips were applied I added more rubber bands.

Tint a batch of thickened epoxy with 502 Black Pigment

Using a notched spreader, apply thickened epoxy

Press strips onto the form forcing epoxy between gaps

Secure with rubber bands and allow to cure.

After sanding, fill any voids with unthickened pigmented epoxy

I allowed the epoxy to cure for about four hours so it was cured enough to remove the rubber bands and yet soft enough to remove the excess epoxy with chisels and scrapers. This step saved considerable time that otherwise would have been needed to sand the epoxy away.

One of the challenges in making round tubes with strip planking is it takes some skill to turn the flat wood strips into fluid curves. When different wood species are used, the challenge increases because of differing densities and hardnesses. In other words, the softer woods sand more easily than the hard wood strips, making it difficult to make the tube round.

Creating a curved sanding block

I decided that having a specialty sanding block would be worth the time spent making it. I've used G-5 Five Minute Adhesive to make curved sanding blocks before so I just needed to find a cylindrical object with the correct diameter.

I got lucky and found a roll of fiberglass fabric in the shop that matched the diameter of the wood drum shell. I covered it with plastic stretch wrap to protect the roll of fiberglass and to act as a mold release for the epoxy. I brushed a coat of G-5 onto the stretch wrap then quickly applied a layer of paper towel into it. I applied another coat of G-5 and laid another piece of paper towel into it. I repeated this process four times before allowing the G/5 to cure. (1)

I found some pink foam insulation board that I cut to match the curve and glued it to the G-5/paper towel laminate with G-5 thickened with 403 Microfiber. Fifteen minutes later I had my sanding block. (2&3)

When making curved sanding blocks for use on the outside of a cylinder, be sure to get the curve right or make it slightly oversized (to account for sandpaper thickness). If the sanding block is made on too tight a curve, only the ends of the sanding block will touch which makes it rather useless.

Adhesive backed sandpaper works especially well when using simple curved sanding blocks. (4)

Eventually I took the drum shell home and mounted it in my lathe to cut the grooves for the decorative banding. This step could have been done on the table saw or on a router table as well with a little set up and fixturing.

I modified a cabinet scraper on a bench grinder to match the 8-1/2" diameter drum shell curve for truing up some of the stubborn high spots. Scrapers are amazing for this type of cleanup—if they are sharp. For more information on scrapers, see *Scrapers—Versatile Tools for Working with Epoxy* in Epoxyworks #19.

Once the wood was sanded smooth and round, I applied a single coat of 105 Resin cured with 207 Special Clear Hardener. I allowed this to cure 24 hours then I sanded it smooth and dull and applied one additional coat of epoxy. Alternatively, the wooden drum shell could have been finished with a few coats of clear polyurethane or varnish. The inside of the drum was sealed in black pigmented 105/207 epoxy that was created by adding 502 Black Pigment.

Gluing the composite skin to the drum shell

Protect the outside of the drum shell with masking tape on the end that will be glued to the composite skin.

Be sure to pull the release fabric covering the composite skin that is still attached to your flat shiny mold. Sand the laminate lightly in preparation for gluing. If you did not

Creating a Curved Sanding Block

Sand smooth again

Scrape down any stubborn high spots

Turn a groove for the decorative band

The completed drum

cover the composite skin with release fabric, be sure to sand gluing areas with 80- or 100-grit sandpaper.

Apply unthickened epoxy to the top lip of the drum shell and to the gluing surface on the composite drum skin.

Apply a bead of epoxy thickened with 406 Colloidal Silica (to a mayonnaise consistency) to the top of the drum shell and set it onto the composite skin. This step could instead be accomplished by using Six10 Thickened Epoxy Adhesive (the clear epoxy wet out step is not needed with Six10). If you like, you can color the epoxy with 501, 502 or 503 White, Black or Gray Pigment. Form a small fillet from the excess epoxy that squeezes from the joint on the inside of the drum shell. Wipe off excess epoxy on the outside of the joint.

Put a weight on the bottom of the drum shell (the end that is up for this operation) so it will remain undisturbed while the epoxy cures.

Pull the protective tape from the outside of the drum shell before the epoxy cures.

Allow epoxy adhesive to cure overnight.

Work a wood wedge under the composite skin to free it from the flat mold.

Use a saber saw, band saw or metal cutting hack saw to carefully remove the excess composite skin that projects beyond the sides of the drum shell.

Trim rough edges away with sandpaper wrapped around a hard wood block. Break the corner with a small 45° bevel.

Wipe a thin coat of unthickened epoxy over the sanded edge to bring out the shine and allow it to cure.

To finish out the drum shell, I considered several different accent banding materials. I found a couple old leather belts that I cut into ½" wide strips. I found some salvaged stainless steel cable that I wrapped multiple times around the drum to fill the groove that I also liked. Unfortunately, that presented some aesthetic challenges where the cables started and ended. I finally filled the accent grooves with the better looking ½" wide black leather belting that I glued on with DAP contact cement. I think you'll agree that the black leather offers a nice contrast to the multi-colored wood strips and complements the carbon fiber drum skin as well.

With your new drum built and ready to use, it is time to man or woman up and find someone to drum with. I'm thinking the local nursing home is a good place to start. All kidding aside, you might want to think about forming your own drumming circle. If you do, part of the fun with the group could be building your own drums together. The method shown here is just one way to do it. From the drum group photo, you can see there are many ways to build a composite drum.

Building a composite drum would make an interesting project for Boy Scouts interested in working toward a composites merit badge. See Mike Barnard's article *Composites Merit Badge* in Epoxyworks #38 for more on this merit badge.

Also included are a couple other drums that were built with composite skins and epoxy. They all sound a bit different depending on the composite fibers used, the thickness of the skin and whether or not they are attached to a drum body.

If you decide to build your own drum with a composite drum skin, a good source for small amounts of composite fabric and WEST SYSTEM® Epoxy is at The Composites Store in Tehachapi, CA at cstsales.com.

New for January 2015 **502 Black Pigment**

Starting January 1, 2015 we will begin selling a new West System Epoxy Pigment. In addition to our 501 White Pigment and 503 Gray Pigment, we will now be offering 502 Black Pigment. Just like the 501 and the 503, it alters the color of the epoxy mixture without affecting the cured physical properties. Similarly, the maximum acceptable loading is 3%. This is great for hiding a surface with a single coat of black epoxy. Adding more pigment will increase the opacity, but can skew the mix ratio because there is epoxy resin in the pigment. For more information, contact our technical staff at 866-937-8797.

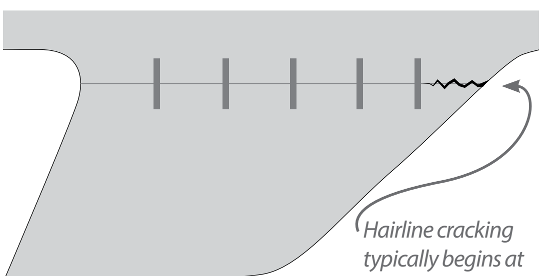
Smiles All Around

By Mike Barnard

For some sailors, there is a common maintenance ritual that occurs every spring—repairing cracks where the leading edge of the ballast keel meets the hull. This annually reoccurring crack is sometimes referred to as a "Catalina Smile" because it often occurs on Catalina sailboats.

The crack can form due to a number of causes but probably the most common reason is the hull isn't as stiff as when it was new. The thousands of fatigue cycles induced while sailing can leave the hull too flexible. This allows slightly more movement at the hull to keel joint, eventually exceeding the limitations of normal caulks and fairing putties causing the crack to return.

Many people try to fix this crack by fiberglassing over it, and it seems to work well… for about a year. After a fairly short amount of time, the crack comes back because there is so much flexing that the repair laminate cracks and breaks. Instead, this repair should be done with a structural, yet flexible, epoxy: G/flex 655 Thickened Epoxy Adhesive.



Rough Rider, one of many boats successfully repaired

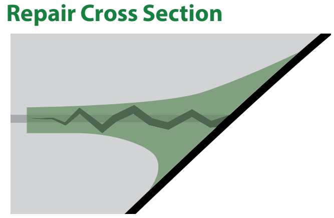
In the years since G/flex was introduced, we have had many customers (and employees) inquire about using it in this application. Year after year we recommend it, and year after year more sailboats are repaired like this. Several customers have used our method and been happy with the results. None of these repairs have had to be been redone.

Here is how we recommend fixing the Catalina Smile:

Open up the joint a bit with a Dremel tool or metal cutting saw blade to expose bright metal and fiberglass laminate. Once the crack is cleaned and widened, bevel the opening generously into the surrounding fairing putty to provide a gentle transition. Dispense G/flex 655 Resin and Hardener in equal amounts on a plastic sheet (or 1.2:1 by weight) and mix by folding it over itself. Begin applying it into the crack then follow up by filling the trough formed by the shallow bevel on both sides of the crack. The pot life of G/flex is 45 minutes, so unless a huge batch is mixed, there should be enough time to dispense it, although mixing multiple batches would give even more time. G/flex 655 has 32% elongation before breaking, which helps to prevent cracks from reappearing in the joint. It can then be wet-sanded, dried and painted for a lasting repair.

The front of a keel repair in progress. The crack has been cleaned, widened and filled with G/flex 655.

Repair Cross Section



Hairline crack to be repaired
Keel Joint
Area to be removed, beveled and filled with epoxy

Surcease restored to its former glory.

Flying Dutchman Restoration

By Douglas Heckrotte

Surcease is a late '50s International Flying Dutchman Class sailboat. The Mahogany hull was cold-molded in Holland and imported by Paul Rimoldi of Miami, Florida. Mr. Rimoldi made everything else, including many pieces of hardware. He raced the boat on Biscayne Bay into the '60s and sailed it for many years. He rebuilt the boat in the late '80s but died before he finished. We bought the boat in August 1992 from his widow and sailed it for almost a season before we discovered that the hull was in very poor condition; the Urea-resin glue between the veneers had begun to turn to dust. We stored the boat and bought another Flying Dutchman.

Close up interior photo of Surcease

I began restoring the boat in 2001, working summer evenings when it was not too beastly hot. I built a rollover cradle which would carry the hull at any angle for ease of working. I stripped off the outer layer of veneer. I removed all of the screws, most of which had corroded to dust, and replaced them with mahogany dowels set in WEST SYSTEM Epoxy. I cut out all delaminated areas in as many as three of the remaining four thicknesses of veneer and epoxied in new mahogany veneer. I steam-bent and installed a new White Oak stem. I re-veneered the hull with 1/16" flat-cut mahogany and coated it in epoxy.

Next, I rolled the boat right-side up and stripped the deck. I added new mahogany stringers matching the originals. I laminated new frames in place. I laminated and installed a new thwart and any small pieces of plywood required for the boat. I also replaced the centerboard trunk cap, all the deck supports, and repaired the original deck frame.

Rollover cradle Douglas built for restoring Surcease

After varnishing the entire interior I installed a new deck of 1/4" Khaya marine plywood. I reinstalled the original spray shield and coamings, and made new rubrails of wood from a 1963 Hinckley B40 mast.

After varnishing the topsides, I reinstalled most of the original hardware and made new stainless steel hardware in '50s style where I felt it appropriate. I rolled the boat upside down and made new rubbing strips from fiberglass rod; the Flying Dutchman class requires the shape of the old-style bronze strips on the hull but I did not want screw holes. The new strips are painted gold and were varnished along with the rest of the hull. I made three new kick-up rudders and centerboards using some old parts, but laminated new mahogany plywood cheeks and made new stainless steel hardware. I replaced the running rigging and we sailed *Surcease* for the first time in 19 years in August 2012.

We showed and sailed the boat at the Chesapeake Bay Maritime Museum's annual Mid-Atlantic Small Boat Festival in October of 2013. They awarded her a First Place ribbon in her class for the race. Of about 70 boats, only a wooden Thistle was really in her class; we were first by a very large margin. They also awarded *Surcease* a First Place ribbon for her restoration.

There are several of us Flying Dutchman sailors in the mid-Atlantic area who refer to ourselves as "Gouge Brothers" (as contrasted with the Blues Brothers)

I have coated several wooden countertops and one antique heart pine bathroom floor in WEST SYSTEM Epoxy and urethane. The shower door and frame are made of cedar coated in epoxy and painted.

We also own a 1970 LeComte North East 38 and much of the work I have done to her over the last decade involves WEST SYSTEM Epoxy as well.

Simple, effective home repairs and projects

By Bruce Niederer

I often get calls from customers asking if leftover epoxy can be used for some small project around the house. The answer is yes, of course! Here are three projects that are perfect examples of what you can do with those partial cans of WEST SYSTEM® resin and hardener.

Interior Door

I live in a house built in the '40s located in the historic district of Bay City, Michigan. The inside is filled with great custom woodwork – trim, floorboards and doors. One of my doors got damaged (don't ask how—kids!) and it had to be repaired since there is no way to replace it.

It has a floating center panel and custom trim. As you can see in the photos, much of the trim holding the center panel was destroyed beyond saving.

Attempting to reassemble the shards of wood like a puzzle just couldn't be done and still look good. I've tried that (again—kids!), so I had to come up with another scheme.

The problem was that only about half the trim that holds the floating panel was intact, which meant getting the panel to fit back in flat wouldn't work as it was.

I decided to cut enough of the intact trim with a razor knife to allow the panel to fit in place properly and flat. Then I purchased some trim molding I found at a home store, which I used to hide all the damage. After cutting the trim pieces to fit and staining them with Minwax® English Chestnut stain, I ran a bead of WEST SYSTEM Six10® around the panel with enough excess to glue the trim pieces in place. Using the Six10 cartridge really made this easy.

I used small finish nails to hold the freshly glued pieces in place while the Six10 cured.

I had to use a little finesse to arrange the four pieces of trim so that all the damaged area was hidden and still maintained the square shape and parallel lines. As you can see in the photo, this threw the fit of my corner joints off a bit. I used a little 105 Resin/205 Fast Hardener filled with our brown 405 Filleting Blend filler to fill the gap and the nail holes after they were removed.

I am very pleased with the results and satisfied with myself for saving the door and not losing a piece of the history of my house.

Completed door rehung in place.

Top left: Damaged door Bottom Left: Close up of damaged section
Top Right: New molding cut to size and laying in place
Bottom Right: New trim held in place with Six10 and finish nails, the gap being filled with 105/205 with 405 Filleting Blend for color.

Completed door back where it belongs.

Exterior Door

My side door, which is off the driveway and is the door used daily to go in and out, had become water damaged. The house did not have eaves troughs but needed a new roof which had to happen before installing eaves. As a result, a few years of water dripping and soaking into the pressboard core had ruined the core and corroded the aluminum facing.

I peeled one side of the aluminum facing to use as a template and then cut off the bottom at a strategic point above the damage. Utilizing some plywood cabinet doors salvaged from our move into the new Gougeon Technical center, I fashioned a new bottom piece.

Top: The damaged bottom of the door.
Above: The aluminum facing being peeled back

Above: New wood core section being dry fit to the original door section.
Right: The butt joint with witness mark sanded after the fiberglass layer has been applied with 105/207.

Left: All sides liberally coated with WEST SYSTEM 105/207 with 410 Microlight filler to create a smooth finish.

I made a witness mark on both sides and glued the replacement piece to the door.

I then coated all the sides and edges liberally with left over WEST SYSTEM 105 Resin/207 Special Clear Hardener and laminated a short length of 4" 732 Glass Tape over the butt joint on both sides of the door. Next I sanded everything and began fairing with a mixture of 105/207 and 410 Microlight® fairing filler.

Once the fairing process was completed and the panels were smooth and flat I primed the freshly sanded surfaces on both sides of the door.

Finally, I found an appropriately colored paint (Saddle Brown) from my local hardware store and painted the entire door with the exception of the window insert. The result is a two-tone look that I'll decide whether or not to keep once I reinstall it at home.

Canoe Brackets

My last project is a new build of some hanging brackets for the company Sassafras canoe—a CLC kit boat—and Tom Pawlak's beautiful stripper canoe. The goal of the design was to make something we could easily rig to lift and hang the canoe so it would be out of our way when not in use. We also wanted something that would look kind of cool, in keeping with other stuff built here at GBI.

I found some Douglas fir veneer left over from our wind blade building era with the grain running lengthwise. The wheels in my head started turning and the seed of an idea formed. As often as not, that can be a dangerous situation, but this time I think I came up with a good plan. I would build a jig, laminate the brackets, install them on the wall, figure out how to rig it with a single line and stand back and collect all my attaboys!

You would think I'd know better by now.

First I had to build the jig. Again using the cabinet door plywood we salvaged from our move, I created a base and the braces I would clamp the laminate to when building the parts. I marked the shape I wanted with a magic marker and glued the L-shaped braces as shown in the photo. No fasteners were necessary.

Top: Plywood jig to bend the brackets around
Bottom: Wetting out the wood veneer

Top: Wetting out the carbon fiber reinforcing
Bottom: Layering the carbon fiber on the wood veneer

Top: A polyethylene sheet is used as a mold release for the foam core bracket
Bottom: The bracket laid up and clamped

I initially used cellophane packaging tape to act as my release surface. That didn't work like I planned so I switched and wrapped the laminate stack in polyethylene sheet plastic, then clamped it in place.

I planned on making four of these brackets using six layers of veneer with a layer of 713 Episize™ Unidirectional Glass Tape inside both outer veneers. After consulting Tom Pawlak, my fellow Tech Advisor, I built each one a little different. One was as I just described, a second was similar but I used unidirectional carbon instead of glass, a third laminate used a 3/8" balsa core with unidirectional carbon on each side followed by a single layer of veneer, and the fourth used foam core instead of balsa.

The above photo sequence shows the lay-up of the foam cored bracket.

My fellow Techies covered my behind on this one while I was at the Port Townsend Wooden Boat Festival. Don "Gootz" Gutzmer modified the brackets seen here by doing the following: after loading the brackets back onto the jig one at a time, he added alternating layers of veneer and biaxial glass (three veneer/two glass) then two layers of carbon unidirectional fibers to each. This added significant stiffness and thickness. He also fashioned a backing plate or caul, as they are commonly referred to, using 1/8" G/10 FRP stock to remount the brackets to the wall bolted through the metal wall studs.

Tom Pawlak tackled the second set and his plan was slightly different than Don's but equally adequate. Tom loaded the brackets to the jig one at a time the same as Don, but he added the following: one layer of biaxial glass, three layers of veneer, second layer of biaxial glass, a fourth layer of veneer and single layer of unidirectional carbon fiber. Once the beefed up bracket was removed from the jig, Tom added a single layer of unidirectional carbon to the inside surface of the bracket.

Success! The brackets Don and Tom modified and mounted are more than equal to the task.

Here is a look at the G/10 backing plate or caul.

Left: Tom's stripper canoe hanging from the reinforced brackets.

Above: The company Sassafras canoe hanging from the reinforced brackets

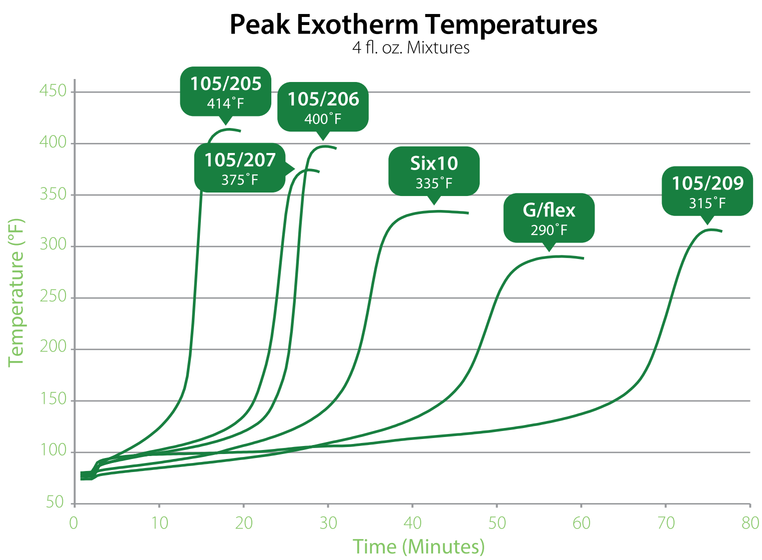
Controlling Exotherm

By Mike Barnard

When mixing larger batches of resin and hardener, pot life— or the amount of time that elapses before the epoxy hardens in the container—is very important. You need to estimate how much mixed epoxy you will use in a certain amount of time. Variables that affect this calculation include temperature, volume, surface area, hardener speed and the insulating quality of the container.

Left: A 1 inch deep pour (70 grams) of 105/206 in an 18 oz. bottle reached 410°F, cracked and deformed the bottle.
Right: 105/206/Quikrete® in 18 oz. bottle (completely filled) reached 150°F (700 grams Quikrete- 250 grams mixed epoxy) without any deformation or cracking.

As a rule of thumb, for every 18°F increase in temperature, pot life is cut in half (see the Hardener Selection Guide in the WEST SYSTEM User Manual). This is useful for an approximation. However, the data we provide on pot life is based on 100 grams or about four pump strokes each of resin and hardener using our 300 Mini Pumps. If you are using a larger amount of resin, or simply a different size cup, the length of pot life can vary. To increase the pot life of a cup of mixed epoxy, spread it over a larger surface area, work in a cooler environment, or mix multiple, smaller batches as you go.



The chemical reaction between resin and hardener is exothermic, meaning as epoxy cures it will generate heat. When this heat cannot escape, it builds up, causing the epoxy to cure faster because epoxy cures faster at higher temperatures. Curing faster because of the heat, the epoxy generates even more heat, even faster. This snowball effect is why a gallon of epoxy mixed all at once may turn solid in about 5 minutes. The resulting massive build up of heat can cause the cured epoxy to crack because of the temperature differential between the top and bottom of the container.

This uncontrolled heat build-up is called uncontrolled exotherm. Epoxy heating out of control can foam, smoke, give off dangerous vapors and generate enough heat to melt its container or cause nearby items to catch fire. It's crucial to understand epoxy's exothermic curing reaction and follow the instructions in this article very closely if you are planning to fill a large area with a thick casting of epoxy.

The mechanism that causes heat buildup when epoxy is contained in a thick mass is also why epoxy takes longer to cure when it is applied in a thin film. The film does not build heat, so the temperature through the thickness of the epoxy film is pretty close to the ambient temperature.

Occasionally customers are interested in filling a void by pouring a large mass of epoxy all at once. This can be very dangerous because it will generate a lot of heat, and can lead to poor results because of the snowball effect mentioned earlier. Some faster epoxy systems, mixed in large batches, can reach temperatures over 400°F, hot enough to melt or at least soften plastic. This level of heat could also damage whatever the epoxy is poured into. High temperature can also result in severe cracking throughout the thickness of cured epoxy; so much so that if the epoxy were not supported, it could fall away. Customers casting large epoxy sections into boat bilges have reported hearing loud snapping or cracking sounds after the epoxy cured, a sign of cracked epoxy. Shrinkage, which sometimes occurs in situations with intense heat, can introduce significant stresses into the structure the epoxy is attached to.

Pouring a large mass of epoxy is very difficult to do safely and effectively. Temperature, volume of epoxy, depth of the epoxy, and amount of heat sink in contact with the epoxy are all major variables in this application.

Proven methods for controlling exotherm

If you do want to pour or cast a large volume of epoxy, here are several proven methods for minimizing heat buildup which we've developed over the years.

Pour the epoxy in timed, multiple batches

Timing is important when doing multiple pours. Ideally, you want to wait for mild exotherm to peak and begin falling before mixing a new batch and pouring. Waiting too long could cause an insufficient bond between the two pours. Not waiting long enough can cause too much heat to build and cracks to propagate.

Choose 209 Extra Slow Hardener or G/flex

Slower cure allows a deeper pour before significant heat buildup occurs. For this reason, we recommend to use our slowest systems when casting larger amounts of epoxy: 105 Resin with 209 Extra Slow Hardener, or G/flex.

Work at cooler temperatures

Cooler shop temperatures and cooling the epoxy itself will both work to your advantage in slowing cure and controlling epoxy's exothermic reaction. A deeper pour can be accomplished with less heat buildup by starting with cooled epoxy and a cool substrate until the epoxy initially cures to a soft solid. Then you could expose it to room temp or higher to complete the cure.

Use heat sinks

A heat sink is any object that can absorb a lot of heat. If you are applying the epoxy into or over a heavy metal object, it will absorb much more heat than a lower-density object.

High-density fillers can also act as a heat sink, reducing exotherm by absorbing more heat than a low-density filler, and taking up more volume. This displaces the mixed resin and hardener, reducing the resulting heat reaction.

If the wrong epoxy/filler combination is used for a certain cure temperature, the epoxy may generate enough heat to smolder and burn. Adding more low-density filler will certainly reduce the amount of epoxy in a given volume, but the filler will act as an insulator instead of a heat sink. This effect is shown in the testing that we did.

The Peak Exotherm graph shows the temperature of about 4 fluid ounces (4 pump strokes each of resin and hardener with the 300 Mini Pumps) of epoxy over time. The epoxy is contained in a small cup with a plastic top covering so little heat can escape. As is typical, the slower epoxy systems generate less heat and take longer to reach that temperature. Keep in mind that the epoxy is not necessarily fully cured when the line ends. Sure, this is nearly the highest temperature it will reach, and it has started to cool, but as the next graph demonstrates, it may not be hot enough to fully cure the epoxy that quickly.

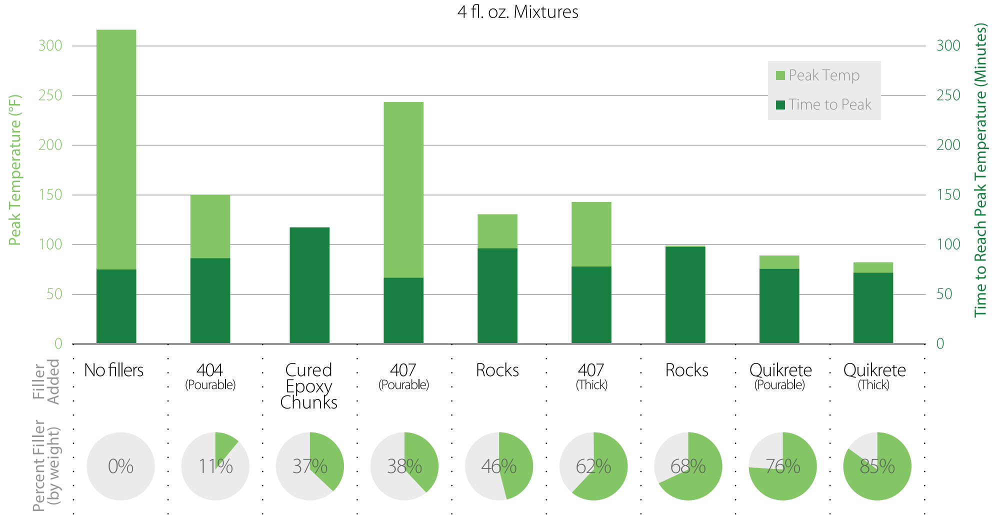
The Peak Exotherm of 105/209 with Fillers graph shows how different additives will affect the peak temperature and the time it takes to get to the peak temperature. For this testing we used the 105 Resin/209 Extra Slow Hardener because it is more readily available at retail stores in larger quantities than G/flex. The various fillers produce effects similar to what is in the graph when used with G/flex, the lowest exotherming product from WEST SYSTEM.

Enlargement of the crack that formed in the 105/206 pour.

Full bottle pour with 105/206 and Quikrete.

Peak Exotherm of 105/209 with Fillers

4 fl. oz. Mixtures



The completed bike fender weighing in at 1.75 ounces.

Light as a feather

By Tom Pawlak

Last Father's Day I received a new light and sleek bicycle from my family. It is by far the nicest bike I've ever owned. I enjoy riding it to work in the spring, summer and fall. Because it is so nice, I decided I didn't want to bolt on the aluminum bracket used previously over the back wheel on my old bike. The bracket had served multiple purposes. It supported my travel bag and it acted as a fender to keep road water off my back while riding. I decided I would ride with a backpack instead to reduce bulkiness and thought it would be nice to make a lightweight fender that I could snap on for those rainy days. That would allow me to remove it for longer trips and on nice weather days.

If you are interested in making your own lightweight composite fender, here's how it is done:

Fender

Locate a flexible hose, or Funnoodle® foam pool toy or other object that has a curve and diameter that looks good. This will be your mold for making the fender.

Flex the hose or other mold object so it matches the diameter of the tire diameter plus a couple inches for wheel clearance.

Drape the hose over a stool and secure it into position with duct tape. Wrap it with stretch plastic film like Saran® Plastic Wrap. This will act as mold release for the composite fender after it cures.

Flexible tubing was used to create the mold of the fender. Plastic wrap is used as a mold release.

Cut 4-oz. or 6-oz. plain weave fiberglass cloth to the length and width needed (I used three layers of cloth). Two layers were oriented with the strands running +-45 degrees to the length of the fender and one layer with the fibers running 0/90 degrees). Be sure to cut more than enough length so the fiberglass fender is a bit longer than needed. That way you can always cut it shorter later.

Brush a coat of 105 Resin mixed with 207 Special Clear Hardener onto the stretched plastic.

Place a layer of fiberglass into the wet epoxy and wet out the fiberglass with 105/207 until the white fiberglass strands turn clear.

Apply the remaining layers one at a time with the previous layer still uncured, and brush on more epoxy as needed.

Fiberglass applied to the mold surface.

Allow the epoxy to cure for 3-4 hours then apply one additional coat of 105/207 to fill the weave of the fiberglass. If you wish, you can add a little 502 Black Pigment. That way the fender would look like smoked glass. See Bruce Niederer's article in Epoxyworks #21 *Adding Pigments to Epoxy* for more ways to color the epoxy.

Allow the epoxy to cure overnight, then work an 804 Reusable Mixing Stick under the edges of the fender to lift the fender off of the mold.

Cut the fender to shape with tin snips or with heavy scissors and set aside

A mixing stick is used to start to pry the cured epoxy and fiberglass away from the mold.

The cured fiberglass and epoxy easily pulls away from the mold surface.

Create snap sleeve to connect fender to seat support tube

Prepare the bike frame/seat support tube by covering it with clear shiny Cellophane packaging tape. (This will act as mold release so the epoxy does not stick.)

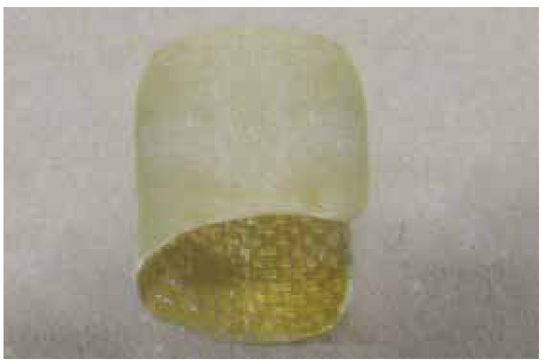
Kevlar/Fiberglass Snap Connector

Cut 3-4 strips of 4 to 6 oz. fiberglass cloth that are 1.5" wide and just long enough to make it 3/4 of the way around the circumference of the tube. I used Kevlar for the first layer on mine so it would not scratch the paint on my bike, and followed that with a couple layers of fiberglass cloth.

Brush a coat of 105/207 epoxy onto the Cellophane tape, then apply the layers of 4-6 oz. fiberglass one at a time using the technique described for making the fender. Be sure you start the pieces at the same point on the tube with the goal of wrapping the tube ¾ of the way around with each piece.

Allow to cure overnight before removing the composite sleeve from the tape covered tube. It should pull away like a fiberglass spring.

Trim it to final size with snips, files or sandpaper.



The Kevlar sleeve trimmed and sanded.

Try snapping it in place. If it goes on and off the round support tube with difficulty, shorten the snap by removing 1/16" to 1/8" of circumference until it snaps onto and comes off of the tube without too much effort. Remember, this snap will keep the front end of the fender attached to the bike so you don't want it too loose. If you trim away too much and it is a bit loose, don't worry because it will tighten up a bit when the spacer strut (info on this will follow) is glued to it.

Left: Fiberglass wrapped around the foam spacer

Middle: Fiberglass completely wet out and wrapped around the foam spacer

Right: Close up of the PVC snap screwed and epoxied in place

PVC Pipe Snap Connector

There is a place on my bike frame just above the rear wheel where an aftermarket fender can be bolted in place. I used the holes intended for the thru bolt as indents for a plastic snap made from ½" white PVC plastic pipe cut to shape.

Spacer Strut

Mock up the fender, PVC fender snap, fender and seat support tube snap sleeve (align opening in sleeve to face the front of the bike) with a combination of wire and cellophane tape. In other words, get all the components in place and secure them temporarily. Be sure the fender is centered over the wheel and centered behind the seat support tube (at the lower front end of the fender). Adjust as needed to get it all aligned. When the fender is temporarily supported in its intended position, look at the gap between the front end of the fender and the back edge of the support tube snap sleeve. Adjust the fiberglass snap sleeve up or down the tube until the bottom edge is level with the front bottom edge of the fender.

Begin measuring and drawing the shape of the gap so you so you can sculpt it from a piece of expanded polystyrene foam or pink or blue Dow® Styrofoam.

Use whatever tools you have for carving/shaping the foam spacer. Band saws, keyhole saws and coarse sandpaper wrapped around wooden dowels are all helpful. Don't look to make it perfect now because it can be further shaped after it is glued in place.

Dry fit the spacer to make sure it fits then glue it in place with epoxy thickened to a non-sagging consistency. Six10 Adhesive, G/5 Five minute Adhesive or 105 Resin with 200 series hardeners epoxy thickened with 403 Microfibers would work for this. Try to avoid smearing excess epoxy onto the foam face because epoxy smudges will be much hardener to sand than the expanded foam when final shaping later.

Allow the epoxy to cure then carefully remove the fender and fiberglass snap from the seat support tube.

Final fair the strut with sandpaper wrapped around wooden dowels or various shaped course metal files with the goal of creating something sleek and aerodynamic.

Cut two strips of 4-oz. or 6-oz. fiberglass cloth (one for each side of the foam strut) with the fiberglass strands oriented on the bias (at +-45 degree orientation). This will enable the fiberglass to better conform to the spacer strut, fiberglass snap sleeve and fender. Leave the fiberglass long enough and wide enough to tab onto the sides of the fiberglass snap sleeve, cover the foam spacer and extend onto the fiberglass fender by about ³/₈".

Apply a coat of epoxy to the strut and ³/₈" beyond the foam onto the fender and onto the fiberglass snap sleeve.

Lay the fiberglass piece oriented on the bias over one side of the strut and press it in place with a small glue brush or with your gloved fingertips.

Apply additional epoxy to the fiberglass until the fiberglass strands go clear. Wipe away any excess.

Repeat the process on the opposite side of the strut. Where the fiberglass meets at the front and back of the strut, you can either let it overlap by ¼" or you can let the two fiberglass pieces contact one another to form a ¼" wide flange.

If you wish to fair the strut and tabbing that connects everything together you can brush on a coat of epoxy thickened with 410 Microlight™

Kevlar/Fiberglass and PVC snaps mounted in place

Fender installed and ready for use

or 407 Low-Density filler (to a stiff ketchup consistency) to fill irregularities while the previously applied epoxy is still sticky or tacky.

Installing the PVC Snap on the Fender
Press the PVC snap into place in the fender mounting holes located over the rear wheel.

Feed the rear end of the fiberglass fender between the seat support post and the rear wheel. Continue feeding it over the back wheel and adjust fore and aft until the fiberglass snap sleeve can be pressed in place on the seat support tube.

Center the fender side-to-side over the rear wheel, lifting it until it touches the PVC snap fitting. Secure it temporarily with tape.

Put a couple witness marks on the PVC snap and fender so you can relocate it later.

Remove fender from the bike.

Align the marks on the PVC snap and the fender and drill a hole through the underside of the fender and into the PVC snap connector. Be sure to select an appropriate size pilot hole for the self-tapping stainless steel screw.

Screw through the underside of the fender and into the PVC snap connector. When it is snug and secure, trim off the excess screw length so it is flush with the inside edge of the PVC snap.

Take it apart and sand the mating surfaces on the fender and on the PVC snap with 80-grit sandpaper.

Apply a bit of thickened epoxy, (I used G/5 Five Minute Adhesive thickened with 403 Microfibers for this) insert the screw, snug it up slightly and clean up excess epoxy after sculpting the “squeeze out” into a clean radius fillet.

Install the fender on the bike, feeding it once again through the gap between the tire and the seat support tube while the epoxy is still soft so you can rotate the snap slightly, if needed, to align with the holes in the bike frame.

If you want to make it really nice, you can sand everything smooth and fair then paint it or clear coat it with an automotive clear coat. I left my fender unprotected all summer long and it still looks good, although it did yellow slightly from UV exposure.

It may be that your bike is set up a bit differently than mine and you may have to improvise to connect & disconnect the fender from your bike frame. That’s part of the fun in a project like this. In the spring, I’m thinking of shedding a few grams by making my next fender out of carbon fiber—just kidding. This one only weighs 1.75 ounces (50 grams) so I don’t think I could do much better, although it would be fun to give it a try. We’ll see.

Enlargement of the repaired section.

Julie mixing epoxy to begin her repair job.

When the Cat's Away

By Julie Van Mullekom

Like a lot of people, when I'm at work I like to keep busy. It makes me feel good about myself and the bonus is that the day just flies on by. Having said that, it's also nice to escape from the walls of my office now and then and head out into the shop to see what the guys are working on. For some reason this gravitational pull I feel from the shop occurs more when my boss is away. We can just call it an unexplained phenomenon and leave it at that. During some of my excursions to the shop, rather than just letting me observe, the guys have me help them with the projects they're working on, which I absolutely love! They show me how to do things I wouldn't dream of doing otherwise: routing a table top, assisting with a vacuum bagging project or helping build a stitch and glue canoe. It's just a nice change of pace from my usual office responsibilities and it's the perfect opportunity to work with our great products.

This year we have been very fortunate; we moved from the old digs into a bright, shiny new Technical Building, which meant new offices! They are simply beautiful in their original state but I like to put a few things up on the walls to add a bit of a "homier" feel to my space. (Sans the dirty dishes, clothes, windows, children and animals). Recently I was in the process of hanging a plaque on the wall when whammo…thud! it came crashing down and put a pretty big crack in it. After a few choice words and a deep cleansing breath I thought to myself "Hmmmmmmm…..broken object? Check. Epoxy? Check! Boss gone? CHECK!" So out to the shop I went for some expert advice from my Tech buddies. As soon as I showed them the issue at hand it was as if we had a code blue in the shop. People were scrambling, the plaque was ripped out of my hands and a crash cart consisting of all the wonderful things we have here at GBI to fix it was put in front of me. So off I ran to don a pair of neoprene gloves and we were on it like flies on…food, yeah that's it…food.

- To prep the piece, I sanded the break with 80-grit to remove any sharp edges and scratch it up a bit to improve adhesion.

Left: Prepping the surface by sanding with 80-grit sandpaper. The metal support rod was exposed when the plastic broke.

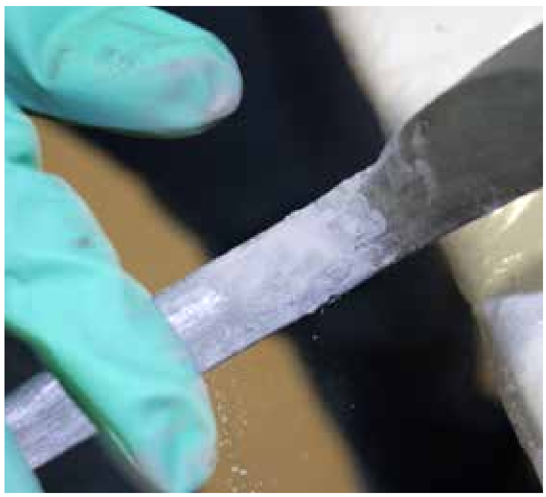
Right: Tinted epoxy being applied to the repair site.

Left: Repair area wrapped in packing tape to form the shape of the stem.

Right: Removing excess cured epoxy.

- I then I mixed G/5 Five Minute Adhesive resin and hardener and added a touch of our 503 Gray Pigment to match as closely as I could with the metal-like finish of the plaque.
- To make the G/5 more like paste and help it stay put, I stirred in a dash or two of our 403 Microfibers.
- I spread the mixture into the cracks on both the front and back sides and brought the pieces together.
- To make the epoxy conform to the shape of the stem I wrapped it with clear packaging tape before the epoxy had a chance to set up.
- After it cured for 15 minutes, I pulled the packing tape off and used a box cutter to trim off any excess epoxy— carefully cutting away from myself so I wouldn't accidentally puncture my jugular.

Next I sanded off any rough spots while eagerly waiting to see the end result. The fix was good and solid, however, because of the shiny texture on the dull, distressed surface it was also pretty obvious. Being the creative thinkers they are



Brushing the repair site with aluminum powder to match the texture of the surrounding surfaces.

someone suggested wiping the patch down with a little more G/5 and with the epoxy still tacky dusting it with dry 420 aluminum powder, rubbing off any excess.

Once it cured, I rubbed it slightly with a Scotch Brite pad and voila! It looks perfectly imperfect and I couldn't be happier about how it turned out.

***Note to my boss: The controversial aspects of this article have been TOTALLY fabricated to enhance the story line. Honest, I swear… really.

Strings Centerboard Adjustment

By Greg Bull

Strings, as unique as the man who designed it, continues to be a work in progress for us at GBI. In Jan Gougeon's first year of sailing *Strings*, he noticed the boat felt sticky at times. He thought it might be the centerboards jibing too much and the solution might be locking them straight. The center boards work as jibing boards by having two high spots on each side of a centerboard head creating the pivot point to get the boards to change angle, or jibe. The actual pressure from the boat going through the water and wanting to slide sideways gets the boards to jibe.

Keeping *Strings'* centerboards from jibing seemed like a simple task at first. Then, as I contemplated the task, I realized that the centerboards have no true flat areas. They have a foil shape that goes through the water, and the head (top) of the board has both thick and thin areas enabling the board to jibe.

My first job was locating the centerline of each board. Luckily for me I could make out the parting line from building the boards; they were built in half and then epoxied together. Using this line, I leveled the center boards so the parting line was the same distance off the table. For a project

Wedges were used to level the centerboard and were held in place with G/5 Five-Minute Adhesive.

Leveling the top edge of the board

The tapered edge of the centerboard.

The trailing edge of the centerboard now complete.

like this, it is important to have a flat table to work from. Another help is to have a table top level in all directions. Once the board centerline was parallel to the table, I used a level to make my modifications.

Wedges were used to get and keep the boards parallel to the table. This proved to be the most time-consuming part of the project because I had to work around each board, slowly tapping in the wedges. I used G/5 Five-Minute Adhesive to glue the wedges in place. (photo 1) With the centerline of the board level, I focused on leveling out the areas that used to jibe the board. Once again I used wedges to achieve a level plane. For this, I mixed about three pumps of 105 Epoxy Resin and 206 Slow Hardener with 404 High-Density filler. (The resin and hardener happened to have our quality control dyes in them; yellow for the resin and blue for the hardener made green.) Once the mixture reached a peanut butter consistency, I added it to the board. I used the level to keep a straight plane on the top edge of the board. This process was repeated to level out the area at the bottom of the head. (photo 2)

Once I had at least four areas that were in a level plane to one another, I used a glass plate to provide a flat surface to rub against the center board trunk. This process gave me a level area around the head of the centerboard. I repeated the same steps on the other side of the centerboard. In lieu of a glass plate, a piece of plywood or metal with plastic on it could be used. The plastic allows for easy removal of the plywood or metal from the epoxy. With glass, it is also a good idea to wax the mold surface that to make sure it will come apart.

After the epoxy set, I pulled the glass plate off and tapered the edges of thickened epoxy to ensure that there were no edges to catch on anything in the center board trunk. (photo 3) When I finished the project, I had doubled the thickness at the trailing edge, which was a surprise to me. (#4)

There was always one thing in the back of my mind: I needed the centerboards to fit back into the centerboard trunk when the project was complete. To ease my mind, I made a jig to slide over the top the centerboards that was the same size as the trunk. Thankfully, they fit fine when they were reinstalled on *Strings*.

Goshen High School students at the 2014 Shell Eco-Marathon.

588 Miles Per Gallon

By The Students of Goshen High School's Engineering Design & Development Class

We are a group of students from Goshen High School in northern Indiana and for the past six years we've had the opportunity to design, build and test high mileage prototype vehicles in a class called Engineering Design and Development. Year to year this program serves about 30 students ages 15 to 18. We begin with little to no background in automotive or engineering technology, and through the course of this program learn many new skills.

We compete in the Shell Eco-Marathon in Houston, Texas. Participants include students from high schools and universities across North and South America. There are two main categories of competition: Urban Concept and Prototype. Urban concept vehicles more closely resemble street legal vehicles while prototype vehicles are smaller and built primarily for fuel efficiency. Each main category has subcategories consisting of different engine types: gasoline, ethanol, diesel, hydrogen, or electric.

The student's entries: the top gasoline, the bottom diesel.

This year Goshen High School entered two vehicles in the Prototype category: one gasoline, the other, diesel.

Over the past two years we've focused on monocoque design, in which the body and the chassis are one in the same allowing us to produce roomier yet lighter vehicles. This past year, we spent time during our summer modifying an existing plug to create a new body shape that gave us better aerodynamics, a tighter turning radius and an easier composite layup experience. Once our school year started we dedicated a large portion of our time obtaining sponsorships to fund our program since we are funded 100% through donations from our individuals and corporations in our community. We sent our foam plug (cut three years ago by Global Composites) to one of our sponsors, Better Way Products/Jasper Plastics Solutions, who produced our mold. When we received our mold back we began laying up our first practice piece with fiberglass and balsa core. We then began prototyping new and existing ideas into the new body design. For our final piece we worked with carbon fiber generously donated by Zoltek. Throughout the course of the year we learned that carbon fiber is as difficult to work with as fiberglass, but sharper. The benefit is that carbon fiber is stronger and lighter, and helped us drop 40 pounds compared to the previous year's body design.

Goshen High School Vehicle Overview

The diesel vehicle used a fiberglass monocoque body that we laid up and competed with last year. We simply made modifications to systems that required upgrading, and swapped out engines going from a small 35cc gasoline engine to 219cc diesel engine. One of the greater challenges we had with the transition from gas to diesel was fitting the much larger diesel engine into a compartment designed for a smaller engine. We overcame this challenge and succeeded in our first year competing in the prototype diesel category.

For the gasoline vehicle we used the carbon fiber donated by Zoltek to make a brand new body with a new body shape, slightly modified from the previous year. Our goal was for this to be our lightest vehicle yet. Our previous monocoque vehicle weighed in at 144 lbs fully loaded with the exception of the driver. We have used composites before, but this was our first time using carbon fiber. With the carbon fiber we used a polyester resin for the top piece of the body, and thanks to a donation by Gougeon Brothers, Inc. we were able to use Pro-Set epoxy for our bottom piece. The Pro-Set epoxy gave us more time to lay up the carbon fiber, which was important for us while learning the lay-up process. This helped us get the balsa core, donated by I-Core Composites, positioned correctly for our monocoque design.

Contest Summary

This past April, after a year of dedication it was time to see the fruits of our labor. Thirteen Goshen engineering students traveled to Houston, Texas for the 2014 Shell Eco-Marathon. On our first day in Houston the

Top: Getting ready for a run at the Shell Eco-Marathon.

Left: Close up of the vehicle.

diesel vehicle made it through technical inspection with little to no setbacks, proving its adherence to the rules but most importantly that its safety features were up to par. The gasoline vehicle on the other hand had a major setback when a weld broke on the steering system during the inspection. On day two of the contest, after some welding and reassembly, the gasoline vehicle made it through technical inspection flawlessly. It then went on to complete a full practice run of ten laps, while the diesel vehicle struggled to control the engine torque. We faced having to reinforce the drive train, which was difficult with limited materials and processes available.

On the third day of the official contest runs began. The diesel engine continued to have issues and the vehicle did not complete a full set of ten laps. The gasoline vehicle completed two official runs with the first run resulting in the best mileage for our team, at 588.21 mpg.

The night leading into the fourth and final day the team completed an engine swap from a 49cc electronic fuel injected engine to a 35cc carbureted engine. This vehicle then went on to complete one official run but did not obtain a higher fuel efficiency. The diesel vehicle completed an official run the last day of the contest with a fuel useage of 442 mpg giving the vehicle a fifth place finish out of nine competitors. The now carbureted gasoline vehicle finished in 17th place of 43. Of the 16 teams that finished above us only four were high schools.

Left: Testing the diesel powered vehicle.

Completed skim board with traction pads attached.

Vacuum Bagging a Skim Board at MITES Competition

By Ben Gougeon and Don Gutzmer

For the past couple of years Gougeon Brothers, Inc. has been involved with the Michigan Industrial and Technology Education Society (MITES). This non-profit organization consists of over 600 members involving both high school teachers and students who believe in the power of hands-on learning. The students build a project throughout the year and compete in the MITES annual regional, state and national competition.

Mold surface: ¼" plywood with a sheet of 1/16" thick G-10 glued on it

Ben Gougeon and I were invited to participate at this year's MITES competition held at Saginaw Valley State University. We demonstrated one of the processes in manufacturing composites, vacuum bagging. We were excited to participate and decided it would be fun to show the students how to build a carbon fiber skim board with WEST SYSTEM Epoxy 105 Resin and 207 Special Clear Hardener by vacuum bagging a sandwich composite.

Applying a 1" rocker to the mold surface

Here are the steps we used to build the carbon fiber skim board:

First we needed a mold surface to lay the board on. We used ¼" plywood and glued on a sheet of 1/16" thick G-10.

Next, we used weights to evenly distribute enough pressure to make good contact between the G-10 and plywood.

Skim boards have a little rocker to make them perform better, so in order to get this we glued a 1" strip of wood on the bottom center of the mold to make it easy to clamp it on a work bench. The ends were propped with 2" angle iron to get the desired 1" rocker into the board.

Five coats of Partall Paste Wax #2 were applied to the G-10 mold surface to provide an adequate release agent. Before applying epoxy we put 883 Vacuum Bag Sealant around the perimeter of the mold to be sure it would stick well, rather than risk applying it later when surfaces may be contaminated with epoxy.

Our core was ½" balsa that was 56" long by 20" wide, and we used a batten to draw a fair curve. We cut the first side and used the cut off excess as a pattern to make it symmetrical.

We used one layer of 5.8 oz. 0-90 plain weave carbon fiber cloth on each side of the balsa core. Before applying epoxy we laid the dry fabric

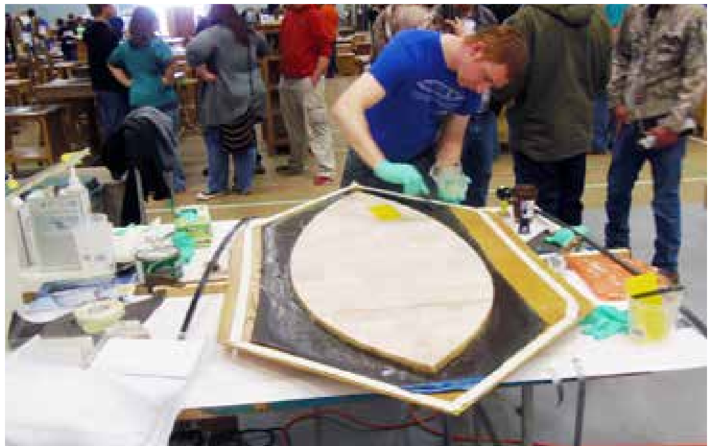
½" balsa core cut to shape

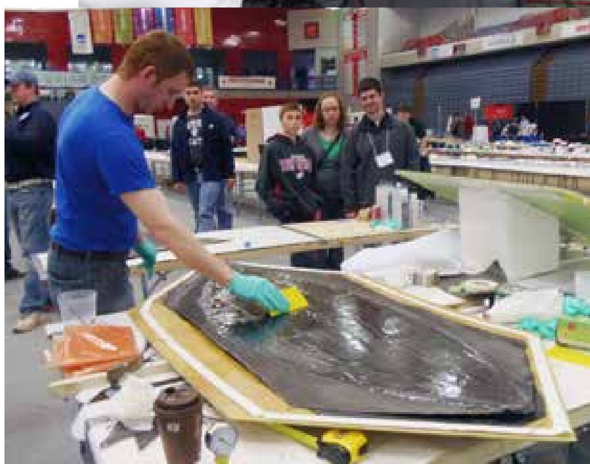
down on the mold surface to straighten the fiber bundles. An 808 Flexible Plastic Spreader was used at a low angle to apply the epoxy. We decided it would be nice to finish off the edge of the board with a pre-made strip of G/flex-650 and 30% finely ground rubber (¼" wide x ½" thick). We wanted to take advantage of the toughened chemistry of G/flex to have an edge that would hold up. The G/flex strips were glued on during the bagging process.

One layer of 879 Release Fabric was applied over the wet epoxy. The release fabric is a finely woven nylon fabric treated with a release agent. This fabric peels away easily and leaves a smooth textured surface that is ready for bonding. After the release fabric, a perforated film was used to control the amount of epoxy in the laminate. Excess epoxy bleeds through the release fabric and perforated film and gets absorbed by two layers of 881 Breather Fabric. The Breather Fabric provides air passage within the bag while absorbing excess epoxy. Removing excess epoxy improves the strength-to-weight ratio of the finished cored composite. We then applied our 882 Vacuum Bag Film to complete the bagging process.

The bag was pulled down to 25 inches of mercury (12.3 psi) until the epoxy gelled.

To provide a smooth waterproof coating we applied multiple thin coats of 105/207. For the finishing touch, the traction pads were attached. The board turned out very nice and is ready for the beach.





Vacuum bagging demonstration at MITES.

Above: Vacuum bagged skim board

Left: Skim board after final coats of 105/207

Boat Building in Bay City

By Bill Bauer

Twenty years ago, some local sailors established the Saginaw Bay Community Sailing Association to provide affordable sailing lessons in the Saginaw Bay Michigan area. Starting out with a few donated Optimist prams, the program quickly grew and additional boats were needed.

Strip Plank Canoe

Gougeon Brothers, Inc. provided the SBCSA with floor space in the loft of the GBI Boat Shop and the SBCSA winter boat building sessions began building 5 more prams for the school. That was about 14 years ago. After that first successful winter of boat building, the idea to form a winter boat building class came to light. The boat building class would meet twice a week for about four months to teach boat building and epoxy techniques and produce a boat that would then be raffled as a fundraiser for the SBCSA.

Wood Duck Kayak

During those first 13 years the class has produced five Optimist Prams, two Newfound Boatworks Rangeley rowing skiffs, three Joel White Shellback Dinghies, two 12' Brooks Boat Designs “Ellen” sailing skiffs, one 13' EddyCat, one 15' Bear Mountain Boats “Bob’s Special” cedar strip canoe, and one 22' Zurn EL electric motor launch.

The class is structured so that there is a boat partially completed from the previous year and another boat to be started. That way a new student will be able to see boats in two different stages and can choose which stage to work on. Usually a boat is finished every year but as projects go that is not always the case. The Zurn EL was planned as a three year project and the EddyCat, which was a reproduction of a 1946 local boat, took longer than expected because the first year was spent lofting the plans.

The SBCSA boat building class is limited to 20 students and there are six volunteer instructors. The class meets two evenings a week from the first week in January until the middle of April at the GBI boat shop. The student body consists of about 10 students that return every year with 10 new students that usually attend for more than one year. The cost is a SBCSA membership and a small materials fee.

For the 2014 session three new Optimist prams were completed. Two Chesapeake Light Craft hybrid kayaks were also started; these will be raffled as a pair in 2016. Also two pairs of “Sam Manning” saw horses and a new flight of stairs for the boat shop were built.

The 8' Optimist Prams were started in 2013 and completed in 2014, they were built to replace three of the aging fiberglass prams. The new prams were made of 4- and 6-mil marine plywood covered inside and out with 6 oz. glass. Gunwales, mast partners, thwarts, dagger boards and rudders were fabricated and installed. After several coats of paint they are ready for the 2014 season.

The new project for 2014 was the starting of two Chesapeake Light Craft Wood Duck 12' kayaks. These are hybrid craft, stitch and glue hulls with cedar strip decks. The boats were made from plans with all parts being cut out concurrently. The hulls were stitched and glassed and the deck laid up on the first boat. Both kayaks will be completed in time for the 2016 raffle

Final touches were done on the Zurn EL, trim, interior, electronics and propulsion all done in time for a June 7th, 2014 launch.

More information on the Saginaw Bay Community Sailing Association sailing programs and the winter boat building classes can be found on the website sbcsa.org.

Electric Launch

Optimist Prams

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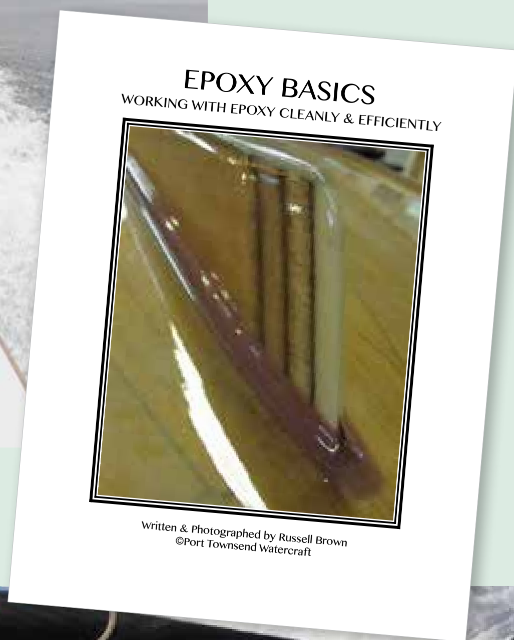
Russell Brown driving a PT Skiff



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By Russell Brown

Renowned boat designer, builder and lifetime WEST SYSTEM Epoxy user Russell Brown has published the ultimate epoxy primer—*Epoxy Basics: Working with Epoxy Cleanly & Efficiently*. Brown is well known in the industry for his meticulous craftsmanship. His clear and concise book is one of the best guidelines you'll find on using epoxy in wooden boat construction. It covers mixing and handling, surface preparation, gluing, clamping, filleting, sanding, glassing, coating, creating flawless gloss coats and more.

Epoxy Basics includes full color photography and its large format is perfect for the shop. It's also available as a digital download. Visit ptwatercraft.com to learn more about this book or order a copy.

Brown, along with his wife Ashlyn, design and sell kit boats through their company PT Watercraft in Port Townsend, Washington.

Russell Brown sailing a PT11 in a regatta

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