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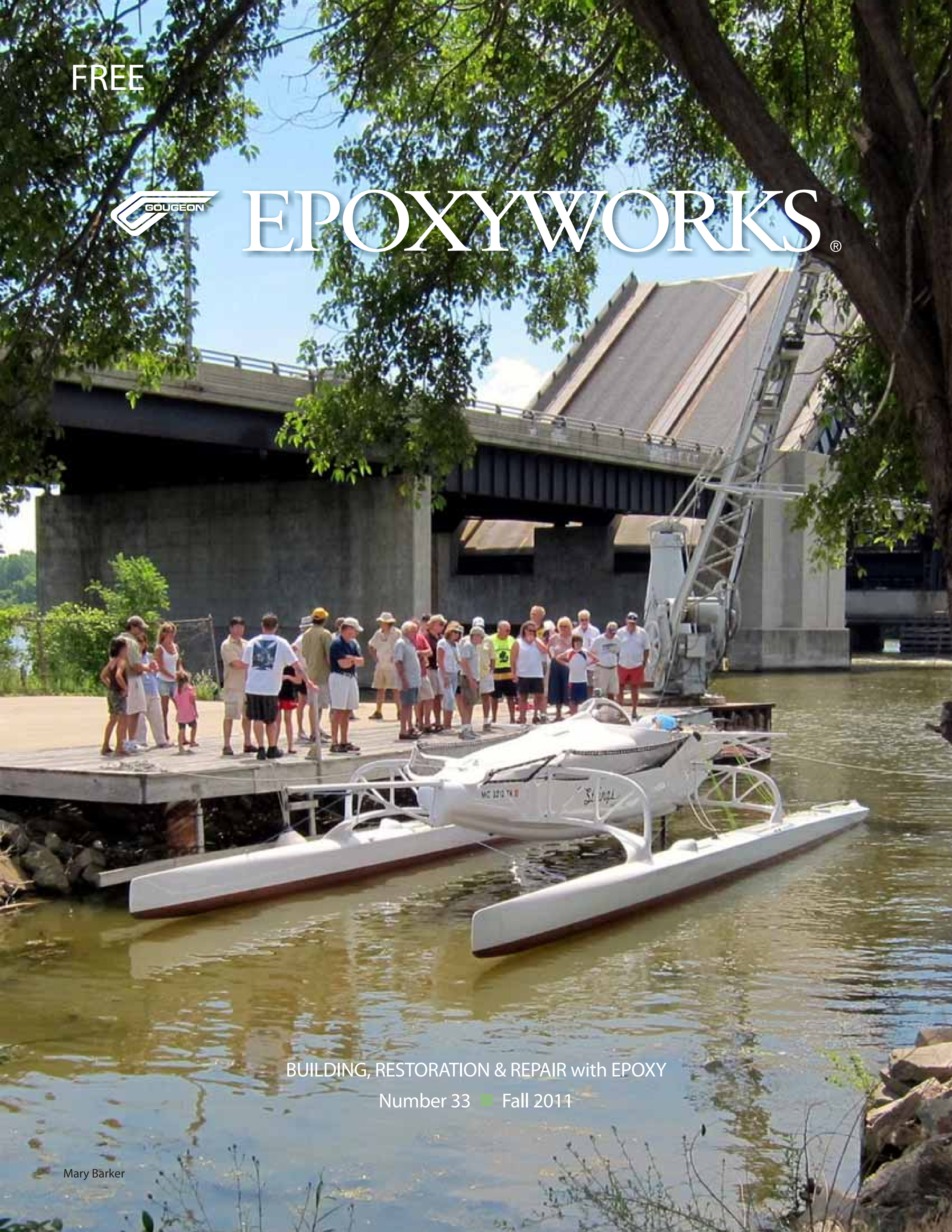

BUILDING, RESTORATION & REPAIR with EPOXY

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Mary Barker

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EPOXYWORKS®

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Jan Gougeon Launches *Strings*

Interior galley area looking aft toward the two bunks under the cockpit. The interior was coated with white tinted epoxy before the deck was installed.

By Grace Ombry

Ten years ago in *Epoxyworks 17*, we published this photo with the following caption:

In the recess of the Gougeon boat shop loft, something unusual is taking shape out of plywood, foam, carbon fiber and epoxy. There is a minimum of plans and drawings. It evolves, piece by piece, mostly from its creator's head. It's not a trimaran. Not exactly a catamaran. Technical you probably wouldn't call this a hull. It's more of a fuselage. (There is an aircraft canopy involved.) For now, let's call it Project J. We'll keep an eye on this project in coming issues and see what develops.

Project J, later upgraded to the nickname Project X, was christened *Strings* and launched into the Saginaw River on July 9, 2011… about 12 years after conception. The long gestation period included a few hiatuses while Jan and Meade Gougeon built Gougmarans and sailing canoes, among other things.

Cover story

On July 9, 2011, the 40' catamaran *Strings* was launched at the Gougeon Brothers boat shop on the Saginaw River in Bay City, Michigan.

Left—Jan applies thickened epoxy adhesive to the tops of the bulkheads and side fuselage skins before the deck is installed. The main bulkheads were 1⁄16" plywood over 1" foam with interior wood trusses, covered with carbon fiber skins. Heavy bulkheads have an additional three layers of carbon on each side.

Right—Jan and Greg Bull carefully place the deck skin over the front of the fuselage.

***Strings* specifications**

LOA 39' 7"
Beam 14'
Draft - boards up 9"
Draft - boards down 4'9"
Displacement 2,000 lbs
Sail area upwind 575 sq ft
Sail area downwind 1,000 sq ft

Jan fitting thin bulkheads to support the cockpit seat backs. These carbon/plywood panels made stiff, light building blocks. The lightweight fuselage skins were built of ½", 7 lb per cubic foot foam with a layer of carbon oriented at 45° on each side. The corners pieces were laminated over a section of 12" PVC pipe and the deck, sides and bottom pieces were laminated in a generic curved female mold. Jan trimmed, bent and stitched together these basic panels over the lofted frames and bulkheads that were mounted to a strongback. Years later, when the fuselage was assembled to its final shape, another layer of carbon was applied to the exterior. Extra layers of carbon were built-up at key structural areas.

Jan's goals for his "folding cat with a fuselage" were that it be easy to sail solo or double-handed, self-righting, trailerable, with a shallow draft, and have a big enough footprint to be a serious offshore contender. The most important criteria? "You don't have to be a spring chicken to sail it," Jan said.

Strings meets all of Jan's goals, from the sleek pair of 39' 7" foldable hulls flanking the fuselage, which rides high and dry about 2' above the waterline, to the soon-to-be-made roller reefing mainsail and roller furling/reefing jib. When folded for trailering, the boat is just over 8' wide. The fuselage is small but has an effective galley. Jan said the cabin "Can sleep four very friendly people with enough room left over for each to bring along a toothbrush and a sandwich."

Single and double-handed sailing are accommodated by the roller furling sails, self-draining fuselage, easily filled and emptied water ballast in the hulls. From the rigging, to the hulls, to the ballast and the rudders, everything is controlled like a big marionette by lines to the cockpit—hence the name, *Strings*.

Some favorite design tricks included on *Strings* are kick-up rudders. "It was always easier to build those than to learn to navigate," joked Jan. Water ballast was also used on Gougeon's G-32 catamarans, and

Left—By early 2009 the hulls had take shape and the connecting arms were being built.

Right—The port hull's forward ballast tank before the deck is installed. Two small dinghy bailers, one facing forward and one facing aft, are mounted at the bottom of each tank. The forward motion of the boat fills and empties the tanks when the respective bailer is opened via a line from the cockpit. A hull can take on half a ton of water ballast in a matter of minutes, very useful for a 40' catamaran that is only 14' wide. Water-ballasted hulls had proven themselves in the earlier Gougeon G-32 catamaran design.

self-righting has been a staple of Jan's multihull designs ever since his trimaran *Flicka* turned turtle in the Atlantic during an OSTAR qualifying race over 30 years ago. Jan survived four days in *Flicka's* overturned hull contemplating multihull design before a passing freighter rescued him.

Strings goes about 9 mph with its 6 hp motor which when needed, tilts down out of the bottom of the fuselage. At this speed the forward ballast tanks in each hull will fill with 850 lb of water in about 7 minutes. The rear tanks will fill with 150 lb of water in about 2 minutes. With gravity on their side, they drain much faster.

Jan expects *Strings*, with its relatively small rig, will really fly in heavy air. Of course, *Strings* has yet to be sailed. The mast and roller-reefing boom are still under construction as we go to press. Also on Jan's list of things to do is design and build a masthead float with 600 lb of displacement for the top of the 34' 6" mast.

Strings is a little bit like Nathanael Herreshoff's *Amaryllis*—the first catamaran sailboat patented in the US, way back in 1876. Herreshoff's design-with long, narrow hulls and a center cabin that road out of the water-was so forward thinking and effective that it was banned by the New York Yacht Club. Jan thinks he and Herreshoff would have gotten a long just fine. ■

With the fuselage supported, Jan demonstrates the folding hull, Open to its full 14' width (left) and folded against the fuselage (right) to a trailerable 8'—when both hulls are folded.

With all of the components in place, the exterior was filled and faired with epoxy/410 Microlight®. Weeks of sanding was followed by high-build primer, more sanding and a final paint job by resident boat builder, Greg Bull.

Left—One of the many details on what Jan calls the most complicated boat he's ever built. Three lines control each pair of intake and exhaust bailers (that's twelve lines to control four tanks). A pressure gauge measures the depth of the water in the ballast tank and gives a quick read of the level from the cockpit.

Right—Finally, the day before launch, all components are painted and assembled. No longer Project X, *Strings* has her name and numbers. Hardware is installed and functioning. She is ready to be dropped onto her trailer for her short move out to the crane next to the slip.

Sanding Tricks of the Trade

By Damian McLaughlin

All of the boat builders that I know have little tricks that make a job go faster or do it better. Fairing a 40' custom-built hull is an arduous task which is often accomplished with two-man teams and fairing boards. We do 90% of the work with a grinding device. Almost everyone in the business will agree that a grinder will remove a substantial amount of material quickly. The trick is controlling that removal.

Here in my shop, we use a common heavy-duty 0 to 6,000 rpm sander/polisher. What is not so common is the pad we mount on this machine. We glue a 9" × 11" rectangular piece of fiberglass or Lexan™ onto a standard round foam backup pad. Using this setup, it's virtually impossible to gouge the surface.

Now, I didn't invent this device but I think I've gone a long way in perfecting it. These "square pads," as we call them, are used for fairing convex and even concave surfaces. For convex surfaces, we mount a sheet of fiberglass about .095" thick onto a very stiff foam pad. The glass can be commercially purchased, but the best way is to make them in the shop.

The stiff foam pads we use are 3M™ #05579, available from marine distributors, or from Ferro Industries direct (#60658D or #60618D). Concave surfaces are addressed with a sheet of $\frac{1}{16}$"-thick Lexan attached to a very soft pad, Ferro #808D.

The "square" pad is actually a rectangle the exact size of a sheet of production sandpaper. To avoid balance distortions, care must be taken to attach the foam to the exact center. I carefully locate the center with fine pencil lines crossing from the corners of the pad. Also, cut the corners of the square pad to 2"+/- radius and sand all the edges for safety.

The pad is 9" × 11" rectangle, the exact size of a sheet of production sandpaper.

I mark the center with a center punch and mark a circle the exact size of the pad's diameter with pencil compass/scriber. They do vary. This is the glue line. Then I make a concentric ring $\frac{1}{8}$" larger. This is the sight line, for the epoxy will squeeze out and cover the glue line. Both surfaces must be abraded with sandpaper, but the Ferro pads come with a canvas cover which is why I prefer them.

I apply two thin, level coats of unthickened WEST SYSTEM® Epoxy on each surface. The clamping system is simply four 1"×4" boards about 12" long and 4 lb lead weights. Make sure that the surface under the square is flat. This passive clamping protects the foam from permanent distortion. Take care through the life of this pad to never store it on its face with the machine attached because this will distort the foam, rendering it useless.

As with all tools, diligence during use ensures safety to yourself and those around you. The thought of this rectangle zinging around at 3,000 rpms is a bit scary, but in practice you'll find it safe and easy to use.

Although beginners will quickly develop an acceptable skill level, there are some useful operational tips.

1. The optimum speed seems to be about 3,000 rpm. If you're using a variable speed machine, slower speeds will help to you gain confidence.
2. Constant diagonal movement across the surface is essential. Never move in a fore and aft direction on a waterline.
3. Move your feet 3" to 4" for every pair of arm passes. Areas that require kneeling or reaching out still need this constant motion.
4. Multiple passes removing small amounts of material on each pass is the best approach. As the job progresses, the visible

irregularities will disappear. We dust off the hull often and inspect visually and with our hands.

5. Using the flat of a pencil, we mark imperfections. In addition to marking trouble spots, we make multiple S-shaped scrawls on the whole surface to keep track of where we've been.

The soft foam/Lexan version we call "Superflex" is used for concave surfaces. It has some quirks of its own, but the technique for use is similar. A very heavy pressure will allow contortions into some tight radii and still do a good job of fairing.

The fiberglass pads may be purchased from industrial suppliers such as Manhattan Supply Co. www.mscdirect.com. These industrial sheets are a bit denser and therefore heavier. I prefer the shop-made version which I lay-up on a sheet of glass placed on a perfectly flat surface. Standard mold release wax assures release. I use three layers of a double bias 12 oz non-woven fiberglass sandwiched between single layers of 6 oz woven cloth and unthickened WEST SYSTEM Epoxy. I allow the laminate to sit for several days just to be sure the cure is complete.

I have found many uses for these pads over the last 30 years. I hope this trick well help those in the trade who are unfamiliar with these devices. ■

The thought of this rectangle zinging around at 3,000 rpm is a bit scary, but in practice you'll find it safe and easy to use.

Soundproofing a Generator

By Ted Wasserman

The enclosure is constructed with 2 lb lead sheet sandwiched between 24 oz double-biased stitched mat using WEST SYSTEM® Epoxy. The thickness of the enclosure is 1⁄16" and has a mass of approximately 2 lb per square foot.

The enclosure is lined with 1½" Soundown's Mass Loaded Vinyl Barrier (Tuff Mass®) with a density of 2 lb per square foot

The combustion air intake muffler is constructed from fiberglass heating pipe covering with an inside diameter of 1½" and an outside diameter of 3½". It is lined with a metal screen. The exterior is covered with fiberglass and is double baffled.

The generator is set on vibration mounts that allow for the base to be completely lined with the Soundown. All hosing, piping and wiring is tightly sealed so as to retain sound. As you can see in the pictures, we retained the factory enclosure.

The net result is that I have lowered the sound level by 10 decibels. We now enjoy our Mase IS2.5 generator. We don't hear it! ■

The generator installed on its soundproofed base.

The generator with the soundproof enclosure in place.

Ted Moores is a renowned boatbuilder, author and teacher whose name is synonymous with stripper canoes. He and his partner Joan Barrett own Bear Mountain Boats in Peterborough, Ontario. This is the second of a series of articles by Ted Moores on lessons learned from 35 years of wood/epoxy boatbuilding, which were incorporated in the building of his 30' Electric Hybrid Launch *Sparks.* ▶

Lesson 2

Fiberglassing a Strip-planked Boat

By Ted Moores

Ted 's Cheap Tricks

"In this series, we will take a look at how we used WEST SYSTEM Epoxy to utilize less than ideal wood and look at ways of building wooden boats that will be low maintenance and age gracefully."

Working clean to get the best results with the fewest number of steps.

Photos: Ted Moores

With our strip-planked hull faired and the outside stem attached, there are many techniques that could turn these strips into a boat.

Strip-planking may have been the first step after the dugout in the evolution of boatbuilding techniques; the way the quality of wood is going, it might be the last to survive. At the La Routa Maya canoe race in Belize, SA., we saw a natural progression from chopping canoes out of logs to strip-plank construction with WEST SYSTEM® Epoxy.

Building the depth of a dugout canoe using pegs or edge-nailing narrow planks is universal. The Belizean builders take strip-planking to the limit by building most and sometimes all of the hull with edge-nailed strips and even using strip-planking to replace the rotten end of a large dug-out. ▼

When we add technology to this primitive way of building, wood becomes an engineering material and the possibilities get very interesting.

In the race, the Dory class or dug-out canoe class is popular and competitive. The hulls are chopped and shaped from a large softwood log to a thickness of about one-half inch. Then fiberglassed on both sides with polyester resin. In 2000, we introduced strip-plank/epoxy canoes to the race. The following year, there was a canoe with carved ends and a strip-planked mid-section with everything glassed on both sides. The builder later came to visit to learn how we build the ends without the chopping.

At this year's race there were about a dozen strip-planked/WEST SYSTEM Epoxy canoes built from our molds. Since *Maagga Ting*, the third boat we built, proved to be an excellent design for this challenging four-day race, the boats are now built in country using Kevlar™ and carbon fiber. Of the 75 canoes in the race, about twenty of them were *Maagga Ting* clones that were first place finishers in most of the classes.

Using strip-planking as a foundation for multiple layers of veneer is an excellent building method, especially if the hull is to be bright finished.

When I considered the number of steps and materials involved in fairing the strip-planking, applying two or more layers of veneer, fairing the hull two or more times, glassing the finished hull for durability and then hiding it all under paint, my question was "What are all those layers of veneer really doing?" The way I see it, we have fibers crossing the strip-planking on the diagonal to tie the longitudinal planking together and spread the strong wood fibers in a number of calculated directions.

Looking for the best results with the fewest steps, the question was, "Why not eliminate all the veneering steps and use all glass fibers?" One of my principles in designing a composite hull is to create a balanced panel.

Applying the same amount of glass to both sides of a strip-plank core is a simple way of building a balanced, core-composite panel.

The next question was "How much fiberglass would it take to replace the fiber strength of the veneer?" The 30' C15 sprint racing canoes we build have an average crew weight of 2,300 lb, so we knew what one layer of 6 oz glass on ¼" planking could do. *Sparks* (*Epoxyworks 32*), with a displacement of 6,800 lb, was beyond a wild guess in terms of reinforcement and there was no data I could find.

Outside of keeping up the paint, the hull is one part of our boat that I don't want to have to revisit. To get it right, we needed numbers. The Gougeon Test Lab generously offered to do the testing. Based on the results of these tests (*Epoxyworks 31*), we came up with a lay-up schedule that optimized the amount of reinforcement.

Did we get it right? During our test cruise last summer, we broadsided the end of a jetty. A quick check for damage showed no structural damage to the hull. A scientific measure of how hard we hit would be interesting; a guess is difficult as we were distracted by visions of being sucked over the dam and certain death. One indication is the ⅞" ash trim compressed to about half of its original thickness at point of contact.

"Think Lazy" or the shortest route to the best results

Ending up with a fair hull was high on my list of priorities. Each step, beginning with CNC router cut station molds, had to be a step in that direction and prepare for the next step rather than being a cycle of damage control between steps. Assuming that the mold is fair, executing each step consistently over the whole surface should produce a fair surface. Controlling the thickness of each layer of glass as it is applied eliminates most of the sanding needed to fair an irregular, casual lay-up.

Applying Fiberglass Using WEST SYSTEM Epoxy

Lay-up schedule: Before installing the keel and skeg, we applied three layers of 6 oz × 60" wide glass cloth on the diagonal in alternating directions and running from sheer to sheer. Applying the glass cloth on the diagonal doubles the number of glass fibers crossing the longitudinal wood fibers. ▼

Testing showed a significant increase in stiffness and impact resistance without additional material or weight. The bonus was that at 45°, the cloth easily wrapped around the stem and followed the complex shape of the fantail.

Staggering the joints on a number of layers of lightweight glass meant that the edges of the cloth could be butted. This eliminated the need to overlap the edges of the glass and then wait for the epoxy to cure enough to feather the joint before we could proceed. Glassing could continue as soon as the epoxy was firm enough to work on, and we were sure of a good bond between layers.

The trick to controlling the thickness of each layer of glass and epoxy is to know what each step is meant to accomplish and have a visual reference for the ideal amount of epoxy. When you know what it should look like, simply make all of the surfaces look the same. To get the best bond between layers and keep the hull fair, we saturated each layer of glass until the shape of the cloth was distinct without being starved. Starved, or too little epoxy will show as a whitish glitter. Excess epoxy will look shiny, indicating that the glass is floating in a puddle. If left to harden, these puddles will either have to be sanded fair—with a good chance of damaging the glass fibers—or they'll become another wave in your hull.

Our Three-Step System

Step 1—First layer of glass over dry wood. The purpose is to saturate the surface of the wood and the fiberglass.

What to look for and why: Achieving a consistent amount of epoxy in the cloth calls for more than just carefully applying the epoxy. Each plank will absorb a different amount of epoxy, so it's important to apply enough to feed them all. As the epoxy soaks in, the wood fibers become saturated and the space between the fibers is filled. This increases the density of the surface and the epoxy makes a deep mechanical bond inside the wood.

The wicking action of the cloth is the key to drawing the air out of the wood and feeding the epoxy in. When any finish is applied over bare wood, the film wants to break over any void. It then pulls back and piles up around the edge, much like over-filling a glass of beer. The surface fibers will become saturated but it is hard to work the epoxy into the wood and force the air out. When coating plywood without fiberglass, it takes multiple coats of epoxy with aggressive sanding between coats to eliminate the pin holes and completely level the surface.

To apply epoxy to fiberglass cloth, simply transfer the epoxy from the container and gently spread it over the cloth. Don't work it into the cloth; the cloth will do a good job of feeding the wood at the speed it can absorb the epoxy, and less air will be introduced. On horizontal surfaces, a small puddle can be pored on and moved about with the squeegee or a roller. Both of these tools excel at spreading thin, consistent amounts of material so expect to apply a number of coat before the wood stops absorbing the epoxy.

I use a brush to coat strip-planking to spread large but controlled amounts of epoxy quickly. The trick is, don't even try to make it look good at this point. As long as it is not looking dry, break any big bubbles but don't waste time on the small ones for now, just keep moving on. When the excess is removed with the squeegee, you can expect it to look good.

Using WEST SYSTEM 105 Resin® and 207 Special Clear Hardener™, we wait about 20 minutes for the wood to have a good drink before removing the excess epoxy, brush hairs and bubbles using a squeegee. The trick here is to hold the squeegee at a low angle to avoid removing too much epoxy thus starving the cloth. Expect to do a number of passes before you reach the picture you are looking for; the cloth should be in the same shape as when dry but look saturated with no whitish glitter (too little epoxy) or shiny puddles (too much epoxy). Dispose of the excess epoxy by dragging the squeegee through a ¾" slit in a heavy paper cup or cardboard frozen juice can. It is important to keep the same time between applying the epoxy and removing the excess. If the excess is removed to soon, the wood could continue to draw the epoxy out of the cloth, leaving it starved.

Building layers of cloth

While it is possible to build up multiple layers of glass at a time, we changed directions with each layer on Sparks *and staggered the joints so the logistics for multiple layers didn't work here.*

If you were to saturate a second layer of cloth now that there is a stable base to build on, a more predictable and lesser amount of epoxy may be applied using a roller, squeegee or brush. Apply it to a manageably large area then go back over it with the squeegee to remove any excess, looking for the even, saturated fabric texture.

Removing all the excess epoxy with a squeegee before it cures eliminates a lot of sanding and cleanup, and the surface remains fair. No effort should made to build up the thickness of epoxy until all the glass is on.

The optimum time to re-coat is when the last coat is just firm enough to work on without disturbing it. (About five hours with 105 Resin/207 Special Clear Hardener.) To do this, each coat must be made in preparation for the next because at this stage, the epoxy is too green to remove runs, etc. This will reduce the possibility of surface contamination and result in the best bond between layers.

Build up coats

Step 2—Second coat. The purpose is to level the weave of the cloth.

This textured surface will be coarse enough that air may get trapped in the weave when the next coat of epoxy is applied. To avoid this, we apply this coat with a squeegee. The objective is to pack the epoxy in and force the air out, leaving a surface that is closer to smooth. After packing it in, go back and scrape off the excess epoxy. Work systematically, again looking for a consistent texture.

Step 3—Third and subsequent coats. The purpose is to bury the cloth for durability and have something to sand off later.

I am comfortable with two more coats applied with a roller and tipped off with a bristle brush. Because each coat has been applied consistently, the final sanding will not need to remove very much epoxy to achieve a smooth surface.

Installing the keel and skeg

▲The keel and skeg were glued on over the three continuous layers of glass and tied in with three more layers extending from the top of the keel to the waterline. This doubled the number of layers on top of the keel and put the edge to be feathered where it would show the least.

Masking tape follows a waterline scribed into the wood before glassing to show the area to be wet out with epoxy. The extra dry cloth keeps the brush away from the fuzzy cut edge. When the epoxy reached the green stage, we sliced under the glass with a sharp chisel held at a low angle, cutting it cleanly along the taped line. Carbon fiber was used to prevent the laminated skeg from expanding and to tie it into the bottom. This was the dusty part of the job as the thickness of the carbon fiber required considerable fairing with epoxy thickened with 410 Microlight® filler to make it disappear.

After we feathered the edge of the glass along the waterline, the shape was fair again. ▼

We buried the glass under one coat of 105 Resin/207 Special Coating Hardener applied with a squeegee to level the weave. We followed that with two coats applied with a foam roller and tipped off with a brush. Going from this epoxy surface to an incredibly fair hull ready for paint was a simple matter of consistently cutting the gloss over the whole surface.

Glassing the inside

▲Before glassing the inside, the edge of the hull needed to be stabilized in the designed shape. In spite of drying the wood then letting it come up to average shop moisture content, the project went from late summer into winter and a heated shop. The hull shrunk a little after glassing the outside, causing the sides to curl in slightly. Spacers, the length determined from the plans, were kept in place while we applied the first two layers. This stabilized the hull in the designed shape. To simplify working inside this very awkward shape, we overlapped the fiberglass ends on top of the keelson by the next layer from the other side. A generous fillet along the edge of the keelson and the glass crossing at 45° allowed the glass to change direction without trapping air in the corners.

▲To keep the project moving and still work clean, we alternated the application of fiberglass sections to leave some working room and keep out of the sticky stuff. Ideally, I would like to apply the same amount of reinforcement to both sides to keep the panel balanced. Since we have three layers above the waterline and six below on the outside, we split the difference and used four full layers on the inside.

▲After applying the fourth layer of glass we added one layer of epoxy and used a squeegee to level the weave, followed by two coats rolled on and tipped off to bury the glass. We find that 105/207 has excellent leveling properties so that brush marks flow out and disappear. Runs are not a problem even with the thickest coat if the epoxy is worked into a consistent film thickness.

Working so that each step is preparation for the next might feel inefficient and frustratingly slow for some builders, but adding up all the things you won't have to undo, and the quality of the results, it could be worth the effort. Doing damage control is usually the task builders learn to hate. When everything you are putting on is becoming part of the boat, there is instant gratification and a measurable feeling of accomplishment. You know that when you have finished putting it on, it is a positive step towards getting her out of the shop and into the water.

Next time we will look at building a skeg that won't split, a foam core rudder, a low tech rollover jig and a few more cheap tricks. ■

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◀**Ted Moores piloting *Sparks* on the Rideau Canal in 2010.**

ION

By Captain James R. Watson

I wanted an efficient, modest, contemporary and quiet running yacht for cruising the Intra coastal waterway, Chesapeake Bay, Bahamas and the Great Lakes in my retirement. The boat would require the ability to safely cross several hundred miles of open sea at a good cruising speed.

Ion's **roomy main cabin. The instrument panel and hood and the table were built by Watson in Bay City and installed in the boat as construction progressed.**

Designed by Roger Hill from New Zealand, *Ion* fits this description nicely. The 34' power catamaran cruises nicely at 15 knots, turning 3,600 rpm and consuming about 5 gallons per hour. This efficiency is possible because she's a displacement catamaran rather than a planing cat. *Ion's* top speed is about one half that of a planer. Another penalty of the displacement catamaran is its limited ability to support payload. Thus light construction and limited amenities are requirements of the small displacement cat.

The accommodations on this boat are a little like that on a space craft. The boat has to be light and aerodynamic. Weight, weight placement and judicious use of power are important considerations. Light construction and limited amenities limit the *Ion's* weight for optimal performance.

Blackwell Boats in Wanchese, North Carolina, custom built this boat for me. This diverse boat builder has built Sport fishermen of their own designs up to 72' as well as a variety of sailboats. Their forte is lightweight construction.

Craig Blackwell, originally from Bay City, Michigan, worked for Gougeon Brothers Inc. as a boat builder when he was a young man. He eventually went south, starting his own business that proved very successful.

Blackwell mainly builds with Core Cell, E-type biaxial fiberglass and WEST SYSTEM® Epoxy. These are the primary materials used in *Ion's* construction. The core was shaped over forms and then the fiberglass was hand laid over it. Later, when off the forms the interior skin was covered with fiberglass. Many of the panels were built on a flat table.

Separate fuel, batteries and electrical for each engine provides redundancy, improving *Ion's* autonomy. Except when docked, she runs on DC power. Two 100-amp batteries are dedicated to start the motors. The house battery bank consists of 300 amps of stored energy. All lights are LED. Renewable energy production is harvested with a 400 watt polycrystalline photovoltaic array.

The galley stove, sea swing, barbeque grill and on-demand hot water heater all run on propane.

The boat is propelled by twin Yamaha 90 hp, four-cycle, gasoline engines. These quiet motors permit normal conversation on the aft deck when running at speed. At idle, you cannot hear them. On the bow of the craft all you can hear is your apparent wind and the rush of the water as the hulls pass through the sea. Each motor weighs 369 lb and produces 25 amps for charging the start batteries.

The craft can be controlled in any direction with the throttle. This excellent maneuverability stems from the wide spacing of the motors. *Ion* can turn on her centerline and spin 360° within her length. The motors are not counter-rotating, but slender hulls and skeg work account for good tracking.

The holding tanks, fuel tanks and potable water tanks are composite built. The rowing dingy, *Atom*, is a 60 lb, stitch and glue epoxy/plywood 7' 6" long Sabot design built from plans by Glen-L Marine. The dinghy fits between the hulls, stored in davits that I wrote about in the previous issue of *Epoxyworks*.

Ion has everything I wanted in a retirement cruiser. ■

Flying Dutchman Repair

By Bill Bauer

On July 15th, 2006, a friend and I took my 1958 Flying Dutchman out for a sail in the Saginaw River. This was only the third time the boat had sailed in 30 years and the first hard sailing since my six-year-long restoration. We set both sails and made several runs in front of the Saginaw Bay Yacht Club before we hit something, maybe an old piling or maybe the freighter rudder that went missing the previous fall.

The Damage

The centerboard took the first impact, splitting at the pivot bolt hole. Next the rudder hit, forcing it upward, snapping the tiller and tearing off most of the transom. The board jammed against the back of the centerboard trunk and gouged a triangle out of the trailing edge of the centerboard.

The damage to the newly built tiller made of laminated ¼" strips of mahogany and ash glued with WEST SYSTEM® Epoxy and 403 Microfibers testifies to the strength of the epoxy. The tiller fractured across several grain lines but never on a glue line.

The transom and rudder could have ended up on the bottom of the river. The floatation added last year was a good idea.

Transom Repair

First I removed the remaining portion of the transom. The original builder made the transom sacrificial; it was fastened with small brads through the hull and glued to a frame. The only screws in the transom were those holding the gudgeons.

The remaining part of the transom was removed to reveal a nice solid frame.

The old gudgeons had vertical mounting holes and the new ones had horizontal mounting holes so I installed a wider transom gusset.

Left—The transom gusset clamped with a handy 4 × 4.

Right—The newly shaped gusset glued in place.

The original transom was 9 mm mahogany plywood, the new one is 7 mm with 6 oz glass on the inside and 4 oz glass on the outside coated with several layers of WEST SYSTEM 105 Resin®/207 Special Clear Hardener™.

The new transom glued in place, ready for new gudgeons and a new aluminum rudder.

The transom was the glued in place with 105 Resin/205 Fast Hardener® thickened with 404 High-Density filler.

Centerboard Repair

The centerboard split at the pivot hole, and the smaller trailing edge remained in the trunk still attached by the bolt. In order to maintain the board dimensions, shape and pivot hole position I taped the two pieces together and traced a pattern onto a piece of vellum. The centerboard was sawn forward of the damaged area and replaced with a 6" × ¾" piece of mahogany.

The new section was doweled and glued with 105/205 thickened with 403 Microfibers.

The gouge on the trailing edge was filled with a wedge of purple heart, for valor under fire. The board was then planed to shape, covered with 4 oz cloth and several layers of 105/207 and varnish.

After a new aluminum rudder was built, FD US328 was soon sailing again. ■

Wooden Boat House is introducing its new touring kayak the SUPERLIGHT CUTTER 14'. It weighs just 24 lb. The hull is cold-molded in two halves using WEST SYSTEM® Epoxy. The halves are 3 layers of diagonal veneer between 6 oz glass vacuum laminated over forms. The two halves are joined with Six10® and glass tape. Steven Hirsh is the designer and builder. Contact the Wooden Boat House, De Leon Springs, Florida, 484-336-8006.

Robert L. Yome of Frankford, Ontario, built these four boats as winter projects over four years using Bear Mountain Boat plans and supplies on all four. The boats are the 16' Prospector, the 15' Bob's Special, the 16' Bob's Special and the 17' Endeavour Kayak.

All boats were stripped with western red cedar and ash gunnels and seats, with walnut decks. Yome used WEST SYSTEM® 105 Epoxy Resin® and 207 Special Clear Hardener™ with 6 oz cloth on the exterior and interior.

Readers' Projects

These doors grace the entry of St. Columb's Episcopal Church in Ridgeland, Mississippi. They were built by Fletcher Cox using WEST SYSTEM® Epoxy. The surface veneers of $\frac{1}{8}$" red oak were bonded to a core of two plies of 1" Tricel, using vacuum bagging to clamp the laminate.

This is a shortened version of a Grand Laker canoe which is very popular on the big lakes in Maine. It was built by architect Victor Trodella of Yarmouth. It is 16'-6" long, 42" at the beam, and is equipped with a 2 hp Honda outboard, oars and oarlocks, and of course, paddles. Trodella says, "WEST SYSTEM® gave me fabulous results … again. Thanks for your advice."

We recently received an email from Eric McNicholl, a naval architect and owner of Velox Design in Chelsea, Quebec. "I was really excited to read this article in the latest issue [of *Epoxyworks*] about wood and bamboo used in what is commonly thought to be the exclusive domain of exotic materials. Excited because I am also pursuing the development of similar applications—high performance wood composite foils and bamboo masts. Attached is a few pictures of a L14 dagger-board I recently made. Its core is local clear white cedar with a central web frame of Douglas fir sandwich between strips of tonkin bamboo. The whole thing is skinned over with birch veneer (no glass) and has a leading edge of red oak for impact resistance . It weighs 10 lb and dimensions are 5' 4" × 10" × 1 3⁄16". As you can see in the picture it is very stiff. (Most L14 boards cannot be used to right the boat.) I hope this is of interest to your publication , which I really enjoy." —Eric McNicholl www.veloxdesign.com, 819-827-4509.

Dicky Saltonstall of Rockport, Maine, sent these photos of rifle stocks that he scratch built with WEST SYSTEM® Epoxy and Fillers. He says, "So far WEST SYSTEM Epoxy has performed really well. The [Kevlar *above* and carbon fiber *below*] stocks are very light and stable." A prolific builder, Dicky sent photos of his BlackFly iceboats that appeared in last years *Epoxyworks 31*.

This table is the work of David Cumming of Toronto, Ontario. He tells us, "I used Six10® Adhesive mixed in a cup with colour to glue the stone pieces of the top of the table together and as a filler for any gaps. I then used the Six10 with the static mixer to glue the stone top to the wood base. Expensive, but a lot more controllable and a lot less mess. A good product! Thought you'd like to see a photo. I'm using installed lights as part of the artwork."

This Paul Gartside designed sailing dinghy was built by Daniel Fry of Williamsport, Pennsylvania. The hull is constructed of 9⁄16" × 7⁄8" western red cedar strips with 6 oz glass on both sides. It is trimmed with Spanish cedar. A big fan of small boats and WEST SYSTEM® Epoxy, Fry has also built a 13' 4" Marc Barto designed Mellonseed skiff and a 15' Joel White catboat.

My Biggest Project Ever

By Nelson Niederer

As an outgrowth of my love for woodworking and building stuff for myself, a few years ago I started a small woodworking business out of my garage, which is actually a shop that hasn't felt the rubber of tires for over a decade. With the exception of my Yamaha V-Star Classic 1100, which lounges in heated comfort all winter.

A fella's got to have priorities, right?

An old friend, Tim, has become a good customer of mine. Over the years I've built display shelves for his wife's sports memorabilia, pool cue rack, installed her father's classic fly fishing equipment in a bathroom and other little projects. I prefer working with people who give me a basic idea or design and then step back and let me create the finished piece. An open checkbook is nice too.

We'd talked about building a custom bar for Tim's rec room for years. Originally, it was going to have his custom chopper displayed in an integrated glass case. (I mentioned open checkbook, right?) Different ideas flowed from that over time. Finally, I got the word it was time to "bust a move" and start building. We used masking tape on the floor to get layout dimensions and put together a working design plan. Then his wife came home.

Uh-oh. About three weeks later we had a new plan to work from. To be honest, Beth was right making the changes she wanted because the room is 1,500 square feet and an 8'-long bar would just get swallowed up in the room.

I began with a base built using particle board covered with a wood-grained Formica™ on the inside for easy cleaning. I used pine for the face frames and finished the outside with tongue-and-groove knotty pine coated with Minwax ™Polycrylic satin finish. The corner posts are Sitka spruce with mahogany accents coated with Minwax Helmsman Spar Urethane gloss finish. This was the easy part because all the materials were available locally.

The bar top proved to be a bit more complicated so, armed with a blank check, I drove to L.L. Johnson Lumber Co. in Charlotte, Michigan. This place is like a candy store for wood workers! The top was also to be made with Sitka spruce and mahogany accents, so I was pretty picky selecting the boards. I told the guys at L.L. Johnson what I was doing and they suggested using System Three Mirror Coat™ for the top finish. I told them

Two views of the finished bar in Tim's rec room. It really ties the room together.

"I'm a WEST SYSTEM® man-I accept no substitutes!" Additionally, I know that in four or five years if I have to re-coat or repair anything on the bar I'll be able to get WEST SYSTEM 105 Epoxy Resin® and 207 Special Clear Hardener™ without any problems. Did I mention that my brother Bruce is a Gougeon Technical Advisor?

The top has four coats of 105/207 wet sanded between the third and fourth coat. It is built with a ¾" particle board core, then a ¾" Sitka top and bottom. I had to make the top in two sections—14' and 11'—and the angle where they meet was 27°. I assembled it in my shop to make sure the two sections fit together, then took it apart and moved to the job site. It took four guys to accomplish this.

Once there, I assembled the parts and coated the mating surfaces of the angle with 105/207, then clamped it together with joint ties that I had pre-installed. The whole top got a final sanding with 600-grit paper followed by four coats of High Gloss Spar Varnish for a tough finish. I always learn a few things on every project since they are one-of-a-kind custom pieces. On this project I learned:

1. It doesn't matter what you like—make sure the wife likes it first.
2. Don't try to build a 30' part in a 25' shop.
3. It really helps to have a son-in-law who's a cabinet maker. (Thanks, Brian!) When all was said and done the bar turned out awesome. It's the biggest wood working project I've tackled to date. Most importantly, Beth liked it! ■

The corner detail showing the Sitka spruce field with mahogany accent strips. The top has four coats of 105/207 wet sanded between the third and fourth coat.

The happy owner, Tim, bellying up to the bar, reflected in four coats of High Gloss Spar Varnish.

Below left—The behind-the-bar trash drawer/cabinet door.

Below—When you build a 30'-long bar in a 25' garage the weather becomes a factor.

Pouring 105/207 on a Bar Top

By Bruce Niederer

WEST SYSTEM® 207 Special Clear Hardener™ is formulated for exceptionally clear, no-blush coating and fiberglass application.

I helped by brother Nelson with a different, smaller bar he built for a customer who comes from a long line of dairy men. His family has been in the business for decades. He has a little bar area in his garage where he and his buddies hang out and work on cars or watch their hunting blind videos while they have a couple beers.

The bar is on heavy duty wheels so it can be easily moved when necessary. He collected dairy memorabilia—old milk bottle caps and family photos which he wanted encapsulated in the bar top.

The oak bar top ready for a sealer coat of epoxy. Note the recessed center where the pour will go.

We regularly get calls from customers attempting something similar to this. The photos explain the process we followed and some of the techniques for success.

The recess was sanded with 220-grit and the memorabilia to be encapsulated were artfully arranged in the ¼"-deep recess. Each piece was encapsulated with Mod Podge®, available at most art supply stores. This important step seals the paper so it doesn't wick up any epoxy, which will cause dark or discolored splotches on photos or anything made with paper or cardboard. Under each item, we brushed a thin coat of mixed WEST SYSTEM 105/207 to set the items in before pouring.

We got started with one of us mixing and pouring and the other chasing bubbles with a propane torch. Because the recess was coated with two coats of cured then sanded epoxy, we didn't need to worry about bubbles due to out-gassing of the wood. But it's pretty much impossible to stir the resin and hardener without inducing some bubbles in the cup. One of the best ways to deal with them is with a flame treatment using a handheld torch. A heat gun won't work—it's not hot enough. You must use a flame held so it just barely touches the epoxy surface. Move the flame quickly—12" to 16" per second—you don't want to scorch the epoxy. WEST SYSTEM epoxies don't contain flammable solvents so this is safe, but be careful; the epoxy can ignite if the flame lingers in one spot too long.

Left—The bar top with old milk bottle caps and family photos encapsulated in two coats of 105/207.

Right—Nelson was mixing and pouring the epoxy while Bruce chased bubbles with a propane torch.

You typically get bubbles when you mix in a cup with a stir stick. With smaller bubbles, if they don't pop after a quick pass or two, don't get all crazy about it and risk a scorch or worse. Just walk away for 10 or 15 minutes, have a beer, and then try it again. Those little bubbles will rise towards the surface and then you can get them out.

The finished top is clear and beautiful with no bubbles. The bar has some nice custom features including a replica of a 1957 Chevy Impala hood ornament flanked by chrome strips, lighted milk bottle corner posts and orange lighting under the bar rail. An antique milk box with the old family dairy logo serves as an ice box that drains into an antique metal milk can.

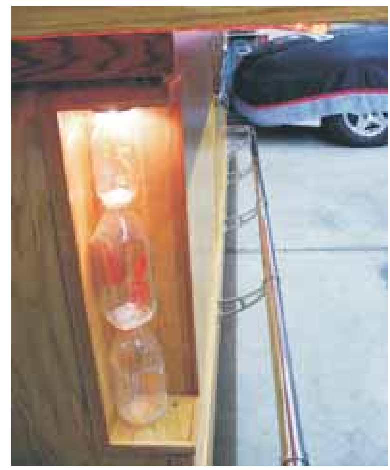
Things we learned

The recess was about ¼" deep and it took about 1½ mixed gallons of 105/207 to fill level. We could have got the same result with a ⅛" recess and saved some epoxy bucks.

The client brought in a couple of additional pictures after the first pour cured. We added them, then finished the pour. Those last two pictures look like they're floating in the middle of the epoxy. They look more three dimensional as a result—a nice effect for photos. ■

The front of the finished bar with its 1957 Chevy hood ornament.

The back of the bar. An antique milk box serves as an ice box.



Lighted milk bottles decorate recesses in the corners.

Another Great WEST SYSTEM® Epoxy Project

from Paul Butler

Rock Creek Drift Boat—A slightly de-tuned drift boat, with somewhat less rocker and a widened transom can still function quite well as a drifter and handle moderate whitewater, but also make an ideal all around family recreational craft. This wide-body lightweight14 footer can be built as a single or 2-part hull. Using ply/epoxy techniques it's easier to build than using traditional wood boat construction methods, and useful modifications like compartments and the take-apart option are easy to accomplish with this adaptable technique.

Still a car-topper at 135 lb or less for lightweight versions, and with the slick graphite coated bottom it can be dragged with a tether over parking lots and down launch ramps. The chines and bottom can be virtually bulletproofed with layers of fabric and glass tape, and the more it's dragged the slicker it gets. Built with the optional take-apart bulkheads the unbolted hull can be nested and hauled in the back of even compact trucks, and the aft section can also be used alone as a stable 9' compartmentalized pram, rowed or equipped with a small motor.

30-page building plans written for amateur builders, with sketches and photos, step-by-step and discussion of options are $45 from: butlerprojects.com, or by sending a check or money order to Butler Projects, Box 1917, Port Angeles, WA 98362 ■

Shop Floor Testing

By Jeff Wright

Boat builders or advanced hobbyists often want to learn more about the characteristics of the fiberglass laminate they've just created. But sending samples to a professional testing laboratory can be expensive and impractical. Fortunately, there are some tests you can do in the shop that yield reasonably accurate results.

Before you begin to test laminates in your own shop, it's important to understand the difference between shop tests and standardized tests. Many organizations such ASTM, ISO, or UL provide established test procedures defining a specific test method. These may specify things like sample preparation methods, equipment and acceptable environmental conditions. These standards allow the test to be repeated by different people at different locations all over the world.

A shop test isn't designed for scientific repeatability, but it is a fast and easy way to get solid data, with the understanding that it will not be used for any certifications. Here at Gougeon Brothers Inc. we use both shop and standardized testing. All of our published data is generated by specific ASTM test methods. But during the early stages of new product development we may perform some quick shop tests to understand the direction and magnitude of changes.

Here are a few tests you can perform on fiberglass laminates in your shop:

Determining percentage of fiber to resin content by weight

Tools needed:

- ☐ Old cast iron frying pan
- ☐ Propane torch
- ☐ Well ventilated area
- ☐ Accurate scale
- ☐ Saw for cutting laminate

The most common way to determine the percentage of fiberglass and resin in a laminate is to use a high-temperature oven as shown in Figure 1. The sample is placed a ceramic crucible and then the weight is measured before and after the resin is baked out of the laminate at over 1,000°F.

You can obtain reliable results weighing a cured sample of the laminate on a small, accurate scale such as the WEST SYSTEM® 320 Small Batch Scale. Next, place this sample into a clean cast iron frying pan (that will no longer be used for food!) and use a propane torch to burn away the resin (see Figure 2). Do this outdoors, away from flammable materials, and do not inhale the fumes. Once the resin is completely burned away, which is evident when no more smoke is generated, weigh the remains of the sample. The change in weight divided by the original weight is the percentage of the laminate that is fiber versus resin.

This data is very useful for both vacuum bagged and hand wet-out laminates. For hand laid laminates, a fiber content of about 40%–50% is typical. Vacuum bagged laminates will have fiber content around 65%, if the fiber content is higher than 75%, the laminate may be starved of resin.

Evaluating a laminate's impact performance

Tools needed:

- ☐ A fixture to hold laminate panel in place. You can build a framework, clamp the panel around its perimeter and suspend the center of the panel above the floor.
- ☐ A large weight you can drop repeatedly from the same distance.

Impact testing can illustrate how well a laminate will resist damage in service. In cored laminates, the skin thickness, fiber orientation, and core

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2

material can all affect the final laminate's damage tolerance. The results of impact testing won't give specific values useful for engineering calculations, but the results can be used to compare different laminates. This requires testing more than one sample to get useful results.

Gougeon Brothers has built its own impact testing device (see Figures 3 and 4). In impact testing, it's critical to have a fixture that lets the panel be clamped securely in place while allowing the center of the panel to deflect.

We use a PVC tube to guide the impact weight into the center of the panel. This tube provides a convenient way to pin the weight safely in the suspended position. The weight is allowed to fall. Immediately after the first impact, we slide a piece of dense packing foam under the weight so the panel is impacted only once. This single impact is important in comparing the results from different panels.

An example of the results from this test is discussed in detail in *Epoxyworks 31*.

Understanding the Heat Distortion Temperature of the resin

Tools needed:

- ☐ Pot of water to near boiling and some way to heat it to near boiling
- ☐ Work bench with vise
- ☐ Large washers or other weights
- ☐ Thermometer

The Heat Distortion Temperature (HDT) of a resin indicates how much (when?) it will soften at ele-

vated temperatures. The fixture used for the standard version of this test is shown in Figure 5 and 6. A cured sample of epoxy is placed into the fixture, submerged into oil and then the oil's temperature is increased. Weights apply a force that will deflect the sample when it the oil reaches a high temperature. The temperature at which this deflection occurs is the HDT. This test was discussed in *Epoxyworks 23* in detail.

You can perform a rudimentary version of this test in your shop using hot water as the heat source and a vice to hold the sample while applying weights to force a deflection.

Place a rectangular laminate or neat epoxy samples into the water. Heat the water to a specific temperature, remove the sample and clamp it into the vise. Apply weights to cause a deflection. The amount of deflection, or weight required to deflect the sample, will change as the temperature of the sample increases.

This test demonstrates how much the reinforcing fibers increase the high-temperature stiffness compared to unreinforced, neat epoxy. Our Technical Advisors receive many questions about HDT because the published HDT is lower than what the customer anticipates the laminate will see in service. An example of this is the repair of the fiberglass tubing used in wet marine exhaust systems. Although the water temperature in the exhaust system may be higher than our published HDT, the epoxy combined with the fiberglass cloth will be very stiff at temperatures higher than the neat resin's HDT. This shop test can help to understand how well epoxy performs at elevated temperatures when combined with fiberglass fabric.

Adhesion testing

Tools needed:

- ☐ Vise
- ☐ Saw for cutting samples
- ☐ Sander or saw for creating scarfs

There are many standardized adhesion tests. In our lab we often use the PATTI test device (Figure 7) and lap shear testing (Figure 8 and 9). Both of these tests have ASTM standards and require special equipment. Fortunately for those who want to test adhesion in the shop, it's easy to create a peel test. Peel stresses are generally the most difficult loads for a bonded structure to tolerate.

In *Epoxyworks 20*, Tom Pawlak performed a test to determine the adhesion of a WEST SYSTEM repair to DCPD polyester laminates. He created a scarf joint between the existing polyester laminate and the WEST SYSTEM laminate that was bonded to it, simulating a repair. He clamped the laminate into a vise and bent it, creating a peel stress at the scarf (see Figure 10). You could test the adhesion of a WEST SYSTEM fiberglass laminate to various woods, metals, composites, and plastics the same way.

The test is limited because the actual force required to create peel is difficult to measure. Adhesion performance is better measured by the failure mode. After testing the sample, examine it to determine if the substrate failed, if there was a cohesive failure that left adhesive on both surfaces, or was the failure in the adhesion to the substrate. The failure mode will reveal the "weakest link" in the structure. For example, if a substrate failure indicates the adhesion exceeds the strength of the material, while an adhesion failure may signal a need to reevaluate surface preparation or the surface area of the bond.

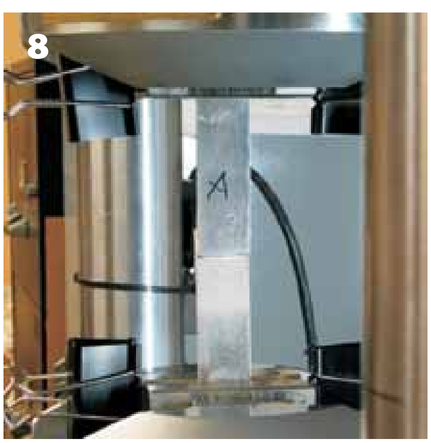
Be creative, scientific, and safe

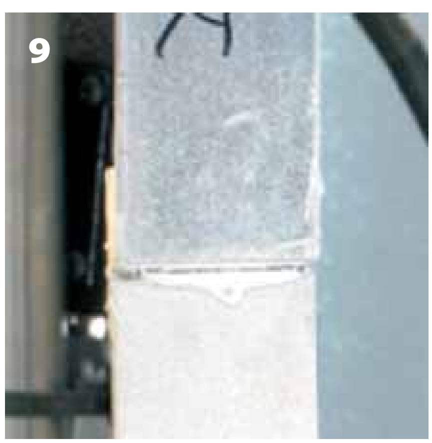
There are countless ways to test laminates in the shop. The examples given are not intended to create new test procedures, but to inspire testing solutions in other shops. It is important to understand what the results do and do not tell you. Most shop testing will only show the difference between samples, not the actual value of the property being measured.

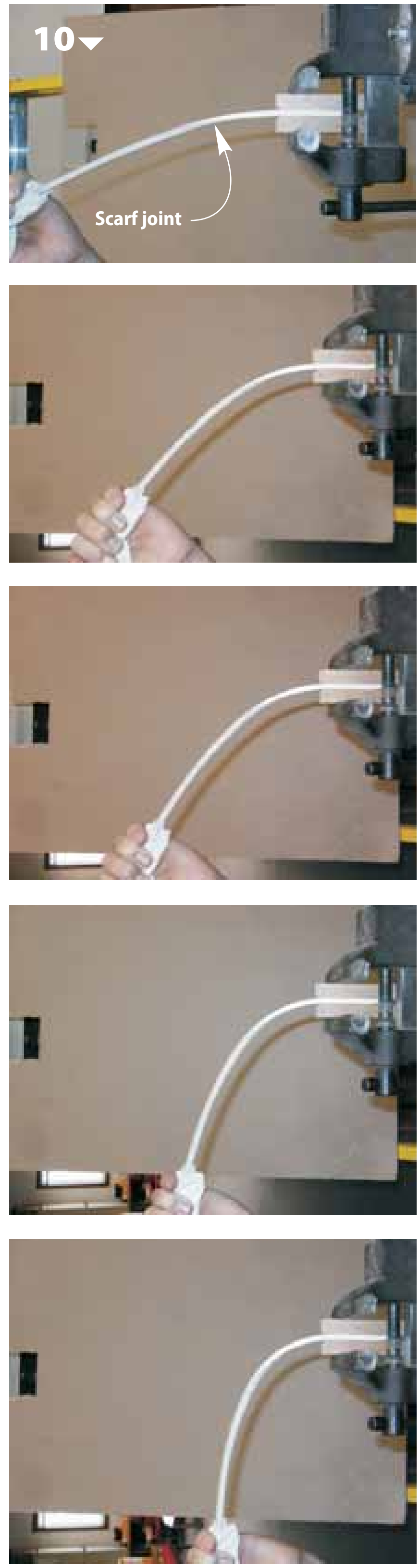
Good documentation is critical when testing. Record as much as you can about the procedure, samples and conditions. It is amazing how much can be forgotten a week after you finished the test.

When testing, always keep safety in mind. It's easy to create a lot of energy when attempting to fail a laminate, and that energy will find somewhere to go when the laminate fails. Also take proper precautions anytime you use heat.

Gougeon Technical Advisors are always available to discuss any test data. Don't hesitate to call us when you have questions. ■





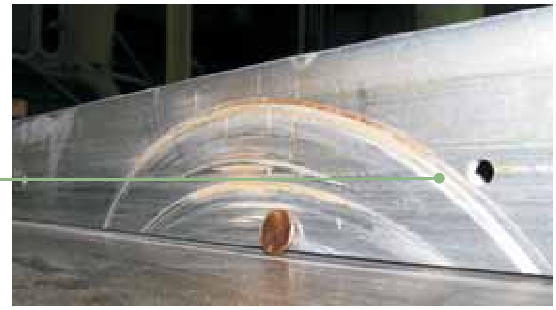


"The failure mode will reveal the 'weakest link' in the structure."

Quick Fix for a Damaged Table Saw Ripping Fence

By Tom Pawlak

25 years of use (some might say abuse) had taken its toll on the heavy aluminum rip fence on our Delta Rockwell 12"–14" Tilting Arbor Saw. Deep saw kerf grooves on the face of the fence had become a hazard because wood occasionally got hung up on it when ripping stock.



Over a few months, each time I used the saw I thought about how it could be repaired. While the plan was still developing in my head, more than once I clamped a flat piece of plywood to the ripping fence face to temporarily create the smooth surface that I needed.

In the end, I decided to permanently repair the damage with thickened epoxy. To make the repair smooth and simple I used a smooth board covered with plastic as a mold release to reform a flat surface. Just about any of our epoxy products would have worked for filling the grooves, but I chose G/5® Five-Minute Adhesive® thickened with 403 Microfibers so the saw would not be out of service for long.

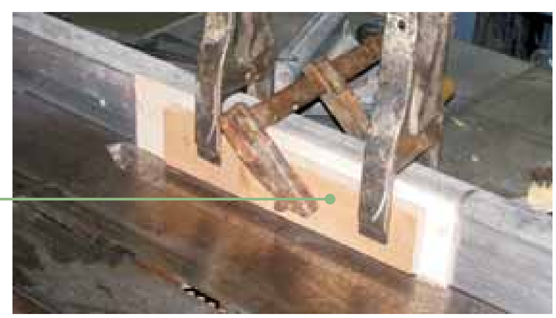
The photos pretty much tell the story. In the end, we have a rip fence just as smooth as new. The good news is if similar damage occurs in the future it can easily be repaired by repeating the process.

Here are the steps:

1. Clean the surface of the aluminum with an abrasive pad.
2. Abrade the surface with a wire brush, taking care to remove dirt in the grooves.

3. Protect the deck of the saw with plastic drop cloth or by covering it with wide, shiny packaging tape.

4. Locate something flat and smooth to use as the form for molding the epoxy into a smooth surface.
5. Cover the form with shiny plastic packaging tape (this will be the mold release surface).
6. Mix an appropriate sized batch of G/5 Five-Minute Adhesive and thicken it with 403 Microfibers to a mayonnaise consistency. (Additionally, 420 Aluminum Powder could be added if you are trying to make your repair less noticeable.)
7. Quickly apply the mixture to the damaged section on the rip fence.
8. Immediately position the flat form on the face of the rip fence and clamp it in place.



9. Clean up excess epoxy that squeezes out before it hardens.
10. Allow 15 minutes for the G/5 Adhesive to fully cure.
11. Remove the smooth & flat mold form by working wood wedges under the edges.

Clean up any slight irregularities on the surface of the fence with a flat scraper or with 120-grit sandpaper wrapped around a hard & flat sanding block.

The surface should now be as smooth as new. ■

New Tech Advisor **Mike Barnard**

Our newest Technical Advisor, Mike Barnard, is a recent graduate of Winona State University's Composite Materials Engineering program. It is the only accredited undergraduate degree in composites engineering in the USA.

Mike has enjoyed water sports his entire life, and is beginning to take interest in the different aspects of watercraft.

He has also been around a manufacturing environment his entire life. His grandfather was a wood worker, his father a metal worker, and continuing this material progression in his family, Mike is involved with composites. His father taught Mike the basics of both wood and metals manufacturing while he was growing up in a Minneapolis suburb.

Mike's combined technical and personal skills make him a strong asset in our Technical Department. ■

New tech advisors Mike Barnard and Don Gutzmer reflect on the conference table top they recently renovated by laminating a layer of carbon fiber over the old plastic laminate top. The carbon was vacuum infused, coated with three coats of WEST SYSTEM® 105/207 and sprayed with 10 coats of 2-part polyurethane, which was wet-sanded to 2,000-grit then buffed to a high gloss. Any questions?

The Composite Materials Engineering Program at Winona State University

By Mike Barnard

Winona State University in southeastern Minnesota has offered a undergraduate degree program in Composite Materials Engineering since the late 1980s, but it is still relatively unknown. With graduates now working all across the country, it is gaining popularity. Of the 140+ freshman who declare Composite Materials Engineering as their major, about 20-25 students graduate each year from the program.

The degree sounds very specific but in reality is as broad as a mechanical engineering degree. As with all engineering programs, it is grueling.

Composites are used more and more in everyday life, making Winona State's Composites program more relevant than ever. Graduates of Winona State's program are ready to evaluate, test, redesign composites and composite structures.

While taking the usual science courses, (calculus, differential equations, physics, etc.) the students are also submersed in basic engineering classes such as fluid mechanics, statics, and dynamics. After a couple years of doing well in these classes, the students apply to be in the composites program where they'll take the upper-level courses such as manufacturing and microscopy.

Winona State University has all the basic composite manufacturing equipment available to students. Autoclave, filament winding, pultrusion, injection and RTM are some of the methods taught in the program. The labs at Winona State University include characterization equipment as well. Much of this same equipment is routinely used here at Gougeon Brothers.

Winona State's Composite Materials Engineering department rents its equipment and student worker time to provide test results to businesses that don't have proper testing facilities. Businesses use this mainly for normal ASTM standard tests, but there are many different tests students can perform. ■

New Tech Advisor Don Gutzmer

My Staudacher Shop Experience

By Don Gutzmer

Staudacher S600F

In February 2011, Gougeon Brothers, Inc. hired me as a technical advisor. I graduated from Delta College with an associate's degree in Mechanical Engineering Technology in April 2008. I am privileged to say I have worked alongside a very talented builder over the years. If the name Jon Staudacher sounds familiar, then you probably know of some of the innovative projects he has designed and built—over 100 race boats and more than 30 airplanes, not to mention building his own race car.

I began working at Staudacher Hydroplane in Kawkawlin, Michigan, in 2003 on my time off from school. One of the first projects I was involved with was the Staudacher S600F. Jon was looking to design a monoplane capable of performing aerobatics and also having cross country utility. We started by creating a wood fuselage plug which we used to build fiberglass female molds to build the composite parts for two planes. The finished parts were hand laid with three layers of fiberglass cloth. Jon fabricated the fuselages by tig welding together 4340 chromoly tubing, and I assisted in the build of the wooden wings.

First we built the spar, and then tested it to see if it could withstand a high load without failure. The spar could support the loads because many layers of carbon fiber provided the majority of its strength.

The fuel tanks were built into the leading edge of the wings. We coated the inside of the leading edge with WEST SYSTEM® Epoxy 105/205 and 423 Graphite Powder for a barrier coat to protect the wooden tanks from the fuel. Aviation fuel doesn't have ethanol in it, so there was no worry that the epoxy would break down over time.

The outer skins of the wings were ⅛" Okoume plywood scarffed and glued with WEST SYSTEM 105 Resin/205 Hardener and thickened with 406 Colloidal Silica filler to bridge any gaps. I had the job of rib stitching the fabric onto the tail section of both planes. The fabric on the fuselage and tail section needed to be stitched onto the plane so all the stress exerted onto the plane wouldn't tear the fabric away.

The planes were powered with a 300 hp Lycoming engine and the total empty weight was 1,380 lb. After both projects were completed Jon offered to give me a ride in the plane in the photo above. I was amazed how responsive the plane was when moving the stick back and forth; I have to say I probably will never forget the experience. It took just under one year from the time the wood plug was built to complete both planes.

Over the years I helped Jon build and repair 2.5 liter hydroplanes. The race boats we built were all wood construction, and the wood worked well to maximize the strength-to-weight ratio. Jon designed his new 2.5 liter hull to have a low center of gravity by keeping the engine and driver position low to contribute to a low propeller shaft angle, which in turn made the boat more aerodynamic. The design has three sponsons, and one advantage of the center sponson was to keep the driver lower in the boat.

Jon started this project by lofting the boat full scale. I helped cut all the wood patterns needed to frame the hull, and then we built a jig to mock the boat up on. The boats were built upside down, and then turned over to skin the top side. We used ⅜" Okoume plywood for the bottoms and ⅛" for the top skins. The entire boat was held together with WEST SYSTEM 105 Resin/205 Hardener and 406 Colloidal Silica filler was used to thicken the epoxy. The filler was versatile enough to use for the entire project.

It took roughly 10 weeks to build a new hull. I assisted with all the phases, from gluing the frames to spraying the final clear finish. The only thing I didn't help with was the design.

Working for Jon was a great experience. I am grateful for the many things I learned from him through the years. I look forward to applying what I learned from hands-on building experience and from my college education, when advising individuals using WEST SYSTEM Epoxy in many different building and repair projects. ■

The Michigan School

Student builders

By Dave Lesh

Located in the Petoskey area of northern Michigan, The Michigan School's nine month vocational program will teach students contemporary boat building and marine industry skills. Composite manufacturing technology is used extensively in a number of industries such as aerospace, recreation, transportation and alternative energy. The skills learned at TMS will be widely transferable.

There are immediate employment opportunities for graduates of the Marine Composite Program, so it will be offered first in Fall, 2011. Programs in Marine Systems and Restoration will roll out later in 2012.

Classes in the safe use of contemporary boat building materials and methods such as resin infusion, wet bagging, fiberglass and cold molding have been developed with the guidance of some of the leading composite engineers in the industry. The project boats in this course will be 12-22' long and constructed of practical composites. These will be built from start to finish, then capped off by a formal launching at graduation. Students will construct decks, hatches and other components using composite methods and materials. Basic mechanical system installation will also be part of the curriculum.

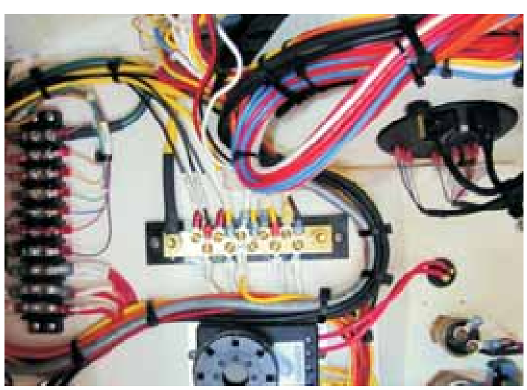
Several manufacturing sectors expect strong growth in the composites industry in the coming years. Composite manufacturing generates $13.7 billion a year in the USA, and $45.3 billion a year for suppliers and manufacturers, according to the American Composites Manufacturing Association's 2009 Composites Industry Report. Boeing's Current Market Outlook 2010-2029 predicts that air carriers in North America will take delivery of 7,200 new aircraft, valued at $700 billion, over the next 19 years. Lucintal predicts the composite automotive market will reach $1.5 billion in 2014 in their Opportunities for Composites in the North American Automotive Market 2009-2014: Trends, Forecast and Opportunity Analysis (May 2009).

The Michigan School will teach boat building and marine technology as an application of composite materials, yielding graduates who can respond to the need for a workforce skilled in composite construction and manufacturing. Students will learn how to create composite fabrication using open molding, wet bagging, resin infusion and pre-preg manufacturing methods. The design and construction of composite tooling will also be taught with a focus on the materials and methods used in industry to construct one-off or production tools.

A strong emphasis will also be placed on teaching "real-world" project management, communication, and leadership skills. The course will be taught through a series of lectures, guest instructors, bench demonstrations, and the fabrication of composite boats. Guest lectures and field trips to regional boat builders will augment the course.

For more information on The Michigan School, contact davidlesh@charter.net. ■

The Michigan School will offer programs in Marine Systems that include basic Mechanical System Installation and Marine Technology.



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Also included are the current price list, stocking dealer directory, and the *Fiberglass Boat Repair* brochure.

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002-970 ***Wooden Boat Restoration & Repair***—Illustrated guide to restore the structure, improve the appearance, reduce the maintenance and prolong the life of wooden boats with WEST SYSTEM epoxy. Includes dry rot repair, structural framework repair, hull and deck planking repair, and hardware installation with epoxy.*

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002-150 ***Vacuum Bagging Techniques***—Step-by-step guide to vacuum bag laminating, a technique for clamping wood, core materials and synthetic composites bonded with WEST SYSTEM epoxy.*

002-740 ***Final Fairing & Finishing***—Techniques for fairing wood, fiberglass and metal surfaces. Includes fairing tools, materials and a general guide to finish coatings.*

002-898 ***WEST SYSTEM Epoxy How-To DVD***—Basic epoxy application techniques, fiberglass boat repair and gelcoat blister repair in one DVD.

*Available as a free downloadable PDF at www.westsystem.com/ss/use-guides.

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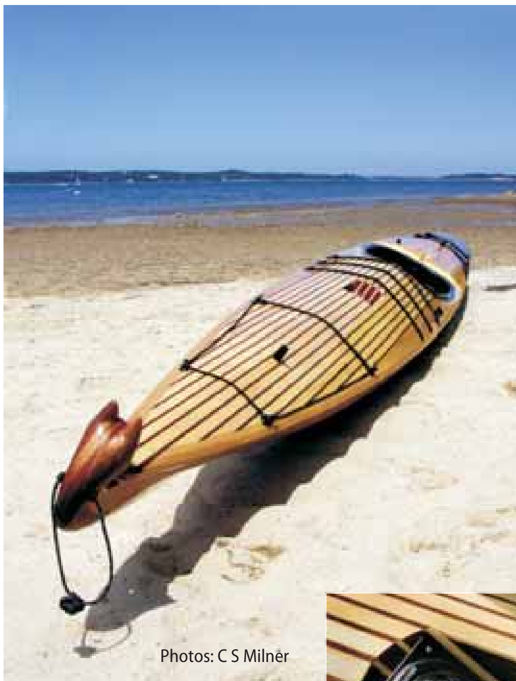

Photos: C S Milner

Therapy in Detail

I fell in love with the North Star baidarka-style kayaks developed by Rob Macks of Laughing Loon Custom Canoes & Kayaks in Maine. But when I tried one out, the cockpit was too roomy for me. So, I bought plans for the smaller Fire Star. When I realized it was going to be smaller than I wanted, I put the Fire Star plans into my CAD program and blew it up proportionately to be halfway between the two models.

My inspiration for the bow piece was an image I saw online of an Inuit-style bird looking back over a baidarka's bow. Instead of a bird I used my 15-year-old Siberian Husky, Boz. I experimented with having him face forward, but the lines of the boat dictated that he face me. Plus, this way my guardian angel can keep his eyes on me.

The design for the woodwork started with red and white cedar, recommended because they are readily available, light weight and easy to bend. I added Alaskan yellow cedar and mahogany because they reminded me of beautiful old lake boats with teak and holly decks.

Six years of working on this project gave me plenty of time to search the web to see what others were doing and borrow their fabulous ideas. I wish I could take credit for all the little details on the boat, but the majority are refinements of things I have seen other builders do.

To give myself the motivating pressure of a deadline, I signed up for the "I Built It Myself" exhibit at the 2011 Wooden Boat Show in Mystic, Connecticut about six months ahead of the show. I finished the boat on the Thursday before the show. The big surprises were people's reactions to *Therapy*, followed by winning Honorable Mention in the "I Built it Myself" exhibit and then winning Outstanding Innovation as part of the Concourse d'Elegance judging.

My wife was wonderful in putting up with me for the past six years while I worked on Therapy. While I do some much needed work around the house, I'll be thinking about what to build for an encore.

***Bill Curtis**, Malden, Massachusetts*