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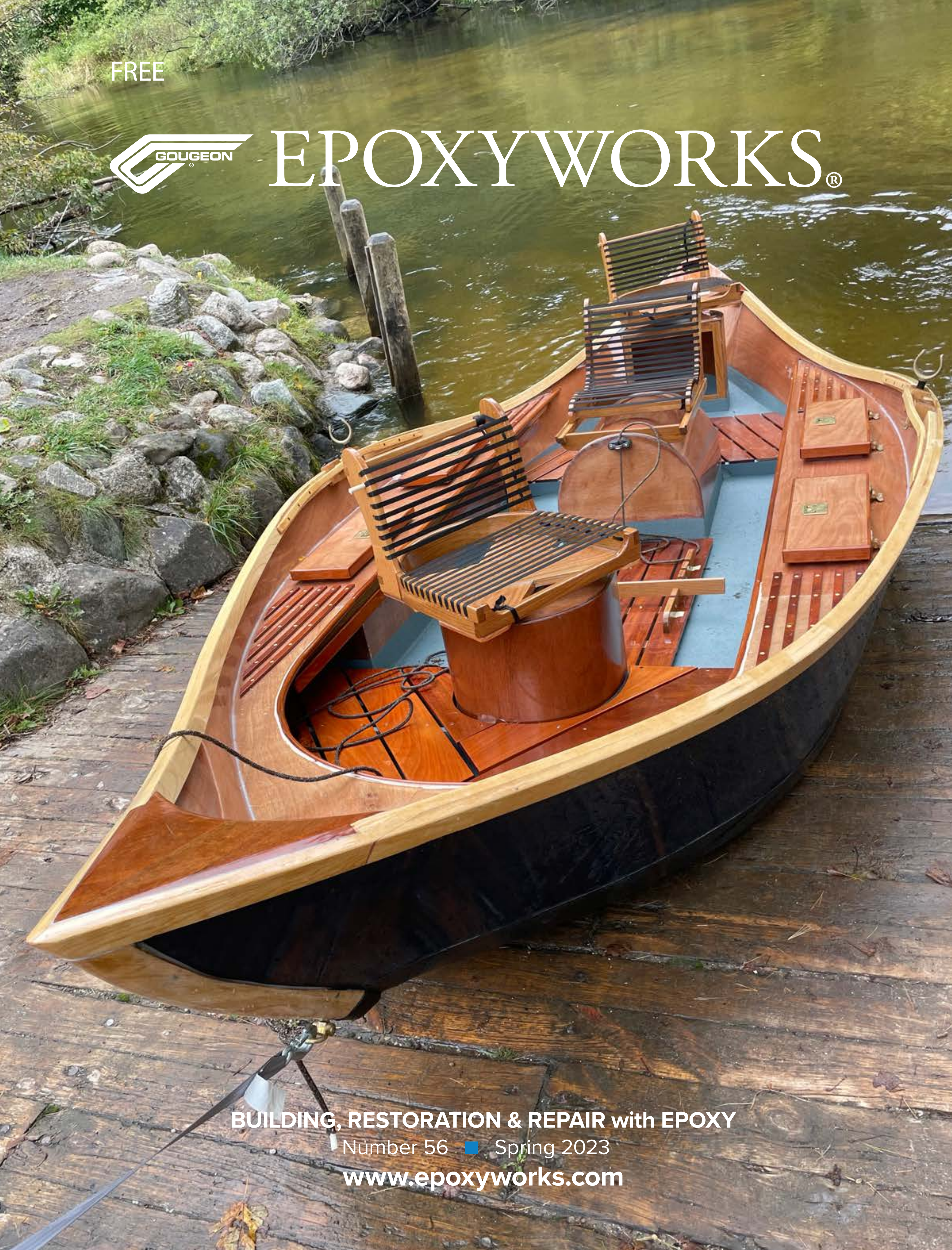
EPOXYWORKS®



BUILDING, RESTORATION & REPAIR with EPOXY

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EPOXYWORKS®

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Building a Soaking Tub

By James Thomas

Tongue and groove pine was used for the base of the tub.

Cut 2x4 cedar strakes, with a bead and cove edge, formed the walls of the tub.

Ratchet straps were used to draw the vertical strakes together while the epoxy cured.

After a long time in the planning stage, my son Adam and I began work on a tiny house in 2022. While it was possible to purchase small, modular shower pans and enclosures, small soaking tubs were virtually impossible to find. I've built several small boats using wood and WEST SYSTEM® Epoxy, so it occurred to me that building a small tub might be possible.

On YouTube® I found videos of several do-it-yourself hot tubs made from 2x4 cedar strakes. Because these were made for mounting outside on a deck, there was no need for adhesives. They relied on steel bands, and the natural swelling of the cedar, to enable the tubs to hold water. Since our tub was going to be inside a tiny home, it needed to be waterproof. The construction would be similar to a boat, however the goal would be to keep the water in rather than out.

The bottom of this tub is made of 2x6 tongue and groove pine. These were epoxied together with WEST SYSTEM 105 Epoxy Resin® with 209 Extra Slow Hardener®. I chose the Extra Slow Hardener for the glue-up of the tub base and the vertical strakes forming the walls of the tub so I had sufficient working time for assembly—first the base and then the walls.

Once the base was cured, I traced the dimensions of the tub interior, plus ½", onto the base. This additional ½" accounts for the loss due to the dado I planned to cut into the vertical strakes later. Then I cut out the tub bottom using a sabre saw.

I fabricated the vertical strakes from cedar 2x4s. The 2x4s were cut into 24" lengths and a bead and cove edge was routed onto the long dimensions of the strakes. Bead and cove is familiar to cedar strip canoe builders—it enables the construction of curved shapes, with convex bead edges, to fit into concave cove edges. Finding appropriate router bits and cutting these edges proved to be the most challenging part of the build.

Once my 36 strakes were cut to length and routed, it was time to cut my dado. The dado would receive the bottom of the tub so that way the strakes would be mostly self-supporting during assembly. 1" in from the end of each strake, I cut a ½" deep by 1 ½" wide dado with the table saw. The tub was then dry assembled on a large worktable. During planning, we did not take the time to calculate the circumference of the tub so that each strake would end up the exact same width. This left us with a gap between the first and last installed vertical strakes. I custom trimmed and routed an additional strake a little narrower to fit this remaining space.

Because of the sheer number of linear feet of edges to be epoxied, I knew the glue-up was going to be difficult. I surveyed a wide range of adhesives to find a product that would be waterproof and give me enough working time during assembly. I concluded that using WEST SYSTEM 105 Epoxy Resin with 209 Extra Slow Hardener would produce the working characteristics I needed, when combined with 404 High-Density Filler and 406 Colloidal Sillica Fillers for my adhesive mix.

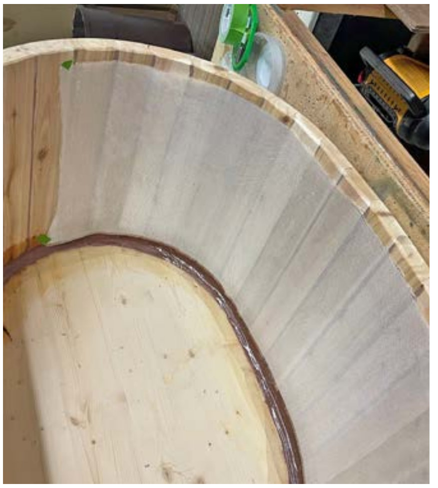
For the glue-up, I started by wetting out all of the edges to be epoxied with unthickened 105/209. I then applied my adhesive mix to the concave edges and the dado slot. Standing the strakes on end, the tub began to take shape one strake at a time. At this point the strakes were loosely assembled, attached only on the bottom. I wrapped painter's paper around the tub, then fitted two rachet straps around the tub to draw the strakes together.

The final steps to finishing the tub were quite similar to building a small boat. I added fillets to reinforce the joints, laid fiberglass tape over the fillets, applied 4 oz. fiberglass to the interior of the tub, rolled fill coats of epoxy over the fiberglass, and coated the entire tub with 105 Epoxy Resin and 207 Special Clear Hardener®.

Once the drain was installed in the tiny house, its location was marked on the tub bottom. I used a router with a top bearing, guided by templates, to cut the countersink for the drain fitting. I used a hole saw to drill the 1 ½" hole through the tub bottom. The drain holes were then coated with epoxy and allowed to cure before installing the drain fittings using conventional gaskets and plumber's putty.

As you can tell by his smile in the picture, my son is thrilled with his custom, tiny house tub. This adds a lot of character to the house, and is built sturdy enough to be enjoyed for years to come.

Once the epoxy cured, the tub needed to be sanded and the vertical strakes trimmed.



Close-up of dry-fitting the fiberglass lining. Fillets were added to reinforce the joints.

Fiberglass tape was applied to the fillet around the base and 4 oz fiberglass fabric to the interior walls.

The entire tub was clear coated with 105/207.

Adam enjoying the finished custom tub.

Calculating Laminate Thickness

By Rachael Geerts – GBI Composite Materials Engineer

Have you ever wondered how laminate thickness can be determined without breaking out the epoxy and reinforcement fabric? The answer is simple—use math. While some of you may have just lost interest because you think math is too difficult, I can assure you that this math requires nothing more than some basic multiplication, addition, and division. Let's get to it.

Here is the equation we'll use to calculate the average thickness for a single layer of laminate:

$$t_L = \frac{W_F}{\rho_F} + \frac{(\frac{W_F}{X_F} x \, X_R)}{\rho_R}$$

In this equation:

- t_L represents the total composite laminate thickness.
- W_F represents the aerial weight of the woven or knit reinforcement fabric you are using in your composite laminate.
- ρ_F represents the density of the reinforcement fibers.
- ρ_R represents the density of the resin system you are using. In this instance, the resin system is West System Epoxy.
- X_F represents the fiber weight fraction, which is determined by the process you are using to create your laminate.
- X_R represents the resin weight fraction. Like the fiber weight fraction, this will be determined by your processing technique and can be calculated as $X_R = 1 - X_F$.

Now that we know what our variables represent, we need to determine their value.

Reinforcement Aerial Weight (W_F)

The aerial weight is given by the fabric supplier, but it's also what you typically call the woven fabric you buy. Ever wonder why fiberglass was called 10 oz. or 17 oz. or maybe why carbon might be called 200 gsm? These are the aerial weights of the fabrics (exact aerial weight is typically given on the spec sheet). 10 oz. is referring to 10 oz./yd^2. The same is true for 17 oz. Now, weights like 200 gsm carbon may confuse those of us in the US a little, but gsm stands for grams per square meter. This is a common unit of measure for carbon fiber.

This brings up a good point—check your units! For these equations to work properly you need to make sure you are using the same units—inches to inches or mm to mm, etc. I could go into great detail here about how to convert between different units, but with all the resources available today, you hardly need to do the conversions by hand (although you can if you like math that much!) There are plenty of apps or websites that will do these conversions for you in a matter of seconds, so I would recommend using one of them (or checking your work with one of them).

Fabric and Epoxy Density (ρ_F and ρ_R)

While you can find the densities of different fiber reinforcement types in various reference materials, we typically use the values given in this table.

Fiber type	Average density in oz/in^3	Average density in g/cm^3
Fiberglass	1.47	2.55
Carbon Fiber	1.04	1.80

The average density of the West System® 105/20x is about 0.68 oz/in^3 or 1.18 g/cm^3. Specific densities can be found on our technical datasheets on our website.

Weight Fraction (X_F and X_R)

Through much research and experience, the composites industry has agreed that the processing technique you use impacts the weight ratio of each component. This means that, if you hand lay up your laminate, the weight fraction (X) values will be different than if you vacuum bag your laminate. This second table contains the X value ranges that are typically accepted in the composites industry. Since the only components of your reinforced laminate are the fibers and the epoxy, $X_F + X_R$ should always equal one.

Processing Technique	X_F Fiber Weight Fraction	X_R Resin Weight Fraction
Hand Lamination	0.45-0.55	0.45-0.55
Vacuum Bagging	0.55-0.7	0.3-0.45

The hand lamination technique is suitable for a wide range of applications, however there may be certain times where you need to optimize your laminate for higher performance. Since the laminate fibers carry the majority of the load, it is often best to increase X_F and decrease X_R to maximize the composite's strength.

The most common way to increase X_F when using epoxy is to vacuum bag your laminate. This means that, after you have thoroughly wet out your reinforcement fabric, you would follow the directions outlined in our *Vacuum Bagging Techniques* manual. For a flat laminate, you would want to apply a vacuum pressure of 5-12" of Hg (inches of mercury). For a more complex shape, you would want to apply 12-25" of Hg to get an even vacuum pressure across the entire laminate. This vacuum pressure helps remove entrapped air and excess epoxy, consolidating the laminate. Again, this is a great way to optimize your laminate, however, it may not be practical or needed for every project. Make sure to consider the full scope of the project before determining which processing method you are going to use.

The Formula in Action

Let's put our new knowledge to the test. We will calculate the thickness for a fiberglass, hand layup panel made with one layer of 10 oz. fabric and 105 Epoxy Resin® with 205 Fast Hardener®.

W_F - If we use one square yard of 10 oz./yd^2 fiberglass then W_F = 10 oz./yd^2. We'll convert this to 0.0077 oz/in^2 which will help with units later.

X_R and X_F - We can use 0.5 for our X_R and X_F (right in the middle of the ranges) since our panel will be made via hand lamination. ***Note:*** *This amount of epoxy will allow you to thoroughly wet out the fiberglass by hand.*

ρ_F - From the density table, we know the average density of fiberglass is 1.47 oz./in^3.

ρ_R - We also know that the density of 105/205 is 0.68 oz./in^3.

If we start putting all of the known values into the equation, we get:

$$t_L = \frac{W_F}{\rho_F} + \frac{\frac{W_F}{X_F} x\, X_R}{\rho_R}$$

$$t_L = \frac{0.0077\ oz./in^2}{1.47\ oz./in^3} + \frac{\frac{0.0077\ oz./in^2}{0.5} x\ 0.5}{0.68\ oz./in^3}$$

$$t = 0.0052\text{ in} + 0.011\text{ in}$$

$$t = 0.016\text{ in}$$

(Using 2 significant figures)

Glass Fabrics

Woven E-glass fabrics are ideal for building composite laminates and repairing fiberglass structures. May also be used to provide an abrasion-resistant covering for wooden structures. When wet-out, the 4 oz. and 6 oz. fabrics become transparent, allowing a clear, natural wood finish. Perfect for stripper canoes. May be painted or varnished.
(740, 742, 745)

Glass Tape

Versatile WEST SYSTEM 9 oz. woven E-glass fabric tapes, with bound edges, are ideal for reinforcing chines, hull/deck corners and similar structural applications. When bonded with WEST SYSTEM Epoxy, they provide additional tensile strength to resist hairline crack development and abrasion.
(729, 731, 732, 733)

Biaxial Fabric

17 oz. non-woven E-glass fabric. Two layers, ±45° fiber orientation. For composites, repair and reinforcing. Achieves high fiber-to-resin ratio with hand wet-out.
(737)

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A Few Last Thoughts

While the laminate thickness equation may look a little intimidating at first, you now know exactly how to fill it in and solve it. This is a great tool to help you in calculating your laminate thickness, but keep in mind that this equation only gives you an average single-layer thickness. The average takes into account the high spots and low spots in the fabric from the weave. If you were to take some calipers and measure the thickness of a panel made with a single layer of fiberglass, you would likely get a slightly higher number than the calculated thickness because the calipers would rest on the high spots of the fabric.

Remember to double-check your units! They are slippery little fellas and can sometimes get away from you. Make sure to always keep them in check (you should never end up with a single-layer thickness even close to an inch or more with a standard woven or knit reinforcement fabric).

I hope this makes you feel a little more confident heading into your next composite application. If you have any additional questions feel free to contact our technical staff online or over the phone at 1-866-937-8797.

Disclaimers

We do not engineer laminates and cannot recommend a final laminate thickness for builds or repairs. During repairs, we generally recommend replacing the original laminate thickness to maintain or exceed the strength of the original laminate that was designed.

While this equation is accurate, it is still based on some average and nominal values. We do not guarantee that your laminate will be the exact thickness as calculated using this equation.

Short Cut

If you're steadfast in your aversion to math, I've got a shortcut for you. This chart has the approximate single layer thickness for all of our WEST SYSTEM fiberglass for a hand lay-up laminate.

Product	Fabric Weight	Single Layer Thickness*
740	4 oz.	.006" - .008"
742	6 oz.	.009" - .011"
702	11 oz.	.015" - .018"
729	9 oz.	.013" - .017"
731	9 oz.	.013" - .017"
732	9 oz.	.013" - .017"
733	9 oz.	.013" - .017"
745	10 oz.	.014" - .019"
727	17 oz.	.025" - .032"
737	17 oz.	.025" - .032"
738	23.8 oz.	.039" - .053"

Extract from the WEST SYSTEM *User Manual & Product Guide*, Reinforcing Materials.

iaxial Fabric ith Mat

oz. non-woven E-glass ric. Two layers, ±45° fiber entation. The same as 737 ric with a .75 oz./sq. ft. mat king. Approximately 23.8 /sq. yd. total fabric weight.

8)

Biaxial Tape

17 oz. non-woven E-glass fabric. Two layers at a ±45° fiber orientation are held together by a light stitching. Flat, non-crimped fibers yield reduced print-through and higher stiffness than woven fabrics. Ideal for repairs, tabbing and reinforcing.

(727)

Have a question about Calculating Laminate Thickness?

Scan the QR Code to contact our **Technical Services Team**.

Bond Girl's New Custom Rudder Support

By Jenessa Hilger – GBI Marketing

Test fit of Bond Girl's new rudder support.

The weekend before our wedding, my husband and I bought our S2 7.9 meter sailboat. She was exactly what we were looking for, a trailerable racer/cruiser that was a diamond in the rough. We felt fate had drawn us to her. She was hull number 7, 007 to be exact, and I had about six months under my belt working at Gougeon Brothers, so the boat basically named herself: *Bond Girl.* Over the past nine years, we've made many improvements, the latest of which was building a custom fiberglass and carbon fiber rudder support, or as I nicknamed it, a rudder hook.

Because of the length of the rudder, and how low these boats sit on the trailer, it's important to support the rudder kicked up for launching and retrieving. When we purchased the boat, it came with a fabricated stainless steel rod that had hooks on both ends. One end inserted into a lifting eye in the trailing edge of the rudder, and the other would hook onto the vertical wood spacer on the back of the rudder box. The lifting eye in the rudder was susceptible to stress cracking. We tried a few different repairs to reinforce the area, but were never truly satisfied with the results.

Last year, while out for a leisurely afternoon sail, spinnaker flying, with grandparents and kids on board, *Bond Girl's* 40-year-old rudder finally had enough. We surveyed the carnage of our poor rudder. It looked like a dead fish floating on the top of the water. The rudder broke at the very top of the blade, right through that problematic liftingeye. We hauled it on board and used the outboard to motor back to the dock.

The immediate problem was that in four days we were scheduled to compete at the Red Fox Regatta in Charlevoix, Michigan. This is our favorite race with the boat, and we didn't want to let a "little" thing like a rudder keep us from attending. Luckily, a friend loaned us a spare rudder to use until our new one arrived.

The new rudder we ordered through the class arrived mid-winter. While unboxing it, we discovered it had not been pre-drilled for the eye. We seized the opportunity to eliminate the weakness of our previous rudder. The challenge was devising a new fixture to support the rudder securely, with no mechanical attachment point through the rudder itself.

We decided on a concept that would hook like a "J" around the leading edge of the rudder, then run vertically up to the wood spacer on the back of the rudder box, and take a 90° turn at the top of the wood to run under the tiller bolt and between the cheek plates. This device would be locked into place with a vertical pin running perpendicular to the tiller bolt. To prevent wear, on the rudder we wanted to use ½" thick roll foam to pad any part of the fixture that would touch the rudder.

To create this highly custom design, we needed to use the borrowed rudder and our rudder box as a mold to create the perfect fit. We positioned the rudder at the correct angle for pulling the boat out of the water. Then we laid out pieces of our foam and fiberglass to get a feel for where we wanted the hook to be. We also determined where we were going to support and clamp everything once it was wet out with epoxy. The transition between the rudder and the rudder box would need additional support. We determined sandwiching that area with some scraps of foam left over from padding would be sufficient support. Satisfied with our plan, it was time to begin the epoxy work. We masked just about every inch of the rudder to be certain no stray epoxy accidentally got where it shouldn't be.

We cut the glass and foam to size, intentionally leaving about an inch margin on all sides to be trimmed off later. Oversizing the materials ensured the full laminate thickness continued all the way to the edge of the final part for maximum strength. The first layer applied to our masked rudder was the ½" foam. The foam was springy and wanted to lift off the rudder, so we taped the edges down to get a tight fit (figure 1). We brushed a light layer of WEST SYSTEM® 105 Epoxy Resin® and 206 Slow Hardener® on the top of the foam. Applying the epoxy directly to the foam did two things: Created better adhesion to the fiberglass, and it kept the foam from drawing epoxy out of the laminate, which could make the finished laminate weaker.

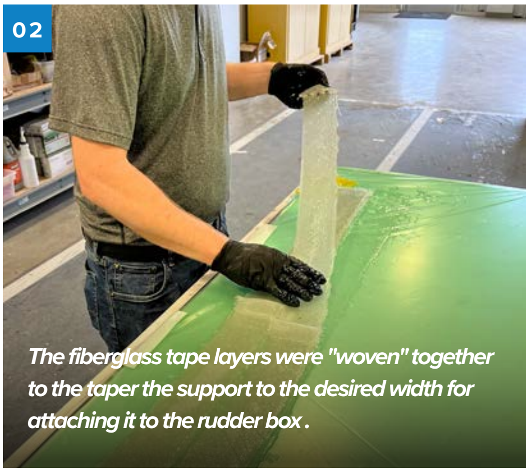
Next, we needed to wet out the 737 Biaxial Fiberglass Tape (17 oz.) on a flat surface, using more 105/206 (figure 2). We wanted to be sure each layer was fully saturated, which is much easier to do on a flat table than on the underside of the rudder. Why use fiberglass tape you ask? Even though we needed a broader surface area where the hook would cradle the rudder, as we transitioned up to the rudder box, the glass would need to taper down to the exact width of our fiberglass tape. The strips of tape would allow us to "weave" them together, tapering down to the single width dimension we needed. This method of weaving would also help evenly transfer the load down the length of the fibers, giving a stronger result than simply cutting away the unnecessary portion. (It's also less wasteful).

In total, we were going to need 6 layers of the tape, two strips wide (a total of 12 lengths). We wet out the first two strips of fiberglass tape side by side, followed by all the subsequent layers stacked directly on top of those. Then we folded all but one length of fiberglass back on itself, about ⅔ of the way down the length of the fiberglass. Here we began to "weave" the layers together.

With the first strip left in its original position, we took the strip that was wet out next to it and crossed over the top of the first so that the two ends were on top of one another. Then we moved to the next layer. Again, the first strip was laid back down straight and the second crossed over with the end on top of the others. This continued for the remaining layers. Then we trimmed away some of the excess carbon fiber so it roughly resembled the shape of the fiberglass (figure 3). We wet this out with our epoxy too.

01

The rudder assembly has been masked. Foam was taped onto the rudder where the support will go. The foam was wet out with epoxy so it will bond to the layers of fiberglass.

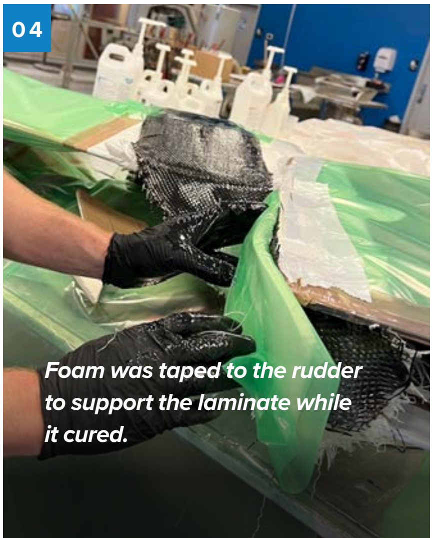


02

The fiberglass tape layers were "woven" together to the taper the support to the desired width for attaching it to the rudder box .

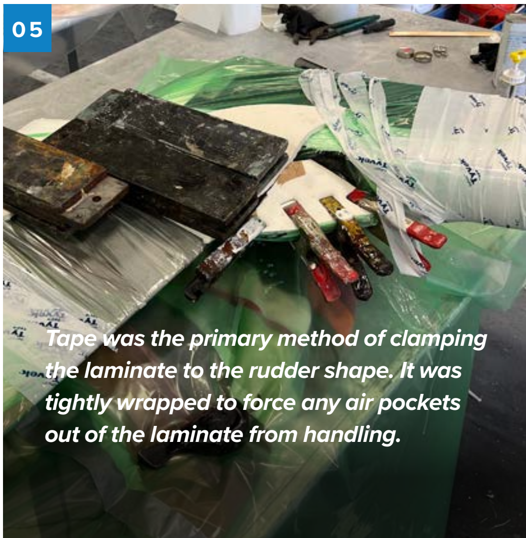
03

A layer of carbon fiber was applied over top of the fiberglass tape for cosmetic purposes.



04

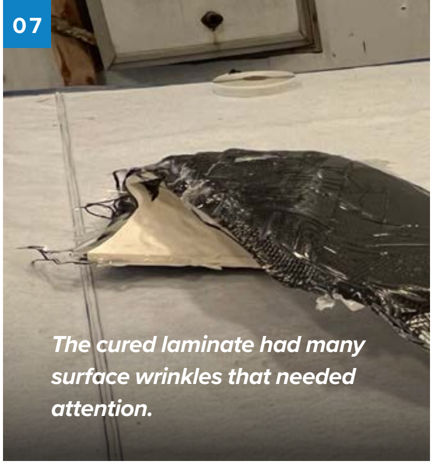
Foam was taped to the rudder to support the laminate while it cured.



05

Tape was the primary method of clamping the laminate to the rudder shape. It was tightly wrapped to force any air pockets out of the laminate from handling.


06 The fiberglass layers split around the pin to help the support lock in place.


07 The cured laminate had many surface wrinkles that needed attention.


08 Black tinted 105/206, with 406, was spread on the surface to fill in some of the wrinkles.


09 The 105/206 filler layer was sanded smooth.


10 A fresh layer of carbon was bonded to the surface..

Now it was time to transfer all those heavy, saturated layers to the rudder. Carrying the laminate conjured the feeling of holding a python. Even the texture of the coarse weave carbon was reminiscent of scales to my gloved fingers. We laid the double width section of the laminate on the rudder blade, the single width section on the wood of the rudder box, and the transition section was suspended in between.

The saturated laminate was heavier than we had expected, creating more difficulties positioning the laminate than we originally anticipated. We anchored the single width section to the rudder box first. We laid a piece of release film on top of the laminate. Then, using tape, we encircled the box and laminate, compressing the laminate tightly. Securing this point allowed us to keep tension on the laminate. This was important because the transition from the box to the rudder did not have a ridged support, so it was sagging more than expected under the weight of the wet out laminate.

Under firm tension, we wrapped the double-width end of the laminate around the leading edge of the rudder. We used our tape wrapping method again to evenly clamp the laminate to the rudder.

Despite our best efforts to keep the laminate taut, the transition section was still sagging more than we liked. For support, we used scraps of the foam that were covered in mold release tape. We sandwiched the laminate with these, compressed by a couple of spring clamps. The foam helped smooth out the arc of the laminate to a gentler curve without creating hard transition points. Plus, the foam helped cushion and distribute the force applied by the spring clamps holding it together (figure 5).

At this point, the epoxy was kicking off, so we needed to wrap things up. The last section to position was the bend at the tiller pin. The span between the wood of the rudder box and the pin was not wide enough to feed all 13 layers of laminate underneath it. Instead, we split the laminate so 7 layers went below the pin and 6 went above (figure 6). Our reasoning was, if this proved to be a weak area when the epoxy cured, we could easily add reinforcing layers once we separated the part from the rudder. That section would be more accessible. Trying to fit our hands into the small cavity was proving difficult, and we were running out of time. The epoxy was curing.

It was back to the tape again. We continued securing any areas we thought may be too proud or had the possibility of sagging. We also added a few weights for good measure.

Once the part was cured and demolded, we inspected our work. Not terrible, but definitely room for improvement. The pressure from the tape left some uneven banding and many wrinkles in the part's surface. Not great from a cosmetic standpoint, however, the laminate was as strong as we had hoped for (figure 7).

We trimmed the extra material from the edges and did a quick test fit. It functioned better than we had guessed. Because we made the mid-epoxying decision to split the layers around the tiller bolt, the excess epoxy squeezed out on the inboard side of the bolt. This left a little bump on the top and bottom between the laminate split. The resulting effect was that the hook snapped into place around the tiller bolt.

Now it was time to do something about those cosmetics. Our approach was to create a filler layer to even out some of the wrinkles so we minimized grinding into the laminate fibers, and weakening the part. We used 105/206 thickened with 406 Colloidal Silica Filler to it to reach the consistency we were looking for. We also added some 502 Black Pigment to help this fill layer blend in with the carbon fiber (figure 8). Once this frosting layer had cured, we came back with some 80-grit to prep the surface (figure 9).

One more layer of carbon fiber was applied to give us the beautiful aesthetics we were looking for (the added strength wouldn't hurt either) (figure 10). The part underwent one final trim to clean up the edges, and our pièce de résistance was complete.

If I were to repeat this project, I would have paid closer attention to the tape's tension while applying it. We were inconsistent with our tension when we were problem solving on the fly, so some wraps were pulled more tightly than others. This caused the release film that was laid on top of the laminate to wrinkle, imprinting the part, and resulting in more finish work. Also, we were running out of tape left and right, so we were grabbing any roll that was handy. Using this hodge podge assortment of tapes, each one could have applied different pressure depending on their width, adhesive, and the material's stretchiness. I definitely should have been sure to have all the materials I needed at hand before starting to mix the epoxy.

Having gone through the process, I now know that I should have applied the carbon fiber layer after the fiberglass had cured. If I had been more realistic (honest) with myself that there would be imperfections after the initial layup, then I would have planned on applying a thickened coat to address the surface imperfections before applying the highly visible outermost layer.

The resulting rudder hook looks pretty darn racy for the old girl, but with a name like *Bond Girl*, she deserves nothing less than beautiful epoxy work. I can't wait to do some durability and ease of use testing over the summer as we compete in our regattas. That will be the true gauge for our success.

Scan the QR Code to download the ***West System Fiberglass Boat Repair & Maintenance Manual*** and learn how to repair cracks, holes, damaged skins, cores, keels, rudders, and gelcoat, as well as how to install hardware and teak veneer decks.

Bond Girl, sailing in the weekend race series on the Saginaw Bay.

Babka's Dog Haus

By James Powers

Babka on duty, surveying the premises.

The day after Thanksgiving 2020, we adopted a 60 lb. dog from a shelter in Danbury, CT. She came with a plastic bag of turkey scraps and not a lot of info.

I thought we might have accidentally got a Leonberger pup, but a DNA test showed we had a mutt with no dominant breed. My wife and I named her Babka because of her heavy double coat of black and brown. In hindsight, we were lucky. Babka is relaxed, rambunctious and playful. She is good with children. Perhaps she had come from a family.

Oddly, the shelter had given us strict warnings against leaving Babka outside in the cold. This was a conundrum, as Babka seemed quite comfortable napping in snowdrifts, delicately slurping flakes off the seat of our picnic bench, and lumbering about the premise disguised as an abominable snowman. Dragging her inside in the evenings entailed bribes in the form of choice cuts of skirt steak and sautéed shrimp (with the shell on).

Soon enough, Babka made it clear that she was OK with the fluffy dry snow, but the wet wintry mix was simply unacceptable—especially, if she was going to focus on her career. Her job had thankfully evolved from displacing all our shoes, scarves, and mittens into the yard every morning to guarding the premises against deliveries and other scurrilous interlopers lurching out of suspicious dark vehicles. After negotiation, we agreed that her working hours were 8am - 6pm, with the possiblity of overtime shifts on weekdays (paid under the table with skirt steak). We also agreed that she urgently needed a sturdy handsome Dog Haus commensurate with her commitment to our health and safety.

I threw together a makeshift shelter and hit the drawing board to design the real thing.

In my initial research, I was appalled at the abundance of dog houses designed as shrunken human homes with ill-conceived blind spots and misplaced suburban ornamentation. The dominant style did not adhere to the fundamentals of modernist canine architecture, ie. "form follows function". The physical and emotional necessities of working dogs, such as Babka, was being stifled by baroque pre-fabs. Now this was a housing crisis!

In desperation, I turned to my bookshelves, and revisited a standby—*Soviet Bus Stops* by Christopher Herwig. As a young graduate student in the early 2000s, Herwig trekked the former Soviet Union documenting the remnants of a mostly defunct continental bus network. His research goes further than the brutalist Communist concrete structures we would expect and brings to light some incredibly unique designs from obscure rural areas in the Soviet satellite states. There was an unusual lack of bureaucratic supervision given to the craftsmen and architects involved in this bus stop project in the later era of Brezhnev. What results is a diverse array of buildings that mirror the cultural and geographic diversity that Russia had struggled to mask for decades.

With some of these cool forms mulling around in the back of my mind, I started

The ribs were cut from marine fir plywood, and the cladding was salvaged redwood planks.

This custom design was inspired by referencing Soviet bus stops.

105/207 was used to clear coat the structure, and was topped with several coats of spar varnish for UV protection.

Babka on duty in her new office.

laying something out in a CAD program. Returning to observe the makeshift shelter through the course of a couple snowstorms, it was apparent that a considerable overhang was needed to give adequate protection from the gusts of rain and wind. There also had to be a really wide field of view so Babka could keep tabs on the neighborhood at a glance. While it might appear she was snoozing she absolutely wasn't…

I used my CNC to cut the ribs out of marine fir. Alexander Bender from Tri-Lox, a millworks and wood salvage company, had gifted us a pile of redwood scraps from a New York City water tower. This became the cladding. I basically strip-planked the redwood—running a bevel on the strips for the curves.

When the first warm spring weather arrived, I flow coated the entire structure with several coats of WEST SYSTEM® using the 207 Special Clear Hardener®.

The redwood was quite old, delicate and porous in places, but the WEST SYSTEM Epoxy did a fantastic job of soaking in and adding structure without drawing attention to itself. I was worried that if I used too much, the surface would start to look like a bar countertop. That wasn't an issue. The hue of the redwood was foregrounded.

I finished off with another several coats of spar varnish for UV protection. (After two years, and comparing photos, I haven't noticed any distinct yellowing. I will reapply a few coats of Epifanes® this summer to stay ahead of that.)

No sooner had I put a blanket down, and Babka was inside. She's there snoozing (working) from dawn to dusk, all year round. At the height of the summer she may retreat into her kiddie pool, but if it threatens to rain, we know where to find her.

Just Being Bored

Crafting a decorative board

By Don Gutzmer – GBI Technical Advisor

What do you do with 154 sample size specimens of wood? I decided to craft a decorative charcuterie board for my kitchen. While doing a large shop cleanup here at GBI, we rediscovered a set of 154 samples of wood species from all around the globe. They had previously been used for an *Epoxyworks* article on adhesion testing. Having served their purpose, they were now sitting around the shop collecting dust. Since the samples were still in good shape, I wanted to turn them into some sort of decorative project. A light bulb went off in my head. I should make a decorative piece for my kitchen inspired by a charcuterie board. (***Note:*** *WEST SYSTEM® Epoxies are not certified as food safe.*)

Selecting my Woods

The first thing that I did was select 20 wood pieces that caught my eye with their color variations. When the samples were tested for tensile adhesion, a portion of wood was removed with it, leaving a small divot. I sanded each of the wood samples until the divot was gone.

Next, it was time to determine the pattern. I knew I wanted my pattern to stand out, so I decided to alternate lighter and darker colors for higher contrast. Once I was happy with the order of my pieces, it was time to bond them together.

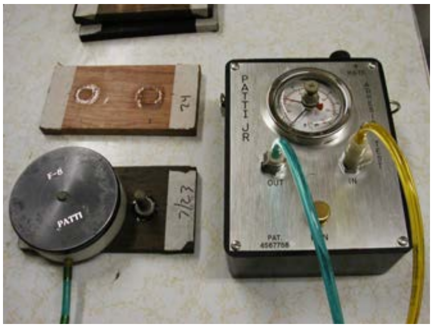
Breaking out the Epoxy

I chose to use 105 Epoxy Resin® with 207 Special Clear Hardener® to bond the wood samples together. This would give me ample time to assemble all my pieces at once. Fortunately, 105/207 is exactly the epoxy that was in the shop's 306-Metering Pump. I love the convenience of being able to dispense the proper ratio of both the resin and hardener in a single pump stroke.

I laid the first wood sample flat on the workbench and coated the top of it with a layer of mixed epoxy. Then I set my next piece in the wet epoxy and applied a layer of epoxy to the top of that piece as well. I worked my way through the pile of samples, stacking one on top of the next like making a sandwich. Once I had two stacks of ten samples each, I lightly clamped the wood pieces to the workbench and allowed them to cure.

Creating the Patterns

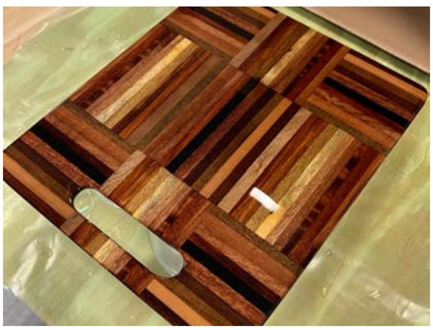
Now that I had my solid wood blocks, it was time to resaw them down into smaller slices. I cut the blocks into ¼" thick strips on the band saw, perpendicular to the



Pneumatic Adhesion Tensile Testing Instrument used to test the adhesion to wood samples.


The wood samples are cut and dry fit to create a unique pattern.


Small gaps between the wood samples filled with clear epoxy.


A flood coat of 105/207 was poured over the board for a high gloss finish.


Finished board on the window sill.

epoxy line. I took these banded strips back to the sander to smooth each side.

Here's where I could really begin to see the final pattern for the board. I played around with the banded strips until I discovered a pattern that I found appealing (and one that hopefully my wife would like too!) I did a little additional sanding so the pieces fit together neatly, then edge bonded them with G/5® Five-Minute Adhesive. My approach was to epoxy each row of three pieces together first, so I only had two glue joints to worry about at one time. Then I bonded each of these rows together to make the finished size of the board. Once the epoxy had cured, I rounded the corners and cut out a handle with a sabre saw.

Sealing with Epoxy

I wanted the finish to be high-gloss, similar to a bar top, so I flood coated the board with epoxy. Drips are inevitable in this process, and make sanding more difficult, so I took the preventative approach. I taped the edges to prevent any drips of epoxy from getting on the backside.

Using the 306 pump, I dispensed, then mixed a batch of 105/207. I used a squeegee to spread a thin seal coat of epoxy on the wood before the flood coat. The seal coat was to prevent air bubbles outgassing from the wood into the flood coat. As the epoxy exotherms, or as ambient conditions warm up the wood, air bubbles can be released from the wood into the thick epoxy coat.

I waited about four hours before I poured the next batch of epoxy in a flood coat. I poured the epoxy in the middle of the board and gently spread it out to the edges with a bristle brush until it was running off all sides. Since the epoxy was about ⅛" thick, I waved a propane torch over the surface to break the surface tension and release any air bubbles. I removed the drip tape along the edge once the epoxy had stopped dripping. Both sides of the board were done the same way so it had the same finish on both sides.

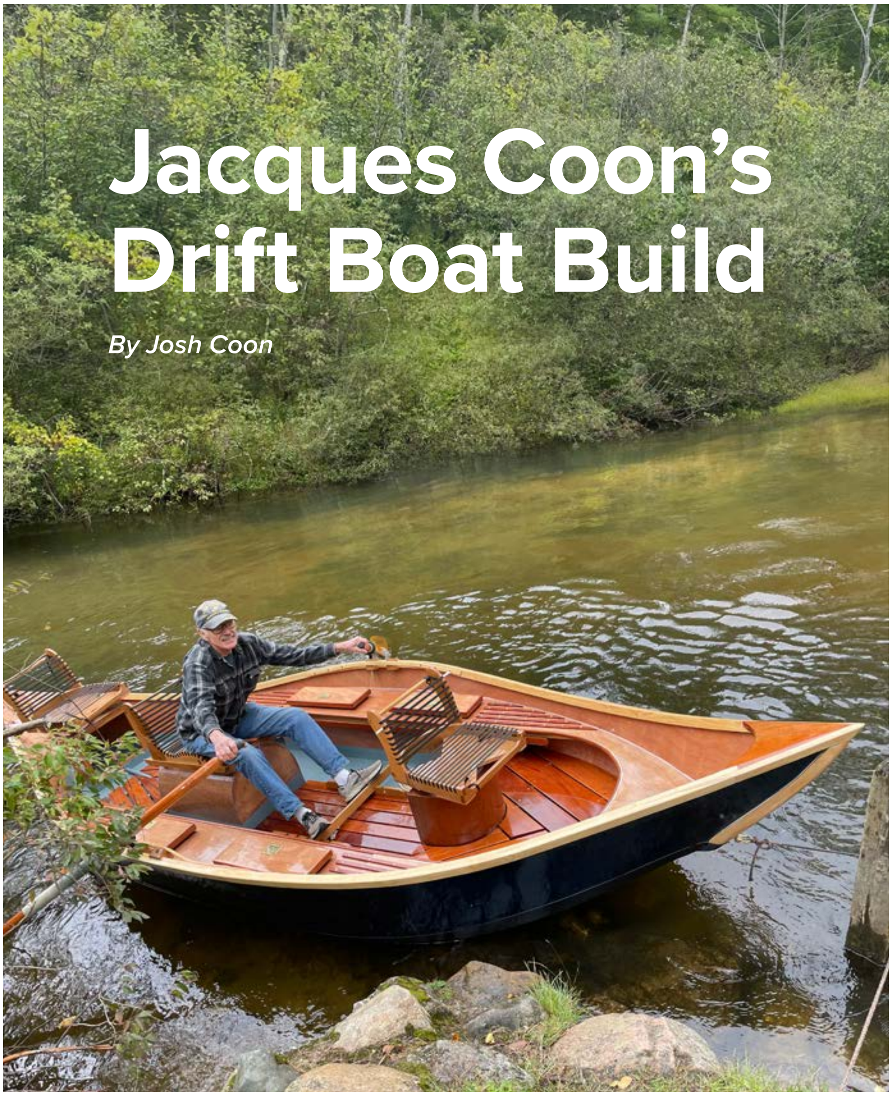
I'm delighted with my decorative board. If you look closely between some of the wood strips, you can see completely through the board. Some may not like that, but I think it gives the board unique character (and it's a good reminder to have a bit more clamping pressure next time). I love that I was able to find a way to give these discarded blocks a new, artful purpose.

Want To Learn About Epoxy Adhesion?

Take a look at our **Adhesion to Wood article**.

Jacques Coon's Drift Boat Build

By Josh Coon



The finished drift boat on water.

In the summer of 2018, I saw a Jason Cajune drift boat in the lobby of the Sage Lodge located near the Yellowstone River, in Montana's famed Paradise Valley. The boat was a modern take on the traditional Western river fishing dories that infused the clean lines and flowing curves of low-sided Montana skiffs—typically made of fiberglass at production scale. The boat would be equally at home on the water or in the showroom of a high-end furniture gallery. Two years later, while fishing on the Pere Marquette river (Michigan) with my dad, Jacques, and son Evan, I described the Cajune boat. Six months into the pandemic lockdown, Jacques was looking for a project and excitedly agreed to lead a build.

While Cajune does sell plans, I decided to design the boat, taking heavy inspiration from Cajune, but still allowing me the opportunity to customize the build. Using the computer-aided drafting software Solidworks®, I began to shape the hull – tinkering with form, overall width, and length. River drift boats are flat bottomed with rocker on either end. The flat bottom allows the boat to float in very shallow sections of river while the rocker enables quick pivoting and positioning capability. After running water draft calculations, I settled on a 17' 4" long hull, which should only draw about four inches of water with a 1,200 pound load.

With these plans complete Jacques began to source the materials with help from Gougeon Brothers technical support. The bottom was made of a continuous sheet of honeycomb polypropylene plastic (Plascore®), which offers an extremely high strength-to-weight ratio. The first step was to cut the bottom to shape and apply a Kevlar® fabric using WEST SYSTEM® Epoxy (105 Epoxy Resin® with 207 Special Clear Hardener™ and 206 Colloidal Silica). The Kevlar was then covered by a fiberglass fabric for a sandable surface. The sides of the boat were made from two sheets of ⅜" okoume marine plywood. The sheets were first scarfed together, then cut to overall shape, and finally coated with fiberglass cloth and epoxy. With the sides and bottom shaped, Jacques called on all his friends to assist with the stitch and glue assembly of the hull.

A unique characteristic of the Cajune style is the rounded transom—a key feature we sought to incorporate in our build as well. Having never done a rounded transom, this feature presented challenges. Jacques ultimately used ⅛" okoume plywood by laminating three sheets consecutively to form the desired shape. With the transom installed, the rough hull was complete and Jacques began work on the gunnels. The recurve style sides mandated that the ash gunnels be steamed for up to two hours followed by immediate clamping to the sides. An inner and outer ash gunnel were laminated in place on the sides to form the finished gunnel which measures approximately 1 ½" wide. The gunnels added considerable strength to the hull, which was now taking form. The stem, also made of ash, was next fabricated by hand to fit. The remaining trim pieces were of mahogany and comprised a transom plate, transom brace, and a small bow deck.

Having completed the hull, Jacques next shifted his focus to building the seats and seat pedestals. The three pedestals are made of ⅛" laminated okoume plywood. The oarsman seat was made to accommodate a portable barbecue grill and the others left open to serve as storage. The seats were made of white oak. Next, the interior deck and dry storage compartments were completed

CAD rendering of the drift boat design prior to start of build.

The boat after primary hull construction. Note the rounded transom on the right, recurve sides, and Kevlar fabric on the bottom and chines.

The boat after all major components had been completed. It's ready for the application of finishes.

The rounded transom, mahogany transom brace, and custom designed aluminum block.

The Oarsman pedestal, mahogany deck, and Tuff Coat floor finish.

Front seat and pedestal, herringbone mahogany sole, and interior okoume deck with mahogany decorative trim.

using ¼"okoume plywood that was strengthened with fiberglass cloth and epoxy. Strips of mahogany were then applied to fore and aft regions of the deck—both for strength and beauty. Finally, the cockpit sole was fabricated from ⅜" thick mahogany and installed in a herringbone pattern.

With approximately 20 months elapsed since the conception of the build, Jacques had completed the overall project and the only remaining steps were finishing. He started by coating all wooden surfaces with epoxy and extensively sanded every surface of the boat, inside and out. In August of 2022, he sprayed the exterior of the boat with automotive finish (Nightmist Blue) and covered it with Dupont™ Marine Imron® clear. Interior surfaces were also sprayed with the Marine Imron clearcoat. The interior cockpit sole was covered with Pettit® Tuff Coat™ in Steel Gray. This finish provides a durable, soft, and non-skid surface. To protect the bottom of the hull from rocks and scrapes that will inevitably occur when drifting down a river, a polymeric truck bed liner finish was applied to the entire bottom and chines.

The finished boat was trimmed primarily with bronze hardware: bow eye, hinges, and latches. The anchor system comprises a rope that is terminated under the oarsman seat and runs along the bottom through tubing and out the transom. The blocks on the transom were forged bronze and purchased from Jason Cajune. The blocks on the interior floor, below the oarsman and at the rounded transom, were designed by me, cut from aluminum, and anodized in a bronze finish.

The build was completed in October of 2022, almost exactly two years from the project conception. Jacques, Evan and I are excited to formally commission the boat in the spring of 2023 with its maiden voyage planned for either the AuSable or Pere Marquette, both famed Michigan trout streams. This boat, however, should be equally at home on famous Western rivers like the Madison, Yellowstone, and Henry's Fork.

How Much Epoxy Will It Take?

By Terry Monville – GBI Technical Advisor

Knowing how much epoxy you will need for a project, before you start, will save time, money, and frustration. Luckily, it is fairly simple to get a ballpark idea of how much epoxy your project will require before you start mixing.

Calculating the Amount of Mixed Resin and Hardener

The first thing we need to do is calculate the volume of your project that needs epoxy. The formula to calculate cubic inch is length x width x depth. It's pretty straightforward, but let's use it in an example. Say you want to coat a bar top with a ¼" deep coating of WEST SYSTEM® 105 Epoxy Resin® and 207 Special Clear Hardener™. The bar top is 6' long (72") and 2 ½' wide (30"). To calculate the volume of the coating, we multiply these dimensions together. It's important to be sure your units all match before beginning your calculations. In this case, we're going to stick with inches.

$$72 \text{ in} \times 30 \text{ in} \times 0.25 \text{ in} = 540 \text{ in}^3$$

$$\textbf{Length} \times \textbf{Width} \times \textbf{Depth} = \textbf{Volume}$$

Now that we've calculated the area that needs epoxy, it's time to convert that into a more useable number, ounces. Here's the conversion that will help get us there:

$$1.8 \text{ in}^3 = 1 \text{ fl.oz.}$$

or

$$231 \text{ in}^3 = 1 \text{ gal.}$$

Since we now know our total volume, 540 in^3, we can calculate how much liquid is needed to fill that volume. We simply divide the number of cubic inches for our project by the number of cubic inches in either a fluid ounce or a gallon.

$$540 \text{ in}^3 \times \frac{1 \text{ fl.oz.}}{1.8 \text{ in}^3} = 300 \text{ fl.oz.}$$

or

$$540 \text{ in}^3 \times \frac{1 \text{ gal.}}{231 \text{ in}^3} = 2.34 \text{ gal.}$$

This gives us the total amount of mixed resin and hardener we need to fill the required volumes for our fictional bar top project.

How Much Resin and Hardener Should I Buy?

Now that we know the volume of mixed epoxy required for our project, it is an excellent time to explain the WEST SYSTEM group sizes. The group sizes are based on the size of the 105 Epoxy Resin containers. The corresponding group size hardeners are adjusted according to mix ratio so you use up all the resin and hardener in the containers at the same time.

An A Group of resin has a quart of 105, a B Group has a gallon of 105, and a C Group has 4.3 gallons of 105 Epoxy Resin. Then you buy the 200 series hardener from the same group size. For example, if you want to purchase a 105-B and 207 hardener, you would need to purchase the 207-SB. The last letter in the part number indicates the group size giving you the appropriate amount of hardener for the resin.

205 Fast Hardener® and 206 Slow Hardener® are mixed with the 105 Epoxy Resin at 5 parts resin to 1 part hardener by volume. The 207 Special Clear Hardener

and 209 Extra Slow Hardener® are mixed at 3 parts resin to 1 part hardener by volume. Since the volumetric ratios are different, hardeners of the same group size will have a different amount of total mixed epoxy.

For our bar top, we need 2.34 gallons of mixed 105/207. We usually factor in around an additional 10% for waste, to account for epoxy left in the bottom of cups and soaked up by roller covers. This puts us at around 2.57 gallons of mixed epoxy needed. You can see in the chart that two B Groups of 105/207 would give you 2.6 gallons or 604 in^3 of mixed epoxy.

The coverage information in this chart can also be found on the side of the resin cans.

This makes picking your group size easier when shopping. The coverage is based on one layer of epoxy rolled out using a WEST SYSTEM 800 Roller Cover, applied using the roll and tip method. On a non-porous surface, this will give you a layer about 4 mils thick. Mils is a measurement of film thickness. One mil is equal to 0.001". If you do the math on an A group of 105/206, 121 ft^2, 0.004" deep, it works out to 70 in^3 or 39 fl.oz. of epoxy.

Coverage will vary depending on how hard you press down on the roller, the temperature of the epoxy, and the porosity of the surface. In cooler weather, the epoxy will be thicker and not as easy to roll out to 4 mils. The thicker the coating, the fewer square feet of coverage, and the more likely it will be to run or sag on a vertical surface. The more porous the surface, the thinner the first coat will be.

Package Size/Quantity			**Coating Coverage**	
Resin Quantity	**Hardener Quantity**	**Mixed Quantity**	**Saturation Coat** (porous surfaces)	**Buildup Coat** (non-porous surfaces)
105-A 1 qt (.94 L) 2.40 lb 57.7 in^3	**205-A or 206-A** .43 pt (.20 L) .47 lb 12.4 in^3	1.2 qt (1.15 L) 2.87 lb 70.1 in^3	90-105 ft^2 (8.5-10 m^2)	120-135 ft^2 (11-12.5 m^2)
	207-A or 209-A .66 pt (.31 L) .70 lb 19.0 in^3	1.3 qt (1.26 L) 3.1 lb 76.1 in^3	90-105 ft^2 (9-10 m^2)	120-135 ft^2 (11-13 m^2)
105-B 98 gal (3.74 L) 9.50 lb 226.4 in^3	**205-B or 206-B** .86 qt (.81 L) 1.86 lb 49.7 in^3	1.2 gal (4.55 L) 11.36 lb 302.6 in^3	350-405 ft^2 (32-37 m^2)	462-520 ft^2 (43-48 m^2)
	207-B or 209-B 1.32 qt (1.24 L) 2.75 lb 76.2 in^3	1.3 gal (4.98 L) 12.25 lb 302.6 in^3	370-430 ft^2 (35-40 m^2)	490-550 ft^2 (45-50 m^2)
105-C 4.35 gal (16.46 L) 41.82 lb 1004.9 in^3	**205-C or 206-C** .94 gal (3.58 L) 8.20 lb 217.1 in^3	5.29 gal (20 L) 50.02 lb 1222.0 in^3	1530-1785 ft^2 (142-165 m^2)	2040-2300 ft^2 (190-213 m^2)
	207-C or 209-C 1.45 gal (5.49 L) 12.0 lb 335.0 in^3	5.8 gal (21.9 L) 53.82 lb 1339.9 in^3	1675-1955 ft^2 (155-180 m^2)	2235-2520 ft^2 (207-233 m^2)

How Fillers Affect Coverage

How does adding fillers affect the volume of mixed epoxy? With our 403 Microfibers, 404 High-Density, 405 Filleting Blend, and 406 Colloidal Silica, you will have slight volume increases, but not enough to worry about for estimating. This is because these fillers tend to be wet out by epoxy.

Working with 407 Low-Density Filler and 410 Microlight® is a different story. These fillers are particles that take up space in the mixture and lower the density. Let's say we're working with an A Group of 105/206—70 in^3 of epoxy. If we thicken the entire batch with 407 to a peanut butter thickness, it will give us 2.2 times the volume of the neat epoxy or 154 in^3 of thickened epoxy. This will cover 4.3 ft^2 at a thickness of ¼". This would be handy to know if you were planning on fairing your keel or other repairs.

Using 410 to thicken an A Group of 105/206, you would see the neat epoxy expand 2.5 times, yielding 175 in^3 of thickened epoxy. This would cover 4.8 ft^2 at ¼" thick.

Buying more than needed is not a big issue for epoxy, it keeps, but it might be more money than you wanted to spend. On the other hand, not purchasing enough is always inconvenient and time-consuming. By calculating out how much epoxy you need in advance, you can ensure you hit that happy medium of not running short or breaking the bank.

Want To Learn About WEST SYSTEM Fillers?

Take a look at our **Filler Selection Guide**.

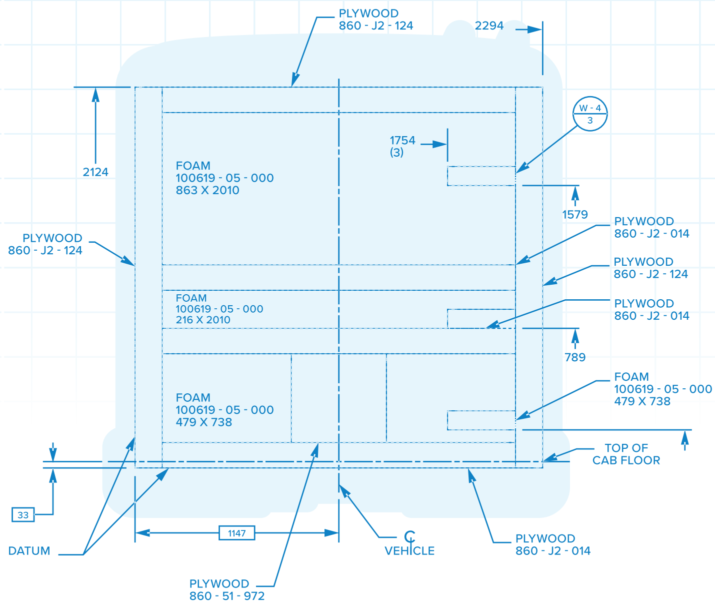
RV Wall Replacement

By Matthew Logering

When we purchased our 2006 Winnebago® RV, we knew we would need to complete some repairs. We never imagined the back wall would need to be removed and rebuilt from the ground up. One of the edges of the back wall was compromised which allowed water to penetrate the wall and eventually saturate a majority of the plywood within. After determining that the damage was too great to spot treat/repair, we began the process of removing the wall.

After studying the engineering diagram from Winnebago, we learned that the wall was a sandwich construction. The wall had a fiberglass exterior, plywood and polystyrene foam core, and a wallpapered lauan plywood on the interior. If we were going to go through the work to rebuild the wall we wanted to insure it was built to last.

This is where the three A's of most projects came into play: Analysis, Acquire, and Action.



Back wall drawing provided by Winnebago.

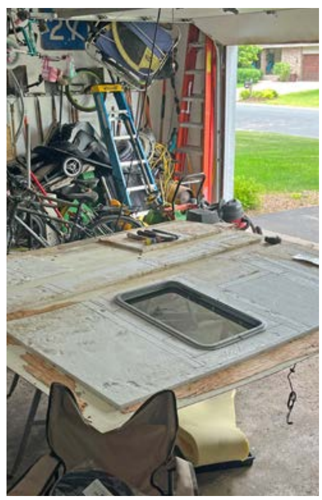
We have come to enjoy the analysis phase the most. For this project it involved researching the construction of the back wall and the extent of the damage. It also involved learning more about the products and techniques available to complete the repair. We have found that a combination of community groups and manufacturers are the best place to seek out the information necessary to do a project well. For this project, we leveraged an RV community on Facebook specific to our model of RV and also WEST SYSTEM® for their technical expertise on how to properly seal and adhere plywood to fiberglass.

With our research complete, it was time to acquire the necessary tools and supplies to complete our project. This is often the least desirable step in the project as it involves a lot of research and time. Despite the work, this is where we realized the value of the analysis step, as we had a good handle on what was needed. For this project, we acquired WEST SYSTEM 105 Epoxy Resin®, 206 Slow Hardener®, 406 Colloidal Silica Filler, ¾" plywood, remnant wallpapered lauan from a local RV repair shop, disposable paint brushes and cups.

The back of the camper with all exterior trim removed.

The rear wall has been removed from the camper.

We sourced a remnant of wallpapered lauan from a local RV repair shop.



The panel has been relocated to the workshop to begin demolition.

With a plan in place, and the equipment and supplies at hand, we put our work into action.

At this stage, we had to remove the back wall from the RV. This required detaching all mechanicals and walls from the inside of the coach as well as all exterior trim pieces. Once the wall was detached, it could be removed from the RV for disassembly. As we removed the interior lauan plywood, the extent of the damage became clear. All the lauan plywood, as well as the plywood framework, had to be removed.

Now we could get working on epoxying the new plywood framework. The technique involved sealing each piece of plywood to ensure, even if they came into contact with water in the future, the moisture could not penetrate into the wood. Using 105 Epoxy Resin and 206 Slow Hardener, we coated each piece of plywood with three coats. Each coat was allowed to dry to a tacky finish, but not any further. Had we allowed the coat to dry further we would have needed to wait until a full cure and then sand to ensure proper adhesion before coating again.

Once the plywood was coated, we could move onto bonding it to the fiberglass exterior panel. We started with applying a coat of 105/206 to wet out the uncoated side of the plywood. We then added 406 Colloidal Silica Filler to get a mayo consistency. This epoxy mix was perfect to strongly bond each plywood board to the fiberglass. We used cement blocks to help compress the laminate, being careful not to apply too much pressure which would cause all the epoxy to squish out.

Once all the internal plywood framework was affixed, we added the final layer of interior wallpapered lauan using a flexible sealant. The finished wall was then attached back to the RV. Any place where we drilled through the plywood during the process of attaching back to the RV, we predrilled the holes, filled with epoxy to seal the wood, and then put our screws in to affix the wall to the RV.

The finished product is sealed and much better than the original. We are thrilled to be back on the road and doing what we love. Sometimes life takes a turn you don't expect, but having a community and partners to help you along the way makes even the worst nightmares a fun learning experience.

Peeling back the lauan panel seeing the true extent of the water damage.

Applying a neat coat of epoxy before bonding the plywood to the fiberglass wall panel.

Cement blocks used compress the boards into the thickened epoxy.

Finished wall from the inside (above) and outside (below).

Preparing to Fair

By Greg Bull – GBI Technical Advisor

Most of the rudder has been shaded with a pencil, so after longboarding, you can see the fairness of the entire surface.

Those new to the process of fairing a boat's hull or deck are quick to mix up a batch of fairing compound, WEST SYSTEM® Epoxy with a low-density filler, and apply it to the surface, so they can start sanding right away. My experience in boat repair and construction has taught me the importance of making a fairing plan and selecting the correct materials before any epoxy is mixed.

Understanding Fair and Smooth

It is important to understand the difference between fair and smooth. Smoothness describes the texture and fairness describes the shape. If you run your hand on the surface, and you feel bumps and hollows (or highs and lows), the surface is not fair. Another way to see a fair surface is by using a wood or plastic batten, which is a thin strip of straight grain wood that is ¾" to 1 ¼" square, it will always bend in a fair curve if only held at the ends. An unfair surface can be smooth to the point of being glossy but not look good to the eye. Simply sanding a surface smooth will not provide the fair yacht-like finish many builders desire. Fairing requires attention to the shape of the entire surface and requires planning where to fill and sand.

Developing a Fairing Plan

Before you apply epoxy, you can save significant time and fairing compound by marking where the fairing compound should be applied. This requires determining the profile of the surface.

Determining the profile, or fairness, of a surface can be accomplished quickly and save a significant amount of fairing compound and sanding. A common method is to take a pencil and scribble over the entire surface. The next step is to sand with a longboard. A longboard is often a custom-made board that sandpaper is bonded to. In the case of the rudder in the pictures, a longboard only needed to be about 12" long. On the hull of a 40' boat, it may be 3' to 6' long and require a couple of people to run. On mega yachts, the boards are often over 10' and require multiple people to move. The reason for the length is to follow the fair curve of the surface, bridging over any hollows and sanding down only the high spots.

If a simple dual-action sander was used instead of a longboard, the surface would become smooth but the small 5" pad would follow the highs and lows of the surface. This would result in a smooth but unfair surface.

An alternative to the pencil method is the chalk stick method. This process utilizes a batten that is coated with carpenter's chalk. By moving this chalk stick back and forth on the surface, the high spots will become visible. This process is described in detail in the *Gougeon Brothers on Boat Construction*, page 245. Again, both of these methods are performed before any fairing compound is applied.

Mixing 407 and 410 Fillers

WEST SYSTEM fairing fillers are added to WEST SYSTEM Epoxy to create a fairing compound. Adding fillers increases the volume of an epoxy batch when blended into the mixed resin and hardener. These fillers are made of microspheres and balloons that are very low-density. This mixture has a lower density than neat epoxy resulting in an easy to sand material.

Generally speaking, when adding 407 Low-Density Fairing Filler to make a thick fairing compound, the volume will be about twice the original volume of

01

When marking the surface, you need to scribble in multiple directions so the low spots are obvious after sanding.

03

Sand pencil marks to reveal high and low areas.

the mixed resin and hardener. With 410 Microlight® Fairing Filler it will be about two and a half times the original volume. This information is very handy so you do not overflow your mixing cup or waste epoxy. To learn more about estimating, see Terry Monvilles' article "*How much Will it Take?*"

***Note:** Just a reminder, surface preparation is required for proper adhesion of the fairing compound. We always recommend sanding the entire surface with 80-grit sandpaper before applying epoxy.*

Dark Colored Topcoats

When fairing an area that will have a dark colored topcoat, you will need to consider what filler to use. WEST SYSTEM provides two options: 407 Low-Density Fairing Filler and 410 Microlight Fairing Filler. 410 is easier to sand and very easy to mix into the epoxy. Because of these traits, This filler is not very resistant to high temperatures. Dark colors can become very warm on sunny days, which can cause the surface to distort slightly. 410 can be used under light colors and below the waterline without concern.

If a dark colored, high-gloss finish is desired, consider using 407. WEST SYSTEM 407 is resistant to higher temperatures. 407 is a stronger fairing compound and therefore is slightly more difficult to sand than 410. This can be beneficial on decks or other areas that can see foot traffic, particularly when someone is not wearing boat shoes.

With all fairing applications, once the sanding is complete, the surface should be coated with neat epoxy. This thin coating of epoxy fills pinholes and provides a uniform surface for your primer.

Fairing Clear Finished Wood Surfaces

On areas that will have a clear finish, using fairing compound is not an option. Adding fillers to the epoxy will obscure the surface and hide the wood grain. When fairing clear surfaces, the chalk stick method described earlier is an excellent process for identifying high spots. The chalk marks will wipe off easier, so that the epoxy does not over coat the chalk marks.

Since the only option to fair the surface is removing high spots, expert boat builders will emphasize the importance of good craftsmanship—having your mold frames in the proper placement, cutting accurately, and fairing from one station to the next. The strip planks and veneers will naturally take a fair shape if the mold is also fair. With stitch and glue construction, care should be taken to have each piece cut accurately, and the edges checked for fairness before assembly. Keep in mind, with plywood construction, only a small amount of wood can be sanded before you may sand through the top veneer. This can result in an undesirable or spotty appearance under a clear finish.

If the boat is completed, and the clear finished area is not fair, it can still be corrected. The process for fairing a clear finished surfaced was explained in a previous EPOXYWORKS article, "*Refinishing a Wood Strip Canoe.*"

Simple steps, like a fairing plan, prior to mixing your fairing compound can save time and materials. Taking the time to identify low and high spots on your surface will make your fairing job much easier. Also taking extra time fairing clear finished wood surfaces early in the construction process pays dividends by the time you get to the epoxy process.

04

The high areas have been sanded down into old fairing compound and fiberglass. The remaining pencil lines indicate the low areas where the new fairing compound needs to be applied.

05

Mark the low areas and then remove the pencil lines with sandpaper, so that the thickened epoxy will bond well to the surface.

Want To Learn About the fairing process?

Watch this video on
fairing from WEST SYSTEM.

Wooden Boat Centre Works Wonders with WEST SYSTEM

By Lorraine Duckworth – ATL Composites

Located on the banks of the picturesque Huon River at Franklin, Tasmania, The Wooden Boat Centre is Australia's only wooden boat building school, creating original masterpieces and restoring heritage vessels while mentoring students from all walks of life.

For the past 30 years, the Wooden Boat Centre has been dedicated to keeping the tradition of hand-made boats alive. Their one year shipwright course, and a variety of shorter courses, give students hands-on experience in both traditional and modern boat building techniques.

Locals and visitors are always welcome to visit for a guided tour to explore the age-old craft of wooden boat building.

"The appeal of the wooden boat is universal," explains Cody Horgan, head shipwright and manager of the Wooden Boat Centre. "They are functional, beautiful and represent the pinnacle of artistic expression in wood. It's an enduring art form. To build a timber boat is an amazing experience and keeping these skills alive is very satisfying."

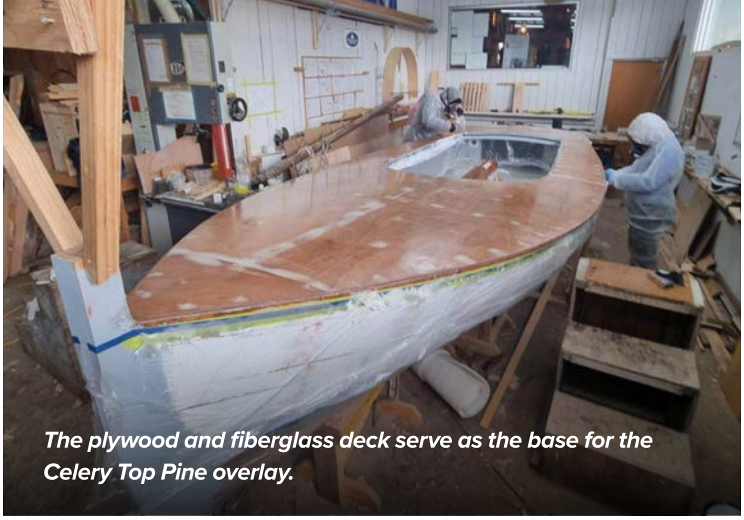
Cody was a student in 1999/2000 and gained a Diploma in Wooden Boatbuilding. He has since worked in various boat yards around Sydney and Bobbin Head on many various projects. For the past eight years, prior to joining the boat school, Cody worked at the Australian National Maritime Museum in Sydney. There he carried out maintenance of the tall ship *Endeavour* (replica), as well as maintained the fleet of small vessels that span Australia's nautical heritage.

In the lead up to the 2023 Australian Wooden Boat Festival, students at The Wooden Boat Centre were working on several unique projects, including the restoration of a historic Tamar Cod Boat from Launceston, with the aim of modernizing and refreshing her for her next incarnation as a family day boat.

As Cody explains, "It's a fishing boat conversion to a Couta-style day boat for her owners to enjoy for day trips.

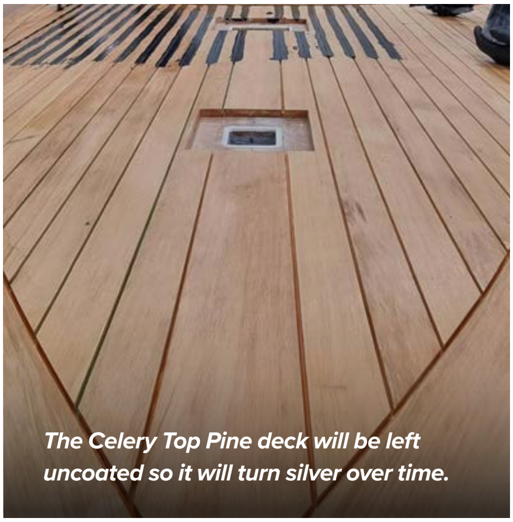
"It's made of Huon Pine with a plywood deck with fibreglass on top. The next step is a false-laid deck of Celery Top Pine that looks like a real deck, held down by modern composites."

The Wooden Boat Centre has relied on WEST SYSTEM® for many years.



The plywood and fiberglass deck serve as the base for the Celery Top Pine overlay.

This 1940's Tamar Cod Boat, Iola, was restored by students and volunteers over the course of 2 years.



The Celery Top Pine deck will be left uncoated so it will turn silver over time.

Cody Horgan, head shipwright and manager.

The Wooden Boat Centre has relied on WEST SYSTEM for many years.

"On this particular project we used WEST SYSTEM 105 Epoxy Resin® and 206 Slow Hardener®, plus 403 Microfiber Filler," says Cody. "The deck will be left uncoated so it will turn silver over time."

"We use WEST SYSTEM for its consistent quality," he continues. "It delivers the same results every time, which is important, particularly when you're instructing students. I'm a stickler for quality and I want products that perform in different conditions and temperatures. ATL Composites also offers technical support and advice which we have found vital."

The Cod to Couta Boat, called *Iola* is on track to be finished by the end of 2022, Cody reports. She will head to her owners on the South Coast of NSW.

The team at The Wooden Boat Centre is aiming to display a Derwent Class racing boat, a Haven 12 ½ sailing boat and skin-on-frame ultra-light kayaks made at the Centre at the 2023 Australian Wooden Boat Festival, February 10th-13th in Hobart.

For More Information

To learn more about the **Wooden Boat Centre** visit, woodenboatcentre.com

To learn more about the **AU Wooden Boat Festival** visit, australianwoodenboatfestival.com.au

Basic Epoxy Safety Practices for DIY Boat Repairs

By Grace Ombry – GBI Retiree

Epoxy safety begins with working cleanly. When handling WEST SYSTEM® Epoxy resin and hardener, take steps to keep epoxy out of your eyes and off your skin and clothing. Ventilate your workspace to protect your respiratory system. Minimize the amount of epoxy that gets on your work surface and tools. Regardless of the type of boat repair you have planned, follow these safety practices:

Protect Your Eyes and Skin

Whenever working with epoxy, wear safety glasses or goggles to prevent epoxy from splashing into your eyes.

Neoprene gloves are a great choice for keeping epoxy off your hands. These gloves offer chemical and puncture resistance, good finger sensitivity, and flexibility for manual dexterity.

While it might seem like you're getting away with not wearing gloves if you haven't developed a rash, skipping gloves may eventually result in a histamine reaction. Repeated exposure to epoxy resin, hardener and uncured mixed epoxy can sensitize your skin over time, resulting in a rash similar to poison ivy. Once this happens, the rash can return after each fresh epoxy exposure.

Protecting your clothes will prevent uncured epoxy from soaking through them and reaching your skin. For especially messy jobs, consider using a lightweight coverall made from a chemical-resistant fabric like Tyvek®. There are other options too, from disposable aprons to single-use sleeves. Choose the best combination for your working style and the task at hand.

It's also a good idea to keep epoxy off your tools and work surfaces. Heavy (4 to 6 mil) plastic sheeting is great for protecting your work area from epoxy drips and spills. Mask your tools with cellophane packing tape; epoxy won't stick to the tape, making cleanup a snap.

Respiratory Safety

WEST SYSTEM Epoxies have very low volatile organic compounds (VOCs). However, when epoxy is heated or used in a poorly ventilated workspace, the chance of overexposure to vapors increases. Even with low VOCs, it's possible for epoxy vapors to build up in confined spaces.

This is why you should provide ample ventilation when working with epoxy in small or tight spaces such as inside a boat hull. Ventilating can be as simple as adding a box fan or as complex as installing a high-tech air-filtration and exhaust system. If you can't adequately ventilate your workspace, wear an air-purifying respirator with an organic vapor or multi-contaminate cartridge.

Pots of curing epoxy can grow hot enough to ignite surrounding combustible materials and give off hazardous fumes. When you notice overheating epoxy, move the pot to a ventilated area far away from people and combustible materials. Dispose of the solid epoxy mass only after it has completely cured and cooled.

Partially cured WEST SYSTEM Epoxy may be firm enough to withstand sanding but you should put it off until the epoxy has cured overnight and longer if curing in a cooler environment. The dust of partially cured epoxy contains unreacted hazardous components. If you breathe sanding dust from partially cured epoxy, the remaining reactive chemicals can become trapped in the mucous lining of your respiratory system. Once there, they can cause severe respiratory irritation and/or respiratory allergies. When sanding epoxy, always provide good ventilation and wear a dust/mist mask or respirator with an N95 rating or better.

For product-specific health and safety information on WEST SYSTEM Epoxy, visit westsystem.com.

For information about WEST SYSTEM® products or technical information for a building or repair project, Gougeon Brothers offers a range of detailed publications that can help you get started. These publications are available at your local WEST SYSTEM dealer or by contacting Gougeon Brothers. They are also available as **free downloadable PDFs at westsystem.com.**

How-to Publications

002 **The Gougeon Brothers on Boat Construction**
A must for anyone building a wooden boat or working with wood and WEST SYSTEM Epoxy. Fully illustrated composite construction techniques, materials, lofting, safety, and tools. 5th Edition, revised in 2005.

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.

002-550 **Fiberglass Boat Repair & Maintenance**
Illustrated guide to repair fiberglass boats with WEST SYSTEM Epoxy. Procedures for structural reinforcement, deck and hull repair, hardware installation, keel repair, and teak deck installation. Also, procedures for gelcoat blister diagnosis, prevention and repair, and final fairing and finishing.

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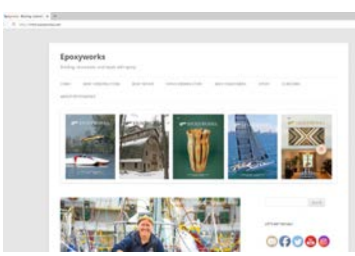

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Maurice Godin built this standup paddleboard and paddle a few years ago. The paddle and the exterior of the board are made of local eastern white cedar. The interior frame is marine plywood. The finish is fiberglass and WEST SYSTEM® Epoxy.

"Thanks to the pre-cut interior frame, and excellent tutorials at WEST SYSTEM and Sliver Paddle Boards, it turned out great. This was my first time working with fiberglass and epoxy. I was pleased with how easy it was to work with and the excellent results obtained."

Micheal Stendzis built this Camilla C, a 14' Seneca Pacific Power Dory from plans. The boat is a plywood on frame design, wrapped in fiberglass/epoxy and paint. Michael Stendzis confessed to using "copious amounts of WEST SYSTEM® Epoxy." As his largest woodworking project to date, he said "the process was incredibly fun, with lots of challenges to figure out as I went". The boat was named Camilla C as a tribute to his beloved grandmother.

Craig Bjarnason built an 8' dinghy. It is a cold molded, cedar hull with mahogany keelson seats and transom. All the laminating was done with thickened WEST SYSTEM® Epoxy. The hull was sheathed with 6 oz. fiberglass/epoxy on the outside and was epoxy coated on the inside. This boat is used as a tender for our 34' cold molded cutter on Lake of the Woods (Kenora, Ontario). It was also built using WEST SYSTEM Epoxy.

James Island is primarily known as a luthier (musical instrument maker). He uses WEST SYSTEM® Epoxy on every instrument, in one way or another - sometimes G-Flex, but mostly 105/207. His comments about the epoxy were "I can't say enough about it. My favorite glue ever!"

This mandolin was carved by CNC for the end-grain checkerboard back. He used 105 Epoxy Resin® and 207 Special Clear Hardener® on it to epoxy it together and fill all the gaps.

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Share your work and fuel your creativity

Submit your projects to info@epoxyworks.com