FREE

GOUGEON

EPOXYWORKS®

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In This Issue

EPOXYWORKS®

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THE ANIMAL has exceeded 100 mph in test runs.

Jon Staudacher's Approach to Projects

By Don Gutzmer - GBI Technical Advisor

My good friend and previous employer, Jon Staudacher, always surprises me with how he designs and builds his projects. Jon creates everything from hydroplanes to airplanes using materials and methods that are logical and practical. He would say he treats most of the things he builds like a science project, experimenting with new concepts in design and materials, and continually learning new things. I will explain some of Jon's unique approaches to a few of his recent projects.

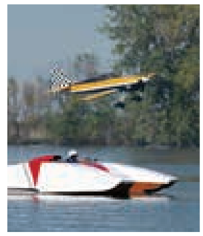
The Animal - Wooden Hydroplane

The first project is a wooden hydroplane boat that is powered with a Big Block Chevy 480 cubic inch motor. The boat was built using Hydrotek® marine plywood and clear spruce bonded with WEST SYSTEM® Epoxy. It's a two-seat hydroplane so that non-racers can experience what it's like to travel 100+ mph on the water. What's unique about this design is the hull, which he built like an aircraft wing. The height of the hull side is around 34", ensuring the boat will float with substantial freeboard while increasing reserve buoyancy.

The boat's longitudinal hull stringers are similar to the ribs of an airplane wing. To minimize the overall hull weight, he designed the hull with wooden trusses instead of solid bulkheads down the center of the sponsons and the areas aft of the engine compartment. The boat weighs only 960 lbs. without the motor.

He used scrap wood for the trusses. Jon always minimizes waste and often finds ways to incorporate it into the build.

To help increase the turning fin attachment's holding power, he cut a wooden block to create a channel for an aluminum rod that has machine threads in the end for a bolt. Jon used his lathe to machine the outside of the rod so notches ran down the length of it. This helps increase the mechanical holding power. He used WEST SYSTEM Epoxy thickened with 404 High-Density filler to attach the aluminum rod, then covered it with a wooden cap. This method ensures the outside of the bar is encapsulated in epoxy and there are no



Cover Photo: THE ANIMAL along side one of John's other projects, an acrobatic airplane.

Photo by Avram Golden

The notched aluminum rod being bedded in its wood housing.

Profile view of THE ANIMAL.

Don and Jon watching THE ANIMAL on the Saginaw River.

air voids. The entire assembly can be epoxied in the hull at the desired location.

This is a major improvement over the usual method of drilling a hole into a wooden block after it is installed. That approach makes it difficult to coat the outside of the hardware with epoxy and can also leave air voids when the hardware is inserted.

The aluminum/wood assembly epoxied into the desired location in the hull.

The design for the propeller strut and shaft on the hull is also unique. The strut consists of a hollow aluminum tube that is bonded on with thickened WEST SYSTEM Epoxy. He applied carbon fiber fabric and epoxy over the tube to tab it onto the hull.

Jon's design incorporated a steel propeller shaft made from 4130 Chromoly steel tube. The aluminum strut is oil-filled with bronze bushings on the ends. In order to use a Mercury propeller, he welded a splined Mercury driveshaft to the 4130 tubing at its largest diameter. On the other end of the steel shaft he welded a driveshaft coupler. The prop shaft tube eliminates the need for an expensive stainless steel prop shaft and reduces weight.

A view of the hull interior as it's being flipped over.

Strange Magic **-** Trimaran

Jon has been intrigued by sailing for many years and enjoys his Hobie Cat. He decided it would be fun to design and build a lightweight, competitive trimaran—using WEST SYSTEM Epoxy—to race with the local sailing association.

STRANGE MAGIC headed out to race on the Saginaw Bay.

The first step was building fiberglass ama hulls from a male plug. The ama bottoms are semicircular (170 degrees) and maintain a semi-circular cross-section from bow to stern. The plywood sides have a shallow bevel where the fiberglass ama attaches to the bottom with G/flex® 655 Thickened Epoxy Adhesive. The semicircular hull bottom gains rigidity because of its geometry. The frames inside of the amas are wooden trusses

The hull bottom and the trussing for the ama ready to be assembled. Shown above is the semicircular, fiberglass hull bottom which will be flipped over and epoxied to the plywood trussing section of the ama.

The final painted trimaran.

made from scrap wood, with gussets. These minimize weight, uses up the scrap wood, and provides access to see or reach down into the amas when assembling.

The same wooden male plug was widened 7" at the stern to build the center section of the trimaran hull. Reusing the mold plug saved time during the building process. The trimaran uses a Hobie Cat 18 mast section that was reinforced as required and lengthened. Likewise, the beams came from a sailboat mast section. The overall hull weight with motor and rigging is around 1,100 lbs. The trimaran has reached speeds of over 20 knots.

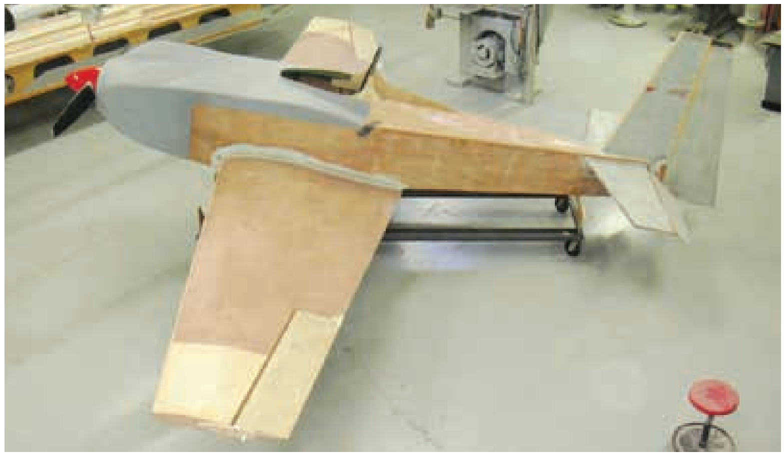
Staudacher-designed Airplane

Jon has designed and built more than 30 airplanes in his career. His most recent plane is unique because it will be powered with a Kawasaki ZX 1400 motorcycle engine. The airplane fits his "science project" approach by pushing design and construction to the limit while learning from the process.

The wing was built with fiberglass/aluminum honeycomb ribs bonded onto a plywood skin.

He designed the plane with a Chromoly tube truss fuselage, TIG welded to help carry the loads between the engine, wing, landing gear, and tail. The tube fuselage structure also provides safety for the pilot, helps transfer loads effectively, and is a great option for attachment points. The tail surfaces are integral with the fuselage/tail cone which eliminates the need for hardware and fairings.

Jon built the wing with fiberglass/aluminum honeycomb ribs bonded onto its plywood skin. He has found that WEST SYSTEM Epoxy bonds the open cells of the honeycomb to the plywood very well. On his previous aerobatic wing designs he has used pultruded carbon bars bonded to the wood spar cap. The mismatch of strain at failure of the wood/carbon-fiber spar made Jon rethink his design



The plane was faired with 410 and 407 in preparation for the primer.

for the spar on this plane. He decided to use hard maple and transition to Douglas fir towards the outer edges of the wing spar. The idea was to keep the strain at failure for the spar similar throughout its cross section.

Because the wood wing is highly loaded and weight matters, the materials were carefully selected. The wing has integral leading-edge fuel tanks sealed with WEST SYSTEM Epoxy. These will hold aviation fuel, which does not contain ethanol, so the epoxy will not degrade or soften over time. Once the wing was bolted to the tube fuselage, the wing fairing was made with a couple of layers of 17 oz. 727 Biaxial Tape and faired with 410 Microlight® Filler. He built the fiberglass cowling for the plane from a wooden male plug and then finished with 407 Low-Density Filler before applying the primer.

Whether it improves performance or simplifies production, John has a talent for coming up with unique solutions to improve every project he works on. It is always fun to stop by Jon's shop to see his new designs and how he uses WEST SYSTEM Epoxy on his projects.

Quality Control: It's what we do

By Pat Dammer - GBI Lab Technician

At Gougeon Brothers Inc., customer service and support are paramount. Throughout the decades (five strong and counting), we've built our West System® product line on a model which places customer satisfaction at the forefront. Many West System users know first-hand that we strive for customer success no matter the project. Our customers' projects range across an extremely wide spectrum. What many users may not know is the extent of product support that grinds away behind the scenes before a batch of our epoxy even hits the retail shelves. I'll provide a look at just one of our churning gears that isn't so obvious at first glance—quality control (QC).

When our Operations team makes a batch of a West System product, they drop off a sample at our laboratory in the Technical Department for evaluation. Operations labels each batch with a unique, identifying lot number designating the product, date of manufacture, and which batch it was, as they make multiple batches within a day. For example, if the lot number retain sample is **1059213B**, this means the product is **105** (105 Resin), the last digit of the year of manufacture is **9** (2019), the Julian day of manufacture is **213** (August 1), and the batch of 105 produced on that specific day is **B** (second batch of the day).

1 0 5	9	2 1 3	B
Product Number	Year	Day	Batch

The Technical Department begins by performing a number of tests tailored to ensure each product will perform exactly as expected out in the field. The first order of business, no matter what the product might be, is temperature conditioning. Many products are heated throughout the manufacturing process, so we must be sure the temperature at the time of testing is always consistent. We place each sample, or QC retain as we call it, into a temperature-controlled bath. These baths operate at a constant temperature of 72.0°F (22.2°C) and are precise to within one-tenth of a degree. We periodically check the samples with a calibrated thermometer until they have reached the desired test temperature of 72°F.

The peak exothermic temperature is measured using 100 cc of epoxy in a standardized 120 cc beaker. A thermocouple connected to a computer analyzes the results.

The reactivity, or cure profile, is a very important facet of our products. It is absolutely necessary that each product cures exactly as designed. This is not only important regarding the expected cure time, but also to the end product's performance and physical properties. There are two tests that ensure our products meet the cure profile characteristics: Peak Exothermic Temperature and Differential Scanning Calorimeter (DSC). Viscosity testing is used to evaluate the physical handling characteristics. I'll shed some light on these analytical tests without going into the dizzying details.

Peak Exotherm

Peak Exotherm testing is pretty simple; the title says it all. We cure a 100-gram mass of mixed resin/hardener in a standardized 120cc beaker. We place a thermocouple into the mixture and a program written specifically for this analysis monitors the heat generated vs. time. Once the mixture's temperature hits its peak, the test is complete. Now we can view how long it took the combination to reach peak temperature during its exothermic reaction. Both the peak temperature and the time it takes to reach it must fall within a set of limits we determined through rigorous testing during product development. When the product meets the acceptable criteria, we're confident it is curing properly and will achieve the desired properties.

Differential Scanning Calorimeter

The other reactivity test is the DSC. Think of it as a tiny oven that has extremely precise temperature control and sensors to monitor the slightest change in the temperature of whatever we place in it. In addition, this oven/calorimeter can be programmed to control its temperature in any fashion ranging from -40°F to 750°F (-40°C to 400°C) via its complex software app. And to a precision that might make your head spin. As the droplet sized sample of mixed resin and hardener is put through a temperature ramp, the sensor monitors every minute change in heat flow within the sample. This data is plotted in real-time for monitoring and automatically saved once the test is complete. After interpretation, which may look like voodoo to some, we obtain specific values which directly correspond to the cure profile and thermal properties of that specific system.

The DSC is typically used to test slower curing systems where finer accuracy and a more controlled environment is needed instead of our standard Peak Exotherm test. With the slower systems, external factors such as air flow can have a greater impact skewing the test results. Again, it is through exhaustive testing that we determine the precise acceptable ranges for each resin or hardener.

Viscosity

Lastly, and maybe the simplest of the tests, is measuring the material's viscosity, or thickness. Think of the difference between water, catsup, molasses, etc. Viscosity is a property crucial to the success of each of our epoxy products.

Each product combination is designed for certain applications. Viscosity is one of the first characteristics we consider during development. In the lab, we use four viscometers to analyze the thickness and consistency of the product. In a very fancy and complex way, these instruments stir the individual resins and hardeners while monitoring their resistance to flow. The data generated provides specific values inherent to that product which must also fall within a very tight tolerance.

The viscometer has a paddle which measures a sample's resistance to flow (viscosity). Each sample is tested for three minutes to ensure an accurate reading.

The DSC is a very controlled environment for testing the exotherm of samples with intense sensitivity.

Other Tests

Quality testing does not always stop at the three tests described. We have many products designed for many applications, and use other tests to ensure our specialty products perform as expected before shipment. These include color analysis, resistance to slump or sag on vertical surfaces, and even the use of lasers and mirrors… literally. However, *Epoxyworks* magazine does not have enough pages to attempt to explain that one.

In addition to QC testing, we measure the hardness, compression yield, tensile strength and modulus, and flexural strength and modulus of our products. We provide these cured properties to our customers on our Technical Data Sheets so they can make informed decisions about which product is best for their projects.

Final Steps

Once a product has passed with flying colors, we automatically notify our Operations Department through a company-wide quality monitoring system. Monitors/screens are located at each production station where our operators can view the progress of QC testing for each individual batch of epoxy made. This way they know as soon as each sample has passed, so they can package and ship the product.

In the lab, when the "Testing Complete" box is checked, we shelve a 16 oz. QC retain of that product batch—labeled with the unique lot number identification I explained earlier—and keep it on hand for three years. This is our record of every batch produced within that time frame, which allows for future observation and testing if needed. Every time you buy one of our WEST SYSTEM Epoxy resins or hardeners there is a sample from the same batch on standby in our lab.

We take all of these steps, every time, before allowing a batch of epoxy to go out the door, through the marketplace and into the hands of our customers.

Improving Impact and Abrasion Resistance

By Rachael Geerts - Composites Materials Engineer

What is the difference between abrasion and impact? What materials hold up best against each of them? These questions often come up when talking about skid plates. Skid plates are a protective layer, typically on canoes and kayaks, that reinforces the areas of the hull most likely to suffer damage from abrasion and impact.

Abrasion is when friction wears, grinds, or rubs away a material. Impact is when a material is forcefully struck. Both of these destructive forces act on the material's surface. The simplest way to differentiate the two is to say impact is a sudden striking force while abrasion is a rubbing force that removes material, typically over time.

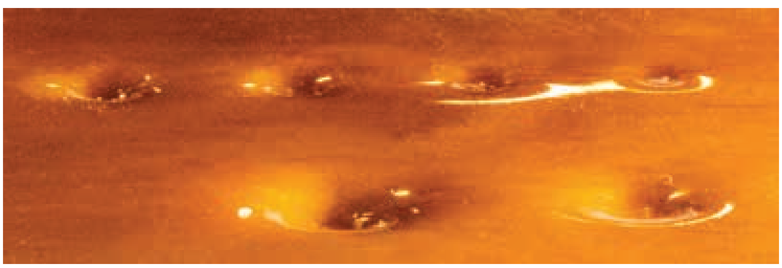
It is common for boats of all types to suffer from impact and abrasion. Canoes and kayaks are dragged across rocks and gravel when we put them in and take them out of the water, and they can hit rocks or fallen trees while we're using them. The decks of both power and sail boats experience abrasion from foot traffic (could be from street shoes with gravel stuck in the treads) or impact damage from equipment like anchors or masts. Next, we'll look at impact and abrasion resistant materials that can extend the life of your watercraft.

Fabrics

Kevlar®

Kevlar is a brand name for aramid fibers made by DuPont™. These synthetic fibers offer good abrasion and impact resistance as well as other structural properties. This bright yellow material is popular for applications that need a lot of abrasion or impact resistance, such as skid plates. Many builders specify Kevlar for powerboats because it resists puncture during impact.

Indentation test on a sample of wood coated with G/flex. Note how the epoxy stays in contact with the wood surface even after it has deformed.



As a fabric, Kevlar is very durable which can make it hard to cut and work with for the average do-it-yourselfer. It is also one of the more expensive reinforcement materials.

Dynel™

Dynel is a synthetic fiber made of acrylonitrile and polyvinyl chloride. Typically less expensive than Kevlar, it's been around since the early 1950s. It remains white when wet out with epoxy.

While Dynel is a good choice for abrasion and impact resistance, it tends to float in the epoxy. When working with this material, wet it out and scrape off any excess epoxy. If there are areas where the epoxy is pooling, the fibers will float and not make good contact with the surface below. Once the epoxy has gelled or cured, you can apply more coats of epoxy to fill in the weave of the fabric. But you can also leave Dynel's weave unfilled to provide a textured walking surface on decks.

Xynole

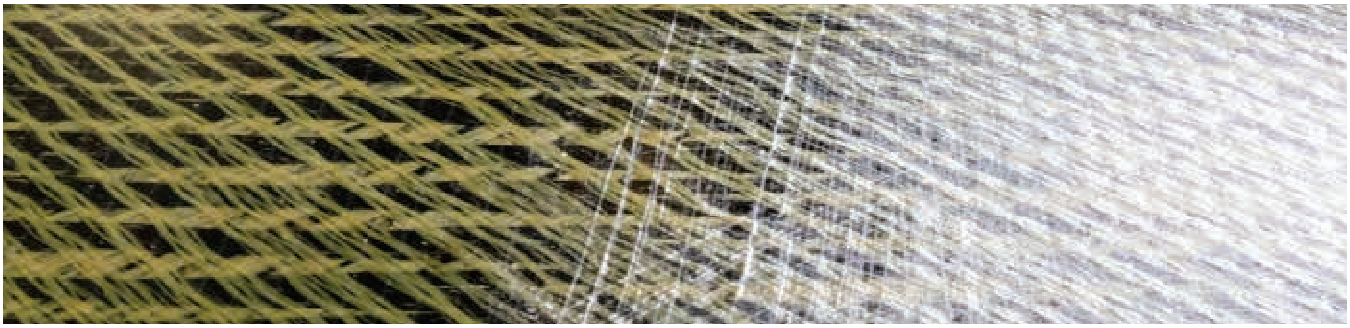
Xynole is also a synthetic fiber fabric. Made of very tough polyester fibers, it's great for impact and abrasion resistance. Low priced Xynole is an economical alternative to Kevlar. However, it's not as strong as Kevlar and can absorb quite a bit of epoxy, resulting in heavier laminates.

Innegra™

Innegra is a fairly new reinforcement fiber by Innegra Technologies™ that is made from a low-density, high-modulus (high stiffness) multi-filament olefin yarn. It has good impact and abrasion resistance and can cost less than Kevlar. Innegra is commonly found in hybrid fabrics. This means it is woven with another reinforcement fiber such as carbon. Hybrid fabrics are priced higher as they combine the advantages of both reinforcement fibers.

Honeywell Spectra®

Honeywell Spectra is another newer reinforcement fiber that shares many of the characteristics of Innegra. These bright white fibers are made out of polyethylene and are very strong with good



Sample of a carbon fiber/Kevlar laminate affected by abrasion. The left side is unaffected where as the right side has been abraded. Note the fraying from the Kevlar fibers.

impact and abrasion resistance. Because of their high strength, they're frequently used in sailboat rigging. Honeywell Spectra fabrics tend to be more expensive, so might not be as readily available as other reinforcement fabrics in retail settings.

Fiberglass

So far we have gone over some of the high-tech reinforcement fibers for abrasion and impact resistance, but let's not underestimate the properties of fiberglass. You can use it in many applications to improve surface durability, and a 4-6 oz. fiberglass layer is frequently applied on the outside of cedar strip canoes and other boats for this purpose. Fiberglass may not hold up against impact and abrasion quite as well as some of these other fabrics but it can hold its own in this application.

Additional benefits of fiberglass are that it's relatively inexpensive, you can find it in a wide range of sizes and weights at most retail stores, and it's generally easier to work with.

Epoxy Resins

105 Epoxy Resin

WEST SYSTEM® 105 Epoxy has been used for years to wet out the fabrics listed above. It has a higher toughness so it's less prone to cracking than standard polyester resins. You can also modify it with additives for better abrasion resistance.

G/flex® Toughened Epoxies

G/flex 650 Toughened Epoxy and G/flex 655 Thickened Epoxy Adhesive are rubber-toughened systems that do well against impact and abrasion. They are great for coatings. G/flex 650 can be used to wet out lightweight fabrics. Some of our customers blend G/flex 650 with the 105 System to give more toughness to a laminate. If you want to do this, first measure and mix each system separately and then blend them together; that way, the resin-to-hardener ratios are correct.
G/Flex 655 is great when you want to apply a thicker coating or if you need to fill in a seam or gouge on a frequently abraded surface.

For more information on coating surfaces, see Tom Pawlak's article "Improve Wooden Paddles with G/flex" in *Epoxyworks 37*.

Additives

Graphite Powder

423 Graphite Powder is a fine black powder that can be mixed with epoxy to produce a low-friction exterior coating with increased durability. The properties are a result of the graphite being exposed as the surface is worn by friction or intentional sanding. Otherwise, it would remain encapsulated in epoxy. While this additive is more frequently used to make a low-friction surface it can also increase durability against scuffing.

Use 423 Graphite Powder at 10% by volume in epoxy. While typically only used in the final coatings, the viscosity remains low enough that wetting out fabrics is easy. You can use it in combination with the reinforcement fabrics listed earlier.

Aluminum Powder

420 Aluminum Powder is finely milled aluminum you may add to epoxy at 5-10% by volume. It will increase the hardness and abrasion resistance of the coated surface. As with the 423 Graphite Powder, epoxy blended with 420 Aluminum Powder at 5-10% by volume remains low enough in viscosity to easily wet out fabrics we've mentioned.

Choose Your Combo

In summary, the right combination of fabrics, WEST SYSTEM Epoxies, and additives will go a long way in protecting surfaces from abrasion and impact. Common reinforcement fabrics are Kevlar, Dynel, Xynole, Innegra, Honeywell Spectra, and Fiberglass. Good epoxy systems and additives are the 105 System, G/Flex, 423 Graphite Powder, and 420 Aluminum Powder.

For further reading, "Ticonderoga: Testing for the Toughest Deck Coverings" in *Epoxyworks 4* offers more information about abrasion and impact resistance. Spoiler alert: it includes the performance results of various laminates tested for impact.

Mammoth Tusk Restoration

By Bruce Schinder

A sampling of mammoth tusks that have been restored and mounted. The broken edges, cracks and stains tell the story of their 35,000 years of survival.

Far left: Layers of exposed, melting permafrost reveals hidden mammoth tusks. Most are broken or partially rotten.

Left: An unusually good mammoth tusk in front of some of the mining equipment that typically uncover these tusks.

I love mammoth tusks. I love their grandeur! I love their immense size and elegant double curve. I love the beauty of mammoth ivory with its rough, stained outer texture and the creamy inside with its carbon fiber-like cross-hatching and rich colors. And I love the stories they tell of their Pleistocene past, of their cold storage in the frozen soils of the north, and of the gold miners who unearth and care for them. I especially love, of course, how mammoth ivory is brought back to life by artists and conservators.

Our mammoth tusks come from the goldfields of Dawson City in Canada's Yukon territory. If you watch "Gold Rush" you've seen these fields. I encounter a lot of mammoth tusks in my forays into the Klondike goldfields, occasionally, tons of them. The miners stumble across them as they dig for gold. Mammoth ivory will rot in the goldfields where it's found if it cannot be sold. Miners protect and preserve tusks when they find them.

The subarctic ground up north is permafrost; it's been permanently frozen for tens of thousands of years. Anything buried in this ground, such as these tusks, is preserved in a natural, permanent, deep freeze. That's how these tusks have survived so well for 35,000 years.

But they are not perfect. Most mammoth tusks we find are partly rotten pieces, or broken by dozers and excavators. We still prize these pieces because they are excellent for carving. Occasionally though, we find a tusk that's completely intact or only slightly damaged. These are rare and highly cherished. But these tusks still need work, as you can imagine, after tens of thousands of years entombed in the frozen muck.

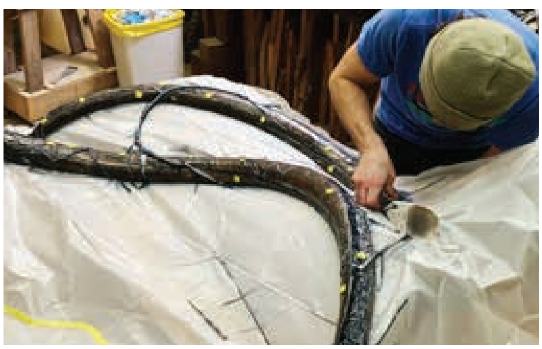
Mammoth tusks carry a rich history. A tusk that once served the mammoth as a weapon, a shovel, a forklift, or as a nurturing nudge to another mammoth, now serves as a modern-day storyteller. To stand beside and touch a well-restored mammoth tusk fires up the imagination and sense of awe that these creatures really did exist. They were elegant and enormous.

In a way, restoring a mammoth's tusk brings that animal back to life. I use WEST SYSTEM® products in my tusk work. These epoxies have nearly zero shrink, they are consistent, and the technical support is solid. I rely heavily on the 105 Resin® and 206 Slow Hardener®. The 206 gives me just the right amount of working time when filling thick gaps and rebuilding smaller tips.

I believe that honoring and using the remains of long-extinct mammoths celebrates their stories and educates us on the value of our living elephants. It highlights how precious and fragile life can be. Therefore, I believe mammoth remains must be used, preserved, and honored, and that living elephants must be protected. The survival of each go hand-in-hand.

Let's continue doing our part to see the protection and survival of elephants and other threatened animals of East Africa while also doing our part to preserve what remains of our extinct mammoths.

Bruce Schinder lives in Skagway, Alaska. Learn more about how he's preserving mammoth tusks at preservationmammoth.com



Far left: Black pigmented epoxy is used to fill the larger voids within the mammoth tusks so they are structurally sound and can be displayed as artwork.

Left: Epoxy being used to consolidate and stabilize smaller cracks.

Surviving FLICKA's Capsize

Part 2

On June 20, 1979, while sailing in a qualifying race for the OSTAR (Original Single-Handed Transatlantic Race), Jan Gougeon's self-designed and built 31' trimaran FLICKA was capsized by heavy seas in the North Atlantic. Jan survived on the overturned plywood/epoxy multihull for four days before he was rescued by a passing freighter. The following is the second half of a transcript of a phone call between Jan, his brothers Meade and Joel, as well as fellow multihull designer/sailor Mike Zuteck. Their discussion takes place on June 26, 1979, just hours after the freighter that rescued Jan delivered him to dry land.

FLICKA was never recovered.

We've divided their lengthy discussion into two parts. At the end of Part 1, Jan described the feeling of leaving FLICKA behind after his rescue. In this installment he goes on to discuss the failure of his EPIRB unit, what he learned from surviving FLICKA's capsize, and his conviction that all multihulls should be self-rescuing.

Meade Gougeon: Weren't the outriggers holding it up pretty good though?

Jan Gougeon: Oh, everything was perfect, yeah. No, the boat to this second—if someone would go out there and get it—all they'd have to do is patch two holes and the boat is perfect, outside of I removed a couple of pieces of the furniture inside to make things. But the boat is structurally, absolutely flawlessly, beautiful. As a matter of fact, I took the time yesterday—while I was stringing up this thing—to look at the A-frames. I was concerned about the A-frames being loaded that way. I was thinking of unbolting one outrigger and trying to right it. But I didn't want to take the chance of losing what I had as a good survival platform. I mean it was perfect. I had it so perfect for surviving in that I figured if I had to stay there for a month, I was going to be able to handle it.

If I ever tried to start unbolting stuff, the chances of something hurting me… As soon as I ever got an arm broken or something, I'd die. You know I knew that. Or even a bad cut or something. I couldn't take many chances. Even though the water was warm, when I worked on the boat I put on my wet suit and boots and anything I could to protect myself so if I fell I wouldn't cut myself.

Meade: Anyway, [boat designer] Damian McLaughlin called and said that the waves in the Gulfstream were running 35 feet.

Joel Gougeon: He said that every twentieth wave was running 35 feet.

Jan: Well I'd say, I never went across the Gulfstream then, that it was good I didn't sail there. I would say at that point, on a trimaran unattended, the only way that it would survive—and I say any trimaran will survive almost anything if you have a sea anchor to keep the nose into the waves—I don't think anything will get it. That's my feeling right now.

Meade: How about going downwind with it?

Jan: Downwind would be no sweat. But I think that going head-to-wind, the problem with [going] downwind is you need a person to steer it.

If you had a head-to-wind, the bows are nice and fine and the sea will kind of crash over it, but it would never tip over.

Joel: How high were [the seas] running when it flipped over?

Jan: Oh, I'd say the [wave] that tipped me over was probably 14 feet. I didn't see it but it was bigger than the rest. I didn't want to get into the Gulfstream because I knew it would just, you know. It was death. It would be death.

Meade: But you had the mast up with some sail area on it, though? You had a double-reef main?

Jan: Double reef main, the mast feathered in the wind. If only I had stayed up and sailed it. I ain't kidding you, the boat with that rig will sail to weather in 50 knots of wind with ease. No problems at all if you're steering it. As long as you're steering it, it's not a problem. As soon as you go to bed though, the boat can't take care of itself. It needs a sea anchor.

Boy, the first two days I had such a fabulous sail though. So fabulous you wouldn't believe it. It's something like you dream about. Like cross country skiing only it's always downhill. Fantastic, man. It's going off the wind and the genny, about half the jib rolled out and one reef in the main. The boat would get on these waves and you'd surf for maybe four or five minutes, going like hell, just beautiful control. And it would hit the next sea and the shape of the outriggers and everything worked so beautiful. There was never even any tendency of nose-diving, never any want to broach, nothing. Unbelievably controlled.

Meade: Did you have the boards down?

Jan: The boards were down. When I was hove-to I had the leeward board all the way down and the windward board up to keep the nose into the wind. The boards up and the boat sitting to beam would never work. The boat never even started to want to go sideways, it just went straight up and flipped over. It was like someone stuck a stick under me and pushed up in the middle of the boat. It's absolutely treachery to lay beam-to. Not the way to do it. And the weight of the boat doesn't matter. It doesn't matter if it weighs 4,000 pounds at that point. See, what happened when the boat was upside down with the cabin full of water it, was more like a catamaran with the two hulls far apart. All of a sudden that gets real stable in the waves. I think of it like a proa*, the main hull is actually a nuisance when you're beam-to, it shouldn't be there, it's something for the waves to hit.

I haven't got money problems at all. There's no hassle that way. I even saved my American Express card, I mean, believe that? It's still in my wallet. They make them out of pretty good stuff. Whatever it is, it held up pretty good.

My ultimate, ultimate point of depression though was standing on the bridge watching my boat disappear behind the ship.

Meade: You had to be pretty happy to be alive though, Jan, didn't you?

Jan: That's what I told the captain. I said, "I still have two hands and I can build myself another boat." A little bit of plywood and some staples and glue and you get another one.

I've had so many great gobs of things to contribute to any of these guys going out to sea on what they should do to be ready, though. If they'll listen to me and believe me, anyone who does all the things that I tell them will always come home again. It's so simple to come home again if you do these few things. Almost any trimaran can have these particular qualities that my boat had. It's obvious what the flaw is when the boat is beam-to. The main hull just displaces. It's 30-feet long and the wave immediately moves the boat because it displaces the entire length of the boat, you know what I mean? So immediately the boat starts going up. Well, when the boat meets the wave head-on, the wave can go right up to the sheer of the boat and it only displaces a small percentage of the weight of the boat because of the shape of the wave.

Nothing happens to you head-on. But [a wave approaching] beam-to will flip you. Every trimaran I can imagine is afflicted by that. The beam is everything right then. The distance between the main hull and the outrigger is the whole key. Because the angle that it finally gets at is less, but the displacement of the outrigger means nothing. The outrigger didn't even—as a matter of fact, the boat didn't—it took a side slam after it got up in the air. It dropped, and when it tipped over I

** proa - a boat with a single outrigger/ama* thought that the outrigger had actually busted underneath. That it had busted the ends of the beams off is what I had the feeling had happened. But when it was upside-down it seemed to be floating pretty level and so the seas weren't hitting the main hull. I couldn't see out at that point, so when I cut [my way] out, I of course cut on the side of the main hull. I looked and everything was still there. All the boards and everything were still operational and everything was like brand new.

Meade: So you didn't lose any of the stuff out of the inside of the boat?

Jan: Well, I lost all the canned foods. They were gone instantly. Anything that sank got sucked out of the main hatch as fast as it could. But all of the rest of the food… I had a lot of dried food and packaged food that was stored in these little bins and stuff. Another key thing is you've got to have some covers on the bins so the stuff doesn't fall out. But I grabbed stuff as fast as I could. I mean, the fabulous cuisine of the transoceanic I could see glowing underneath the saltwater. I immediately grabbed the [fresh] water—first thing—and then the food was next and tools. As fast as you can grab stuff, you grab it. I'll tell you, the really scary thing would be tipping over in the dark.

Joel: What time was it when you flipped over?

Jan: It was about four o'clock, I think.

Joel: Oh, in the afternoon.

Jan: Yeah. My [wrist]watch worked through the whole thing. But, anyway, I looked at my watch. As a matter of fact, I kept a log of the whole thing. But [when] I left I didn't grab it all. I even had the log right up to the point I tipped over. It went down. I was working out the sight and I had paperwork of the sight. I saved that, but left it all on the boat when I ran out of there. Some of the—

The self- rescuing catamaran, WILD CARD. It was the first hull built of the G32 series designed by Jan and Meade Gougeon.

Meade: You actually summoned the freighter? The guy saw you though? You didn't call him on the radio you just…

Jan: No. I didn't have a radio.

Meade: He just saw you.

Jan: He saw me, yeah. I stood on the bottom and I had on a yellow—you know what you call it—and everything.

Joel: What about that Nicro beeper or whatever the hell it was?

Jan: Oh, let me tell you about the Nicro beeper. I mean, [it was only] worth a few minutes.

Meade: The EPIRB [Emergency Position Indicating Radio Beacon]?

Jan: Yeah, the EPIRB, right? OK, the first night I flip over I'm upside down. I figure, tonight I'll turn on the EPIRB and tomorrow they'll come and pick me up, right? So I turn on the EPIRB and I hang my [man overboard] strobe light outside. I put the EPIRB out there and the red lights on. Come morning, I notice that the little red light is out on the EPIRB. I bring it back into the cabin and the thing is real warm. So I tear it apart. Inside is a big cloud of smoke. One of the wires has gotten pinched and the thing was shorting out. I take it all apart and carefully scrape off all the stuff. I get the EPIRB back together and it lights up again. I don't know whether it is broadcasting or not anymore. The thing failed. It's supposed to work for eight days. I don't think it ever—probably ever in its life—broadcasted a signal. So that was just all false security.

Mike Zuteck: That's too bad.

Jan: The VHF radio thing, you can hear them talking and stuff so you know it's working. You know you can talk to them. And if they don't answer you, or if they answer you and it's garbled, at least someone is hearing you.

Joel: Yeah, having a good radio onboard would be the way to go.

Jan: You can't have a regular radio because that gets underwater and it depends on the ship's battery. You've got to have a handheld VHF. You know, the little handheld job that I was looking at, the six-channel one. That's the only way because the regular radio is operating on the ship's battery and those are gone. I had big piles of flashlight batteries, so in the back cabin I had a workshop made and in one of the little areas was a work table. I tore the EPIRB apart and cleaned out all the burned crud in between the little jobbers, figuring I could maybe save it. I tore the EPIRB's battery pack apart to count how many batteries were in it to figure out the voltage, see. When I figured out how many volts it was, I hooked all these flashlight batteries and stuff together to get the right voltage. Among great sparks and smoke, nothing ever did EPIRB again. So I gave up that idea and I figured maybe I could start cutting parts of the boat off and light them [on fire] and let them drift.

Joel: Well, when you were in the back cabin it was fairly dry there?

Jan: Yeah, I was high and dry. Well, there was some surge that would splash in there once in a while, so I took one of the tables and I cut it to fit in there with a towel. I measured about 38 times and I made this line. It was one of those fits where you have only one shot at it because it is going to take you four hours with a hacksaw to cut it. I cut it, put the towel around it, drove it in there with the winch handle. The forces of God would never have moved it. It will be there until the day someone finds the boat and salvages it. They'll just have to put up with that piece of wood in there because that's how tight it's driven in there. And no more water ever got in the back compartment, outside of the window leaking a little bit. The window would have been a nice strong window. It would have stayed dry forever, fully waterproof. Absolutely fortified there. Absolutely, the answer to survival is the place where it's dry. You've got to stay dry and out of the water. After the first day, the sleeping bag got kind of wet. But during the day when it was kind of calm for a while, I opened up the picture window in my back cabin and dried out the sleeping bag.

SPLINTER, the first self-righting trimaran designed by Jan after his capsize. Photo from a race on the Saginaw Bay in 2019.

I took the other table-half with the little pin sticking out, wrapped line around the pins, then cut holes in the side of the boat with my jackknife. I tied the lines around it. I could tie it down at night real tight. I stuffed all my extra clothes in it so that water wouldn't leak through the cracks in the cabin. I've got a pretty good report written for the Coast Guard that I got a copy of. I'll bring that home.

Great amounts of stuff learned in the multihull thing. It's not a dead cause yet. The fact that I survived, the only thing that I won't do, I mean, the criteria for my next boat is it's still got to be fast. But it's got to be self-rescuing. And it's got to be able to be hauled behind my Honda. That's the criteria.

Editor's Note

Jan would go on to design his first self-rescuing 25' trimaran, SPLINTER, launched in 1980. SPLINTER placed first in the Port Huron to Mackinaw Race in 1981, 1982, and 1983, and also set a record for fastest finish. Built of plywood and WEST SYSTEM® Epoxy, SPLINTER is still racing on the Saginaw Bay 40 years later.

Jan went on to design and build the 35' trimaran OLLIE; the trailerable GOUGEON 32 catamaran; and the folding, trailerable 40' catamaran STRINGS. After FLICKA's capsize, every sailboat Jan designed featured self-righting capabilities. All of Jan's sailboats continue to compete on the Great Lakes today.

Jan passed away in 2012 and was inducted into The National Sailing Hall of Fame in 2015. We miss him dearly.

Carbon Skinning

By Jeff McAffer

The completed carbon skinned dash reassembled and ready for installation.

It all started when I got a new 360-degree camera for my racecar. Mounted on the dash, it captures a really cool perspective that allows viewers to see forward, watch cars as I pass them, and to see what I'm doing (check it out at youtube.com/user/jeffmcaffer). Unfortunately, the dash produced considerable glare on the windshield. As you can see in the photo, it also had various holes and divots that were not useful in a racecar such as a coin tray, air conditioning vents, and extra switch panels. I wanted to fill those in. But how?

The original dash had many unnecessary contours that needed to be filled.

After considering options like vinyl wrap, flocking, or paint, I decided carbon fiber "skinning" was the best approach for keeping within the racecar theme. The internet offers many videos on how to do it, some good, some less so. Overall, it looked challenging due to the compound curves of the dash—but feasible. The search for materials was on.

As a recovering boat owner, I was aware of WEST SYSTEM® Epoxy. In my research, I discovered that the 105 Resin®/207 Special Clear Hardener® combo was used on some furniture projects and they looked good! I had a few questions about their use in a skinning project, and talked to Gougeon technical advisor Don Gutzmer. He was prompt with email replies and even called me as the project progressed so we could walk through the process step-by-step.

There were several other options locally and on the web, and even some dedicated skinning kits, but ultimately WEST SYSTEM products were the best option for me. The ease of dispensing resin and hardener with calibrated 300 Mini Pumps, the proven robustness of the epoxies, and the amazing customer service from Don, sealed the deal. I decided on G/flex® 650 Toughened Epoxy with some 502 Black Pigment for the base coat. Don suggested G/Flex to provide a great bonding layer on the sanded and flame treated vinyl of the dash. Over that, I would put one layer of 270 gsm Web-Lock® carbon fiber and quite a few coats of 105 Resin/207 Special Clear Hardener.

The first step was to cut off all the bits I didn't want and fill in the unused areas to clean up the profile. Here you can see spray foam (white) filling the top tray and unused air vent. I also used this foam to change the profile of the center console. The wide pink foam insulation board along the bottom left creates the new profile by filling in areas that previously had switches and a trim piece.

Pink foam insulation board was used to fill in large flat areas. Expanding spray foam was used to fill in the shallower or more contoured areas.

The insulation was faired in with 105/207 thickened with 410 Microlight Filler.

I faired the surface with 105 Resin/207 Special Clear Hardener thickened with 410 Microlight® Fairing Filler. Above you can see the dash after trimming, sanding, and fairing the patched areas. In retrospect, I probably spent too long trying to get these super smooth and contoured. The epoxy and carbon fabric really masked any imperfections. Getting the edges of the fabric straight and clean was key for trimming the carbon later.

In the previous dash setup, all the instruments and switch panels were mounted with no visible fasteners using 3M Dual Lock® re-closable fasteners, which work really well. To continue using that, I needed a lip or flange inside the holes where the panels sit. I made either foam or cardboard backing blocks for each hole, covered them in packing tape to prevent the epoxy from sticking, and then bonded in a 2" wide strip of carbon fiber all the way around each hole—half on

Foam or cardboard backing blocks were inserted into each opening to mold a flange for remounting hardware.

the dash, half on the backing block. You can see the resulting flange in later photos.

To skin the dash, I started by mixing small batches of G/flex 650 and applied with a brush. Don had warned me that it was pretty viscous. He wasn't kidding. It's cold here in Seattle, Washington in the winter, so I had to make sure to get the garage warmed first. I mixed and applied

A black pigmented coat of G/flex was applied to the dash before applying the carbon fiber fabric.

the G/flex to the surface once the garage was warm. I let the application of G/flex cure to a tack stage before enlisting help from my daughter to start laying the fabric on the surface.

The next steps did not start well. The first challenge I ran into was with the fabric, which turned out to have a flaw. It's a long story, but there was a spider's web of white filaments spun right in the middle of the good side. I hadn't noticed as all my work in measuring and cutting had been on the "back." I spent a bunch of time trying to clean the mess. I got it good enough and ventured back to the garage.

Challenge number two: I was overly optimistic about the flexibility of the fabric and its conformance to compound curves. I worked from the center out on the top and got it reasonably laid down. But I was naively trying to do the whole dash in one go with a single piece of fabric. Yeah, well, that wasn't gonna happen.

Next, I ran into challenge number three. Messing around, cleaning the fabric and laying it on the top took a long time, and the G/flex was losing its tack. Oh, that was frustrating. In the end, I swore some, ripped off the fabric and took a break. Sorry, no pics. It was all too maddening to stop and capture the moment.

Key lessons: Check all the materials before beginning time-critical steps, and keep track of the time.

After recovering, I scuffed up the G/flex base and used 105 Resin/207 Special Clear Hardener to lay up the dash in pieces. The picture shows the forward edge and top surface. It turns out that with a bit of planning you can make butt joints nearly invisible—find existing cracks or seams, corners, etc. to distract the eye from the joint.

With a coat of 105/207 applied, the front of the dash was covered with carbon fiber. Butt joints were created at the corners or seams to make them less visible transitioning onto the other surfaces of the dash.

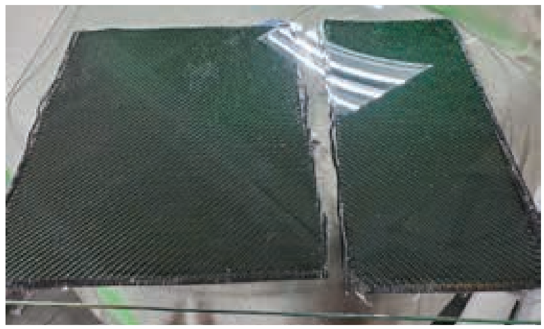
One thing I did learn, though not quickly enough, is that you really need to make sure the fabric stays in contact with the base layer of epoxy while it's curing. I was using fabric with Web-Lock on one side. This is a web of very thin fibers that keep the carbon fibers all lined up. That's great for handling, but I suspect it makes the fabric a bit less conformant. I got inventive with blue painter's tape as you can see here. Honestly, I would get even more aggressive with "clamping" the fabric to the base layer of epoxy if I were to do it again. This is, in my opinion, a critical part of the process. I'd also leave more fabric around the edges to facilitate tensioning.

The net result of getting it wrong is that it bulges and then you must be very careful when sanding. In addition, it will just look bad. I had a few bulges but mostly was able to tame them with liberal amounts of epoxy and careful shaping.

After applying several more coats of epoxy over the face and then the whole dash, followed by a judicious amount of sanding/fairing, it was ready for clear coating. Velvety smooth.

The spray-on clear coat gives the dash full UV protection and a great big shine. Overall, it's pretty delicious. The top will end up partially covered in matte vinyl to cut the glare, but the rest will be eye candy to make all the other racers jealous, and I hear that this will add at least 5 horsepower to the car.

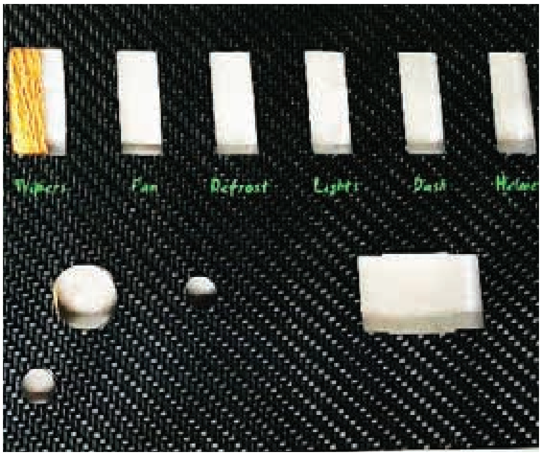
In a whole separate workstream I wanted to make carbon fiber panels to hold gauges, switches, and fill the area where the instrument cluster was. For this I used some fiberglass I had around the shop and some very cool fabric that has a green metal wire woven through—a nice accent given the car is all green.



Two of the panels for the switches and gauges. The finished surface was carbon with green metallic accents woven through the fabric.

I made two pieces, each a simple lay-up of four layers on a glass plate, one layer of the cool green carbon fiber and then three layers of standard carbon fiber each rotated 45 degrees for uniform rigidity. I made larger flat panels for the switches and gauges. There was also a rectangular curved panel for the instrument cluster. I used the gently curved driver's side window of the car as the form.

Above are two of the panels fresh off the glass plate. You can see the green hue and the shiny reflection of the overhead lights. It's amazing how well the epoxy mimics the form of the glass for a smooth, clean result. Despite my best efforts, there were some little bubbles or holes where not enough epoxy got between the glass and the first layer of fabric. In the end, I was going to do a topcoat of epoxy anyway but you should really go to town with the first layer of epoxy if you want a nice clean surface.



Labels for each of the switches were laser etched, then painted green to really pop.

Next, I spent a bunch of time with a Dremel, files, a drill, and a sander to cut and shape the panels before clear coating. The lettering on the switch panel was fun. I put on a strip of painter's tape and then etched the letters into it. Using a laser cutter, I removed a thin layer of epoxy. I added a quick spray of green paint to match the car, and epoxy over the top. It really pops!

And, finally, here is the dash with all the bits and pieces put together and then installed in the car.

Overall this was an ambitious project for my first time skinning and first time working with carbon fiber. It came out pretty well but was a lot of work. A few things that I learned along the way:

- Temperature really matters. I ended up buying a large heater for the garage to get it up to 68°F/20°C and keep the cure times the same and predictable.
- Budget for more fabric and epoxy, especially as a newbie. I used a full quart of resin and corresponding hardener to apply and wet out the carbon fiber.
- West System 300 Mini Pumps are super convenient for dispensing the 105 Resin and 207 Hardener. Measuring or weighing would be messy and time-consuming.
- Really pay attention when laying the fabric down. Do whatever you must to get it to lay flat.
- Compound curves are a challenge. Play with the fabric on the curves before pouring the epoxy to be sure it will contour appropriately.
- Wet sanding is satisfying but not if you have any holes or cracks. The epoxy sanding dust gets in there and dries like rock.
- 105 Resin/207 Special Clear Hardener is not able to tolerate long term UV exposure. I was looking forward to polishing it to a gloss but in the end, spray-on clear coating provided UV protection and required less work to achieve a flawless, high-gloss finish.

The finished carbon skinned dash reinstalled.

Making Knives with G/flex

By Jared Kramer

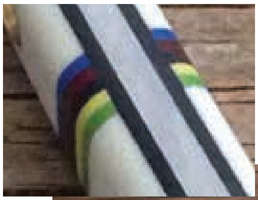
Wood handled hunting knife with blue accent.

G/flex® Epoxy is the adhesive I use almost exclusively for making knives. Years ago, I found out about G/flex from other knife makers. After reading about its properties compared to standard epoxies, I realized it suited my needs just about perfectly. A marine epoxy like the WEST SYSTEM® 105 Resin system is incredibly durable and would likely outlast my lifetime on most knives. However, the "flex" is the main reason I use G/flex instead.

When in use, knives can be subjected to brief but intense stress. Beyond the typical waterproof seal between the steel and handle material, the ability to flex—rather than crack or break—when blades and handles are stressed means the knife won't come apart at a critical time, or in the useful life of the blade.

G/flex does cost a little more than standard epoxies but is worth the superior end product in my knife applications. I use G/flex to laminate multi-piece scales of varying materials, including difficult-to-glue hardwoods like cocobolo, ironwood, and more standard laminates like Micarta or G10. I then laminate to various blade steels, all sealed and bonded with G/flex.

Rainbow inlaid handle.



Belt cleaver with a carbon fiber handle and green accents.

This rubber-toughened epoxy also withstands the stress of frequent temperature changes. Working/hunting blades, even more than kitchen knives, are subjected to wild temperature swings outdoors. G/flex holds up well and bonds the laminate of dissimilar materials in the handle, the blade steel and even the solid handle pins or rivets that hold the knives together. When making knives, I use the best materials I can all the way down to the hardware and adhesive to hold it all together. G/flex has worked extremely well for me for a long time and I will continue using it into the foreseeable future.

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Choosing the Right Wood for Your Boat Repair

Why pressure-treated plywood is a poor choice

By Terry Monville - GBI Technical Advisor

A very high percentage of boats in the U.S. are at least 30 years old. It doesn't surprise me when a boat's plywood components fail due to water intrusion. In my experience, the transom is the first area to rot out in most trailerable boats. That's not to say the first thing to rot couldn't be the cockpit floor, stringers or motor mounts.

I've seen well-maintained, 20-some-year-old boats that look almost new, but have a rotted transom. I've heard this statement from customers so many times over the years that I lost count: *I waxed, tuned-up, and changed the fluids every year. I can't believe they use plywood in a boat! I'm going to put in something that lasts forever.*

After yearly maintenance on everything else, the transom somehow has water damage. The transom that you drilled holes into to mount transducers and such, and used caulk to fill the old holes and bed the new screws. Never remounting and sealing any of the factory hardware, like trim tabs or swim platforms. Is it surprising when the wood fails?

A surveyor friend of mine stated that marine caulk has a serviceable life of eight years. On average, I think that sounds about right. Some marine caulks are better than others and the quality of installation plays a part also. But if we double the caulk's life, at 20+ years, we are still well beyond the usable life of caulk... you wouldn't think of running the same oil for over 20 years.

When they look into getting non-plywood replacements, many boat owners find the cost a bit on the high side and this pushes them into a more cost effective DIY project. There are not many appropriate materials that match the strength of plywood.

Replacing most plywood parts on a boat is not too difficult and can save a lot of money in hired labor costs. The tricky part is getting the right material to replace the old plywood.

Choosing the Wood

It's understandable when a boat owner doesn't want to use something that will rot again. We often get calls asking about using pressure-treated plywood, or exterior grade plywood instead of marine grade.

I would first like to clarify a few things. I think you could get a Ph.D. in plywood, between wood types, grades, and treatments. To keep things simple, we are going to focus on the plywood you're most likely to find at your local home improvement store. To keep things even simpler, we will concentrate on ¾" plywood, which of course is not ¾" thick. The basic theory we will cover applies to other thicknesses of plywood too.

Basic Plywood Grading

These are the basic characteristics for each grade of the plys typically found in plywood available at home improvement stores:

"A" Grade

Sanded smooth, paintable. Though some neatly made manufacturer repairs are acceptable, you should have little trouble finding A-grades that are free of repairs and knots.

"B" Grade

Solid surface with some repairs, usually football-shaped patches and/or wood filler. May have tight knots (no chunks of wood missing) up to 1" and some minor splits.

"C" Grade

Tight knots up to 1½" in diameter and knotholes up to 1" in diameter. Some splits and discoloration.

"D" Grade

Knots and knotholes up to 2½" in diameter, some splits. Generally, no repairs.

Marine-grade plywood found in home improvement stores is generally A- or B-grade. The outer ply, is an A-grade, and the other side is a B-grade ply. The inner plies should be a B-grade or better. In total, the plywood should be a 7-ply lamination with most plies made from Douglas fir bonded together with waterproof glue. Sold as ¾" but will be slightly under due to the finishing.

A- and B-grade plies will be void-free. The higher the ply count for the same thickness, the more stable and resistant this plywood is to cupping and warping. The extra plies contribute to overall strength and stiffness.

Exterior grade plywood is generally B- or C-grade and sanded on one side. Sold as 23/32" but referred to as ¾", it is thinner than 23/32" due to finishing. This plywood is typically made up of five plies of southern yellow pine with waterproof glue used between the plies.

With C-grade plies, voids, and gaps are common and water may sit in them and start to rot the wood. With fewer, thicker plies, the flaws have a more significant effect on overall strength and stiffness.

For use in boat repair, I would limit the use of exterior plywood to areas where the overall strength of the wood is not critical, and the wood can be encapsulated in WEST SYSTEM® Epoxy. A motor mount would be a good example; the fiberglass carries most of the load and the wood will be well sealed (provided the holes for mounting the hardware are also sealed).

Pressure-Treated Plywood

There are many different reasons to use varying grades of pressure-treated plywood. These include protection from fungal rot/decay, termites, marine organisms, fire, and more. Depending on the use of the wood and local climate, there are numerous different chemicals and different amounts of chemicals designed to remain in the wood fiber.

The pressure-treating process is relatively simple. Pallets of plywood are loaded into a larger chamber where vacuum is pulled to remove the air from the wood. At this point, the chemicals—using a water or oil-based carrier—are injected into the chamber often at 160 Psi. This part of the process takes twenty minutes to an hour to complete. The wood is removed from the chamber and moved to a drip-dry rack. Depending on the weather, it takes two days to two weeks until the wood is dry enough for transport. This is not the only way wood is treated, but one of the more common. I've heard of some processes that use a kiln to dry the wood, while others use wax in the treatment.

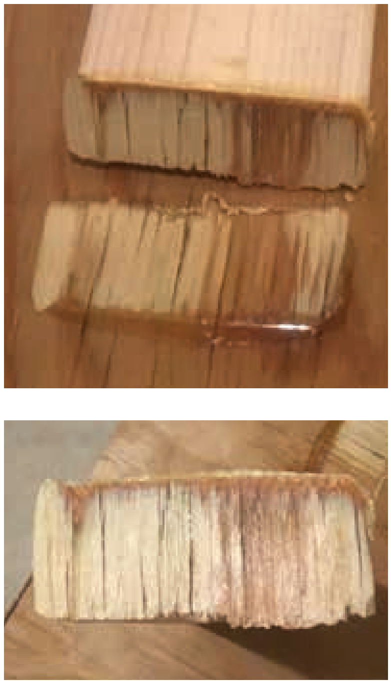
Many different grades of plywood are pressure treated, including marine-grade. The most popular, which you will find at home improvement stores, is exterior-grade plywood treated for ground contact. There are many rating levels of ground contact. Regardless of the grade of pressure-treated plywood, there are a few key things you need to know when using it for boat building or repair. Let's look at the issue of moisture content.

Moisture Content

Plywood pressure treatment uses water or oil-based carriers that leave behind high moisture content. I've seen stacks of treated plywood sheets where the center of the stack is still dripping wet. WEST SYSTEM 105 Epoxy needs wood to be under 12% moisture content and our G/flex under 18%. Most pressure-treated plywood is over 20% moisture content at the time of purchase. Also, pressure-treated plywood has lost 10% to 20% of its strength, mostly due to high moisture content, though some of this strength may return as the wood dries out.

When looking through a stack of plywood trying to find a nice sheet, the top few are warped like a potato chip. Further down the stack you

An example of a home adhesion testing setup. The end of a 2x4 was epoxied onto the surface of a plywood panel and allowed to fully cure.



An example of a successful bond. The bonding of the epoxy to the plywood was stronger than the bond of the wood fibers to one another. You can see the wood fibers still attached to the end of the 2x4.

This timber bonded unsuccessfully. You can see the shine of the epoxy on the bottom of the 2x4. Note that there are no wood fibers missing from the plywood panel in the top image or attached to the end grain in the bottom image.

find a nice, flat piece. But because it's down a few sheets, the piece is still a little damp. You think "that's ok, I won't get around to using it until next weekend anyway. It'll have time to dry." But drying treated plywood down to 12% moisture content takes weeks, if not a year. There is a high chance your nice piece of wood will warp like a potato chip too while drying out.

Once the wood is under 18% moisture content for G/flex, or 12% for the 105 System, you still have the issue of bonding to the chemicals in the wood fiber. With different chemicals and different amounts of moisture left behind by the treatment process, the only way to know for sure is to do a home adhesion test.

Home Adhesion Test

The home adhesion test, is pretty basic. Take an 18" long 2x2 or 2x4 and end-glue it to the wood or other substrate you're trying to bond too. After the epoxy has fully cured, use a hammer to break the 2x2/2x4 off the wood. If wood fiber is stuck to the epoxy you have a structural bond, which is what you want. If the epoxy comes off clean, your bond failed.

Pressure-treated plywood and lumber do a good job for their intended purpose. But for boat repair and building, I would shy away from them.

By using WEST SYSTEM Epoxy with marine-grade or non-pressure treated exterior-grade plywood, you can make economical, long-lasting repairs to your boat. Encapsulating the wood in epoxy and using it to seal any holes you drill into the wood results in repairs that can outlast the original plywood by far.

Conclusion

There are plenty of wood replacements on the market, and the 105 System or G/flex Epoxy products should bond well to most of them. However, you don't need to use a non-wood material. You just need to understand the properties of the materials you select and use them in suitable areas.

Gaff Repair

By Bill Bauer

In preparation for a thorough Coast Guard inspection, we'd stripped the masts, booms, and gaffs on the schooners Appledore IV and V of paint and varnish. This revealed several small rot areas, wear, and damage. Two of the gaff jaws (also called gaff saddles) had significant damage, including cracks in the jaws themselves, probably due to hard jibes and insufficient repairs. Gaffs are the angled spars from which the sails are hung.

The Coast Guard inspector was satisfied with our plan to remove the rotted area from the gaffs, scarf in a "Dutchman" (beveled woodblock), and repair the minor damaged areas. The Coast Guard requested we document all repairs and use WEST SYSTEM® G/flex® Epoxy. They prefer rubber-toughened G/flex on wooden spars because of its flexibility relative to traditional marine epoxies.

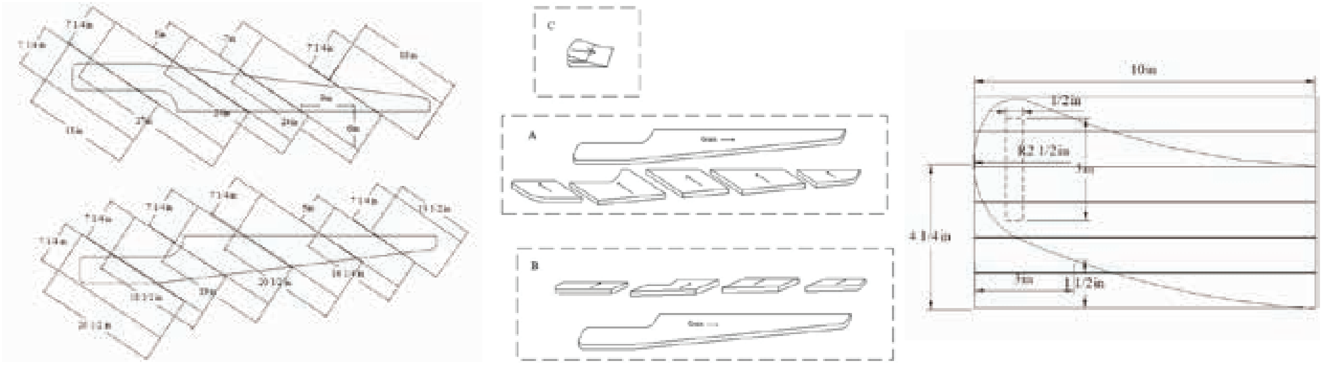
Appledore V. The angled spars from which the sails are hung are the gaffs.

Top: Bill working on the gaff repairs. The dutchman is laying on top of the pole while the cavity is being prepared with epoxy.

Bottom: Half of one of the gaff jaws where the wood is splitting.

The gaff jaws were a different story. The Coast Guard asked that we replace the damaged jaws. On the two gaffs, half of a jaw was damaged. Each damaged half was a 5' x 8" x 6" solid piece of elm. Finding two pieces of elm today would be hard and cost-prohibitive. We decided to laminate with white ash instead. Ash is hard and able to take the shock of an impact but can split easily along the grain.

To reduce the chance of splitting, the center two sections of the laminate would be laid up at opposing 23-degree angles.



The schematics used for laying up the new jaws. Note the offset angle of the grain in the lamination to add strength and stability to the jaws.

Due to the complexity of the assembly, we broke it up into three groups (see the illustration above). We epoxied the A, B, and C groupings separately as follows:

1. Heated all pieces with a heat gun and allowed them to start cooling before we applied a coating of WEST SYSTEM 105 Resin/205 Fast Hardener. Applying the epoxy as the heated wood cooled down helped it absorb the epoxy deeper into the grain. We used 105 to ensure good penetration into the wood.

2. With the 105/205 still wet, applied G/flex 655 Thickened Epoxy Adhesive with a notched trowel.

3. Small dowels were set in each cross-grain piece to hold everything in place while clamping.

4. The A and B groupings were rough-trimmed to size.

5. Both the A group and B group were epoxied to each other in the same manner.

6. The C group was added to accommodate the upward sweep of the gaff jaw.

After epoxying, a power plane and belt sander were used for the final shaping of the gaff jaw.

We strapped the new jaw to the gaff to measure spacing, made some adjustments, then bedded and through-bolted it to the gaff.

Editor's note: Bill Bauer teaches boatbuilding and volunteers with BaySail, a non-profit organization founded in 1998 and based in Bay City, Michigan. Their tall ships, Appledore IV and Appledore V, are the fourth and fifth in a series of six steel-hulled gaff-rigged schooners commissioned by Herb and Doris Smith, designed by Russ Wooden and Parker Marean, and built by Treworgy Yachts in Palm Coast, Fla. The ships were built in 1989 and 1992, respectively.

Thickened Epoxy Application

By Mike Lenemen

1

Roll a piece of glossy paper into a cone.

2

Tape it shut then trim off the points at the flared end.

3

Fill part way, then roll the flared end closed. Trim the tip to the desired opening size.

A painting created by Mike's grandfather using this tube technique.

My grandfather was a notable oil painter. What I remember the most about him is how he painted. He used standard oil paints but did not use a brush. Instead, he painted with cake decorating cones and his fingers.

One day, when I was working on applying some thickened WEST SYSTEM® Epoxy, I had an epiphany: my grandfather used cake-decorating cones to "draw" with oil paints and he was very accurate with them... maybe that would work with thickened epoxy. It has about the same consistency (viscosity) as oil paints.

I had never really decorated a cake before, but I remembered how he made his cones. I've borrowed his approach as an economical and neat way to apply thickened epoxy.

First, you find some paper that the epoxy won't bleed through. I prefer to use high-quality, coated paper from magazines or brochures. I get a lot of junk mail and am happy to "recirculate" the slick paper stock this way.

Starting in the middle of the page, roll the sheet into a cone (Picture 1). Keep the cone rolled into a conical shape by taping it closed. Cut the flared end of the cone into a straight line (Picture 2) and voila; you are ready to fill the cone with thickened epoxy. The thickened epoxy should be the consistency of smooth peanut butter. After you have filled the cone (never to capacity), you can fold over the flared end and squeeze it like a toothpaste tube.

Snip off the pointed end to get the desired opening or nozzle (Picture 3).

Squeeze the epoxy out. When more epoxy is needed, simply start rolling up the flared (closed) end of the tube as you would with a tube of toothpaste. To make a nice fillet, squeeze a bead into the joint and then smooth the fillet with your gloved thumb or the rounded end of an epoxy mixing stick. When all the epoxy has been squeezed out, simply throw away the paper tube.

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.**

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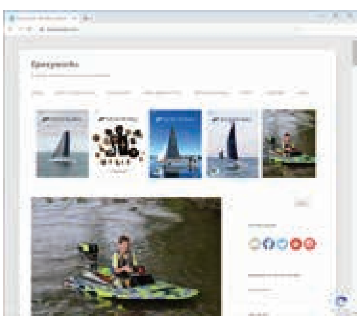

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Readers' projects

Bob Cole built this Colin Angus Cambridge Racer recreational rowing shell using WEST SYSTEM® Epoxy. The shell is 23' 3" long and weighs 39 lbs. The hull and deck are 3mm Okoume.

Doug Finkbeiner of Saginaw, Michigan built this weatherproof carbon fiber and epoxy bike trunk to store his camping equipment. The trunk weighed 38 lbs. loaded with all of his gear. Pedaling his handcycle with his arms, he traveled across Michigan from Saginaw, then took the SS Badger ferry across Lake Michigan into Wisconsin. He then traveled through to Iowa, Illinois, Indiana and back into Michigan. His self-supported 46-day trip totaled 1,480 miles. He plans to build a two-wheeled handcycle next.

Above: Finished and attached to the handcycle.

Right: Stealth camping along the way.

Far Right: Stopping by his favorite truck stop (the World's largest) in Walcott, Iowa.