Chapter 3 - Preparation

SHOP

Jig Table

(Rick Maddy):Build a 12' table. 10' is too short. IT takes more room but it is worth it.

(Bernard Siu): I intend to leave a 3” overhang on each side of the workbench for clamping in the future. I went to Home Depot and bought a 10’ (4x4) and had them cut it down to four (28”) lengths, leaving an 8” piece (this is useful later).

I built the workbench upside down as shown above. First, I laid down a piece of old carpet on the cement floor to ‘take the bumps out’. Then I laid down the table top on the carpet. I used the tabletop (4' x 8' coated particle boards) to line up the frame because the boards are pretty square to begin with. Using 2 C-clamps and the 8” x 4” x 4” post, I held the long and cross beams of the table at 90 degrees. While clamped, I screwed down the top and the side angle brackets. Repeat the above with all four corners and the frame is formed.

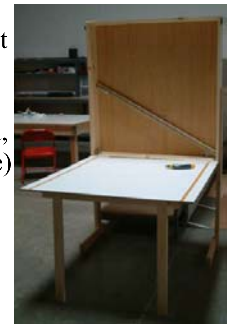
Using a drill press, I pre-drilled 4 bolt holes (3/8” dia.) on one end of the leg, and 1 at the end for the adjustable feet. I then removed the 8” (4x4) and replaced it with the real leg 8"x4"x4" and re-clamp. Using the pre-drilled bolt holes as a guide, I drilled through the crossbeams. Bolt them down with a 6”x 3/8” bolt and viola! – one corner is done. Repeat 3 more times with the rest of the corners.

I used a T-bracket and 2 lag bolts on each end of the crossbeam. The lag bolts help to pull the bows out of the middle of the 12’ beams. I then used 8 L brackets and pre-drilled them in place for holding the top of the table to the frame. Since the tabletop is not part of the workbench support structure, I did not use heavy-duty bolts to hold it down. It rests on the sturdy frame just fine. I just used a few brackets to keep it from sliding around. Besides, the tabletop will be easy to replace as needed.

After I screwed in the adjustable feet, the bench frame was ready to be flipped over onto its legs. I was surprised that I could flip it over by myself. The frame was relatively light but sturdy. I had a harder time getting the table top onto the frame by myself. After lining up the table top(s) to their pre-drilled bracket positions, I pulled them down against the frame and the table is done. Only minor adjustments with the adjustable feet were needed to achieve my 0 degree with the smart level.

Fiberglass Storage and Cutting Cabinet/Table

(Bernard Siu): I built the fiberglass storage cabinet as most builders. I noticed most of the builders had it anchored to the wall. Since I am building my Cozy in a warehouse and the walls are cement, I built a couple of legs to stand it up. This way, I can move it around as needed. I also embedded a couple of measuring tapes along the edge of the table such that I can make the cut readily. To keep the door closed, I used a couple of childproof door magnets (I used them around the house when my daughters were little) to hold up the door/cutting surface. They work well.



(Nate Wolfe): Not wanting to re-invent the wheel and build cabinets from scratch I turned my attention to the isles of Lowe's again and found an 8' x 48" cabinet with 5 shelves on it. It was about 26"" deep and would offer (with modifications) a perfect location for my cloth and epoxy. The first thing I did was remove the top shelf and first shelf from the bottom, leaving only the middle 2 shelves. The top shelf I will leave out and this spot will be replaced with 2 simple dowel curtain rods with "U" holders on each end to hold 2 LARGE bolts of fabric. I could easily reconfigure for 3 or 4 bolts if I desired. The bottom shelf that I removed is turned sideways and remounted (after being cut down) utilizing 4 "L" brackets. This resulted in a spac about 30" x 30" x 26" (W x H x D). I then covered this in 1" foam insulation and used the "light bulb & line voltage termostat" method to regulate the heat. I was worried that every time I opened those big doors I would lose all of my heat for my epoxy so I had to create an insulated door. This was fashioned out of another 1" piece of insulation and mounted into place with some stops on the inside on all 4 sides to keep in from pushing in. I then remounted the doors with some improved fittings,. I'm kinda like home improvement that way, and created a handle for my insulated door. Then, realizing that the insulated door was actually a smidge wider than high I decided to mark which way was up. However a marker malfunction caused me to mis-mark the door causing odd formations of letters on my door. I'll be danged if I use those kind of high-tech markers again ;-). (see below)

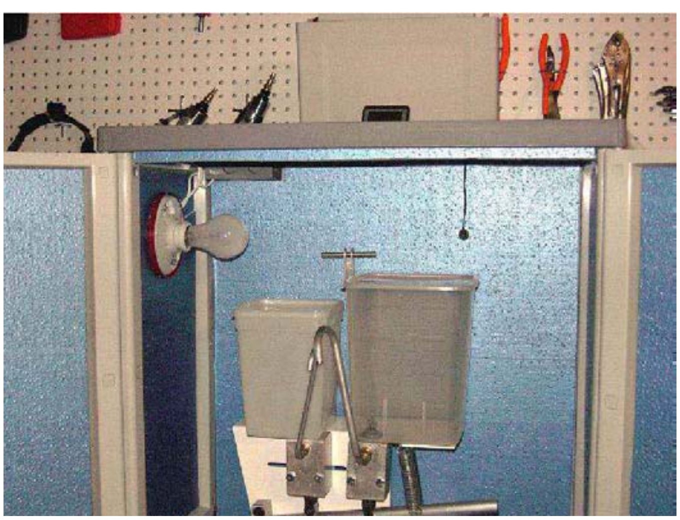
Epoxy storage/cabinet

(Nate Wolfe): Here is what I did to finish the epoxy box. I wired up the bulb recepticle in series with the line level thermostat so that when the temp fell below what I had set on the thermostat It would turn on. I then just wired a plug on the end of a wire whip coming out of the hot area and plugged it into the wall. With this insulation you see here I keep the epoxy between 90 and 100 degrees even if the garage falls to 30 degrees in the winter. Now the good thing about the setup that I have is that the epoxy that you aren’t using can be kept in the cabinet and the leaking heat from the hot area keeps everything around 70 degrees in the winter and ambient temp in the summer... OK... Moving on.

I keep the epoxy that I think I am going to use in the next week in the sticky stuff pump and I plug the ends of the spigots because the hardener has a tendency to get crusty if you don't. Not the resin for some reason. Anyway... I cut a hole for the spigots to hang out the front and I cut a channel on the side for a piece of 3/4" pvc to stick through to extend the handle out the side of the hot box. (see pictures below - click for larger images) That way I don't have to fiddle with opening the insulated area every time I need epoxy.

What I don't have a picture of if a $3.50 thermometer I bought at Walmart that has a probe and measures inside and outside temp as well as having the time in 1.5" numbers. That way I can see what the temp is in the hot box and the garage and still not miss dinner because I lost track of time ;-)

(Jorge Bujanda): - Instead of building a wooden box, I decided to buy an unassembled plastic cabinet and adapt it to keep the epoxy hot during the winter season. I had scrap wood around that I could have used but I did not want to spend the time building and I wanted the box to be light so I could move it easily between the garage and the laundry room (heated area) while not in use. Although I was limited to the sizes available, I found one that gave me plenty of space to place the epoxy pump; a Black and Decker Space Right Wall Cabinet (Lowe's). I installed a slide switch dimmer in a plastic box on the top left back corner, making a hole to access the dimmer switch. I found a large plastic cap to use as a base for a ceramic socket and installed on the left side of the cabinet. I made the proper connections between the dimmer and the bulb socket and finished them with the use of a recycled appliance cord. I insulated the inside of the cabinet with garage door insulation and double-sided tape. A 75w incandescent light bulb took care of the heating. I placed a digital thermometer on top of the cabinet with the outside sensor inside the box. As much as possible, I sealed any joints through which heat could escape with clear and /or electrical tape. I placed the sensor away from the bulb and moved it around until I was satisfied with the average inside temperature reading. Total cost was around $50.

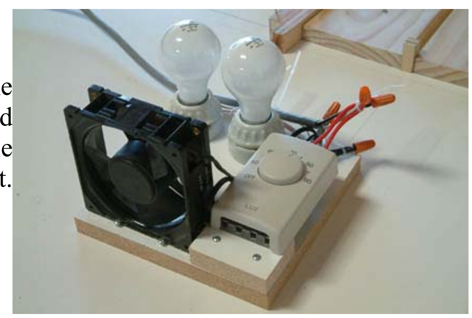


(Rick Maddy): The hot box is a simple structure. It is basically a cube made of plywood and particleboard lined with foam insulation. The front doesn't have any wood. The foam is the cover. The fun part comes from the thermostat-controlled light bulb. I mounted a simple ceramic light socket in the base of the box and ran wires for it out the back of the box. I them mounted the thermostat on the side in the back and ran its wires out the back. I then wired a replacement plug to the thermostat and light. Plug it in and set the thermostat. Simple. The inside dimensions of the hot box are 16" wide, 17" deep, and 18" high. This is enough room the epoxy pump, 2 quarts of hardener, and 1 gallon of resin. Of course the wood box is bigger than this because of the foam thickness. I used 2" foam, which is probably too big, but it is what I had. To make this a better box I made it so I can dispense epoxy even with the box all sealed up. I made a slit in the side of the box for a handle extension. The front cover has been cut so the spouts stick out.

Heat Tent

(Bernard Siu): One of the contributors for poor part quality on my parts (discussed in Chapter 4) was due to low curing temperature (below 70F). Therefore, a heat tent, of sorts, was in order. Since my Cozy factory is in a large warehouse without heating and cooling and it would be impractical to heat up the entire warehouse, I needed to find ways to provide local heating.

The local heat tent is made up of three 4'x8' foam panels (~$10 each). The three panels provide enough material for a 4'x10'x2' tent (as shown). I also cut up some scrap foam strips and glued them to the tent corners and joining edges - making the tent 'box' much more rigid and sturdy for handling.



The heating unit is made up of two 100 watt light bulbs, a small fan (to circulate the air inside the heat tent) and an in-line thermostat. Once the tent is in place, I slipped the heating unit inside the tent and plugged in the power. The heating unit was able to keep the temperature inside the tent within 80F constantly - just about perfect. Time will tell if it is worth the effort.

(Wayne Hicks): I try not to let Mother Nature's icy cold keep me from building during the winter. So when it's cold outside, I use a heat tent to cure parts overnight. All epoxies have a recommended minimum cure temperature from the manufacturer. You'll get the best results if your parts are cured above this temperature within the first 12-24 hours.

A heat tent is nothing more than a tarpaulin or some plastic suspended over a temporary frame. You put a small electric space heater underneath one end of the tent. The parts to be cured are placed at the other end. Heat tents can be made from whatever you have on hand. Saw horses make great frames. I have cured small parts under a large cardboard shipping box. I've even cured parts in the fuselage with the canopy closed! Heat tents don't need to be fancy. Use whatever works to hold the heat in.

In the photos above, I suspended two 5-foot aluminum angles over two of my wing cradles. The heater is on one end and my composite roll bars are at the other. I use bricks to hold the plastic to the ground. I make every effort to seal off openings to keep the heat inside. I have a bucket of clothes pins that come in handy for cinching larger sections of plastic when it's too impractical to use bricks. It's not important that the heat tent be hermetically sealed. It just needs to be free of open holes and gaps that would let the heat escape. I don't like to use duct tape or masking tape because it will come loose once the plastic heats up and the glue on the tape lets go.

The heater I use is a 1500 watt electric space heater available at any Lowes or Home Depot. It is a convective heater, which means that it generates its heat by blowing air over a set of electric coils. It has a thermostat. It also has a safety switch that shuts the heater off if it falls over for some reason. Because the heater has a fan, the heater will circulate the air within the tent. I normally set the thermostat at around 85-95 degrees. While the heater can produce higher temperatures than that, I like to stay at 85-95 degrees. That way the heater will cycle on and off throughout the night. It will run for a minute or so, then shut down for a few minutes. Any higher than that and the heater will run all night.

For safety reasons, I try to set up the tent over the concrete floor and away from convenient flammable materials. I try to ensure the plastic is at least 3 feet away from the heater and that it is taut and cannot be sucked up against the heater. Sometimes it's impossible to keep the 3-foot rule. That's another reason I like the convective heaters. At 85-95 degrees the heater coils do not get very hot. There are very few materials that will combust at that temperature.

I stayed away from using radiant heaters. They generate their heat with wire or tubes that glow red hot. Most of them do not have fans, so they are useless for circulating warm air under the tent. The radiant light can melt parts if placed too close. Plus, "red hot" to me means a greater chance of FIRE. And for goodness sake, DO NOT EVER use a propane, oil, kerosene, or any heater that uses an open flame.

Need convincing of the benefits? These pictures were taken on January 23, 2005. It was 25 degrees in the hangar and the wind was gusting to 30 knots. Yet inside the heat tent, my composite roll bars were curing in a warm, tropical paradise of 90 degrees. I returned the next day to find my parts cured rock hard.

TOOLS-

(Jerry Schneider): Roto-Zip is a must have item. . I used a "Roto-Zip" tool for trimming. It reminds me of a Dremel tool on steroids. And in my opinion, this is a must have item. If you get the 1/4" carbide bit, you can trim cured glass a lot easier than using a saw, or trying to get back to the project during the infamous "stick of gum" stage. Also a set of Sure-Form planes/tools is nice, as well as a couple of the PermaGrit sanding tools available from Wicks. These will make your construction easier, more accurate, and much more enjoyable.

(Chad Robinson): Throwaway paintbrushes are GREAT tools. I no longer use a squeegee except on large lay-ups. You can spread out reasonable amounts of epoxy (instead of pouring it on), stipple, AND squeegee excess epoxy to the edges all with the same tool. Now, I only use a squeegee for micro and on top of plastic when using peel ply. This also greatly reduces cleanup.

(Chad Robinson): I don't have a band saw, and my jigsaw is broken, so I decided to use the table saw as much as possible to cut the hard points out. I'm glad I did because it saved a lot of time. A 60-tooth combination blade produced very clean and perfectly straight cuts. I made my panel a bit oversized (9" wide) so I was able to change the layout of the pieces on the panel from what the plans depict. That let me make straight cuts between the pieces. You can see what I did in the second picture below. (The edges aren't really curved, that was just how I was holding the camera at the time.) I finished the rest of the cuts with a coping saw.

(Chad Robinson): The lay-ups went about to plan. But, I had another piece of good luck - my Fein Multimaster finally arrived, and BOY is this a great tool to use! Unfortunately, it's really only good for straight lines, but it goes through hardened lauyups like butter. This completely ends my issues with being there when it's time for knife trim. I had saved final trim on some of the other bulkheads until this arrived, and I went back and did them all in about an hour, including some final sanding for smoothness. The best part is, the Fein blade (still using the one in the kit) didn't dull at all. My coping saw blades got dull basically every piece I cut.

Credit Card Squeegees

(Bernard Siu): I started with rubber squeegee during my practice lay ups and early part of Chapter 4. I soon got tired of cleaning them - especially when I forget to clean them by the end of the day. Replacements are somewhat costly in a long run. Then I started using credit cards instead of the rubber squeegee (I am sure this is not original). I got a lot of junk ones in the mail all the time, therefore, I have a constant supply of squeegees for FREE!

Here's my experience with them:

- Firstly, I can wipe the epoxy/micro off the cards easily and if I forgot, I just tossed them - they are FREE;
- Note that these credit cards come in different thickness. I like the American Express ones for applying micro onto foam because they are a bit thinner and tend to bend and slide over the foam nicely (ie. they won't dig into the foam). On the other hand, I like the Delta Airlines ones better for applying epoxy on glass because they are a bit firmer;
- Sometimes I trim the credit card into strips for tight places (e.g. applying flox to round off the acute corner at the base of the front seat back in Chapter 6);
- Sometime I sharpen or dull the contact edge of the card for rubbing down the peel ply or plastics.

Home Depot Sanding Stick Special (HDSSS)

(Bernard Siu): I read this from someone's site and followed... I went by Home Depot and picked up several paint stirrers. They have two sizes - you'll find them both useful. I laid a 8"x11" sand paper face down and brushed on left-over epoxy on its back. I then placed the paint stirrers on the epoxied side - butt up against each other. After cure, I used a razor blade and cut along the edges of the paint stirrers. You'll end up with sanding sticks for all occasions. I used this to sand down the heat duct at the aft spacers (Chapter 5). Worked great!

Composite Clecos

(Bob Bittner): Builders of sheet metal airplanes know to buy a gazillion clecos so that they can hold their plane together for riveting. Well, we composite builders have equivalents -- dry wall screws! I use dry wall screws typically to hold pieces of foam together while fit-checking, gluing, and glassing. Dry wall screws have the advantages of holding things very securely without causing damage to cores like nails, bondo, or dabs of 5-minute glue.

MATERIALS-

Tip - Applying flox or 5-min epoxy

(Wayne Hicks): I used sandwich bags for dispensing flox and 5-minute glue. Simply mix the stuff, put it into the corner of a sandwich bag, twist off the top opening, and cut the corner off. Use it like a cake icing tool for controlling the flow and coverage of the fluid onto whatever surface.

Tip - Applying slurry to foam
(Rick Maddy):Go slow and be neat. This way I avoid the problems of getting slurry all over the back of the part I am working on. If I do get some slop I simply wipe it off and keep the plastic under the part clean as well.

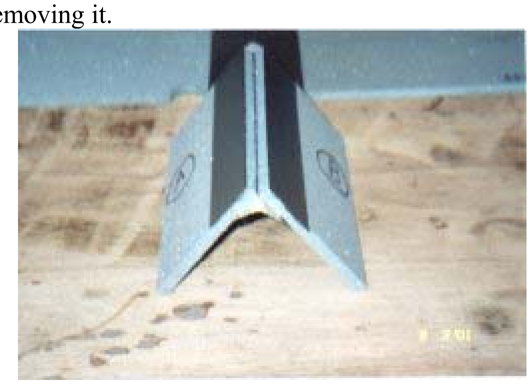
Trick - Flox Fillets
(Rick Maddy):I got this from John Slade. This really came in handy while doing all the taping at the end of chapter 6. Apply the flox to the corner to make a fillet. Don't try too hard to make it neat. Once all the flox is in place you can use a brush and some plain epoxy to smooth the flox into a nice fillet.

Gluing Foam Panels Edge to Edge (a.k.a. "The Hinge Method")

(Wayne Hicks): As the first steps in building the Cozy airplane, the builder is instructed to make the seatback and bulkheads by applying 5-minute glue to the foam panels and gluing them edge to edge. While sounding simple enough, the uninitiated builder soon ends up with glue everywhere but where it's supposed to be, not to mention ill-fitted parts. So here's my "Hinge Method" for achieving perfect glue joins without all the muss and fuss.

Here's everything you need to do a perfect job -- the panels to be joined, duct tape or box tape (I prefer duct tape), 5-minute epoxy, cup and mixing stick, sandwich bags, and gloves. Some of you may recognize the B33 and R33 strake rib in this picture.

Step 1 -- Vacuum the panels thoroughly, butt the edges together, and align the pieces as necessary. Apply one length of duct tape over the seam to form the hinge. The hinge holds the pieces together and keeps the glue from running underneath the parts. Leave a small overhang on the tape to aid in removing it.



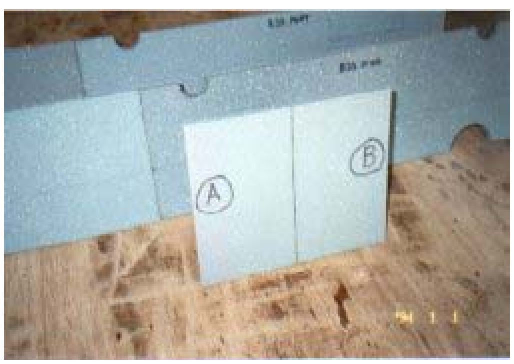
Step 2 -- Carefully turn the panels over. Apply one length of tape on each side of the seam, leaving overhangs as in the previous step. The purpose of these tapes is to catch any glue run-off and keep it off the foam.

Step 3 -- Lift at the seam and stand the panels up into an upside-down V with the now-opened "hinge" facing upward. (For larger panels of foam, it's easier to hang one panel from the edge of a table.) By standing the panels on edge, the panels are still joined together at the hinge, but the seam now forms a channel into which to pour the glue without fear of it running down the panels.

Step 4 -- Mix up some glue and quickly pour it into the corner of a sandwich bag. Cut off a small hole in the corner, and use the bag like a cake icing tool to gently dispense the glue into the seam. You don't need a heavy amount of glue, just a contiguous bead.

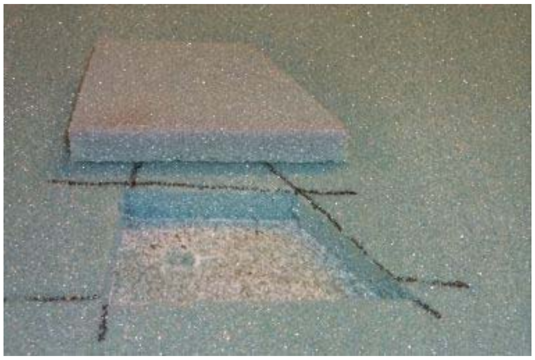
Step 5 -- Collapse the V by pulling on one side of the panels. When the panels fall flat onto the table, the excess glue will squeeze from the hinge. Quickly wipe away the excess.

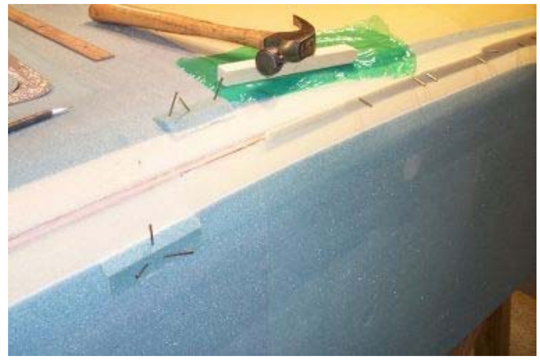
Step 6 -- With no delay, hold the panels completely still and remove the tapes from each side of the seam. When the glue is set, flip the panels over and remove the hinge tape. Voila! The panels are glued together perfectly without gaps in the seam and without excess glue all over the foam pieces. Very clean. No clean up and no more sanding glue ridges prior to glassing.



(Wayne Hicks (FAQ)): - According to Chapter 3, page 4, 5-minute epoxy should be used for joining foam boards together while the next page specifies the use of micro slurry only. Which one is used when?
5-minute epoxy is typically used when joining foam panels "edge-to-edge". Micro is used when joining foam blocks "surface-to-surface". In general, most of the foam joining work in Chapter 4 is edge-to-edge. You will get the chance to micro foam together in Chapter 5.

Repairing Foam





(Rick Maddy): First Picture- There was a big ding in the foam where the cutout is. I layed a piece of scrap over the ding and cut through both the scrap and the bottom so they were the same size and shape. I then chiseled the old foam away. This is what you see here. I simply microed the scrap into place. After a speck of sanding you will never know there was a patch here. One of the great aspects of composite construction.
Second Picture - Here are three different patch jobs. In the bottom left and just left of the hammer head you can see some blue foam nailed in place. I cut too deep in these spots with the hacksaw so I am gluing these pieces back so I can sand it smooth. This will save on a lot of filler later. I had to remove part of the NACA scoop to fill a void. The hammer is holding a small board to weight down some of the foam after being glued back in place. You can barely see the foam that was added to the gap in the fuselage bottom/side corner (center to upper right of picture).

(Bernard Siu): Well, the bubble goblin made its first appearance overnight. I found a large bubble on the longeron after cure. This will be my first repair. I re-read Chapter 3 repair instructions and went for it. I ground out the 4 layers of glass where the bubble was. I then stepped outwards 1 layer less every inch. Since it was a 4 layer UNI, I stepped out 4 inches - both directions. You can see the size of the bubble and the 4 layers of replacement UNI - ready to be glassed in. Once I got the 4 layers done, I added on more layers of BID for the entire length (not shown). I then peel ply the entire repaired area. The result looked ok ... I hope it is really OK! I'll show the repair to an experienced builder next time when I get a hold of one.

Cutting Foam

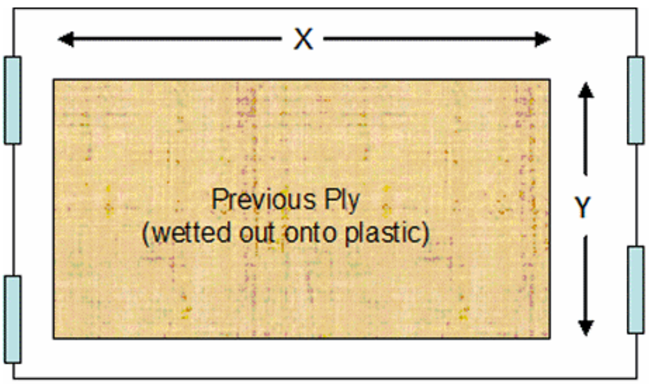
(Wayne Hicks (FAQ)): - What is the best way to cut the foam panels?
All the foams used in construction of the bulkheads are easily cut with a utility knife. Do not try to cut through the entire panel in one stroke. Make several shallow cuts to keep from gouging the foam. Use a metal straight-edge for straight lines; and carefully free-hand curved lines. Some people prefer to use razor saws and power tools such as jigsaws and bandsaws.

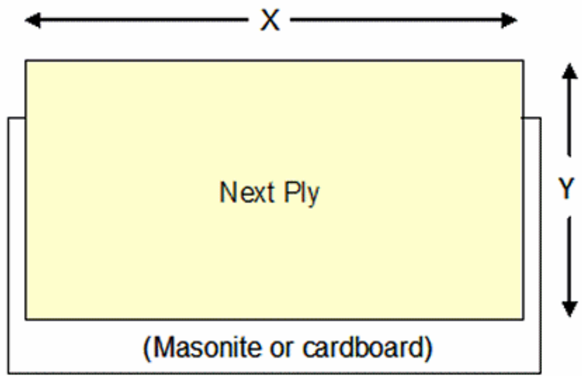
Laying plies

Trick – Precisely Positioning Plies

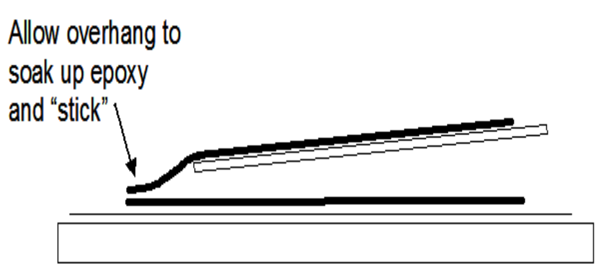
(Wayne Hicks): Most lay-ups require that a second and third ply be positioned precisely over the previous ply. Unfortunately, large plies of cloth will easily distort when handled, especially BID. The plans recommend rolling them up, then unrolling them onto to the previous ply. But that, too, will distort its shape. And once a ply starts to wet out, the ply becomes more and more troublesome to move. The fibers become harder and harder to orient and straighten. The builder ends up with a distorted ply that eventually gets peeled up and tossed in the trash can.

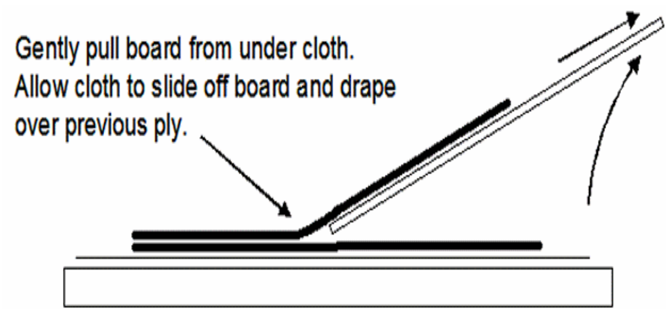
Place the next ply onto a sheet of left-over masonite, Formica, poster board, or a piece of cardboard from a large box. A semi-rigid sheet of anything will work as long as it has a smooth surface. Orient the cloth into the proper shape, making sure to check the dimensions along the edges and to straighten all fibers. Leave about 2-3 inches of cloth overhanging one edge of the board.





When ready, pick up the board and "hover" over the previous ply.   Allow the overhanging edge to come into contact with the previous ply. Wait a few seconds for the overhanging cloth to soak up some of the epoxy and "stick" to the previous ply. Tilt the board upward just a bit and gently, slowly pull the board out from under the ply. With the ply "stuck" to the previous ply, the cloth will slide off the board and drape perfectly into position over the previous ply without getting distorted out of shape.



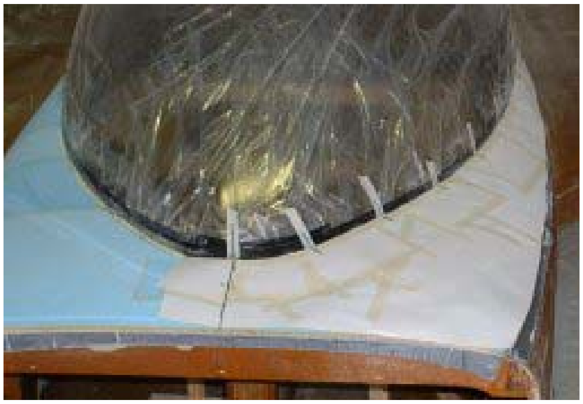


Tip – Lay-up Transfers Using Patterns

(Bob Bittner): During construction of the plane, there are some lay-ups that are best done on the workbench first, then transferred to the airframe. These include ones that are installed in hard-to-reach places, those requiring a sharp line to match an exact shape (like when matching the canopy skin exactly to the canopy bubble), lay-ups to fit odd shapes and sizes, and vertical lay-ups. If you've used BID tapes, then you've already used the most common transfer method!

The process is simple and straightforward:

1. Make a paper template for the shape of the part being glassed. I usually mark out the centerlines, edges, and folds so I know where to position the lay up on the piece being glassed. These pictures show the template being made for the outer lay-ups for the canopy deck. In this case I was able to cut the fiberglass lay-up to the exact shape as to get a perfect edge with the canopy plexiglass without scissor trimming and without grinding away the fiberglass after it cured.

2. On the workbench, wet out the the fiberglass onto your favorite plastic, saran wrap, of foil. It's easier to wet out the cloth and squeegee out the excess epoxy while the fiberglass is flat on the workbench. You have more control of the epoxy. It saves time. It saves materials.

3. Place a second sheet of plastic, saran wrap, or foil over the lay-up. Tape the template over the whole thing. Mark out the outline of the template and transfer all markings for centerlines, edges, and folds onto the plastic for aligning the lay-up onto the part being glassed. In the picture on the left, I am cutting the edge that will fit against the canopy bubble. So I'm being very careful to trim exactly on the line transferred from the template. (The line doesn't show up well in the picture.) The second picture is of the templates used to close out the exposed foam on the insides of the canard cover.

4. Transfer the lay-up onto the piece being glassed. I do this by flipping the lay-up over and removing the bottom piece of plastic (because the top plastic has the markings on it). I hold the lay-up in close proximity to the part, I line up the reference marks, then apply the lay-up onto the part. I usually leave the top piece of plastic on the lay-up and stipple over it. This helps to "stick" the lay-up and remove a large majority of the air bubbles. The plastic also keeps the glass from moving around and going crooked on you when pressing the lay-up into corners and over varying shapes. If the lay-up is a complex shape (as shown in this picture), the plastic may not want to conform to the part. Don't force it just yet. Instead, go ahead and stick down all the flat surfaces first, then stick the curvy parts every 2 or 3 inches. After peeling the plastic off, it's really easy to stick the rest of the curvy sections in place. The picture on the right is an example of transferring a lay-up to a vertical surface, in this case the BL67 rib for the main wing.

Low Pressure Vacuum Bagging

(Jon Matcho) Also known as *LoVac* and 'Vacuum Bagging Lite', this technique was pioneered by the "Cozy Girrrls", which they have documented here. Nick Ugolini has also documented his use of the technique here.

Discovery

During Marc Zeitlin's Western Trip 2004, Marc ran into a bit of bad luck and broke his nose gear. Nick Ugolini happened to have an extra one, and graciously offered to lend it to Marc so he could get back in the air again. The two got together, and ended up at the "Cozy Girrrls" place. While there, Marc described their work to me as 'exquisite'. Asking him, "what makes it *exquisite*?", Marc explained that their work employed a "judicious amount of vacuum bagging". As soon as I heard those scary words, I put it out of my mind, until... just a couple days later I happened to have lunch with Nick Ugolini. Nick also had glowing praise for Chrissi and Randi's work, describing their "low pressure" vacuum bagging technique in detail to me. I quickly became hooked.

I managed to coax a few more specifics from the Girls as well as went on an online pump hunt with Nick. I credit everyone mentioned here for helping me get setup with my first vacuum bagged part: particularly the Girls for pioneering and sharing the technique, Nick for guiding me (I think I'm supposed to say "grasshopper" now), and Marc too (Nick would never have been able to describe this stuff to me if not for your mishap)! 🙂

Vacuum Bagging Supplies

A major obstacle with vacuum bagging, when done "by the book", is that the supplies required for a bagging session can cost more than the actual layup itself. What hooked me on this technique was the supplies list required for each layup:

- Paper towels as the *absorbent*
- Saran (cling/stretch) wrap as the *bagging film* (polyethylene "pallet wrap")
- Peel ply (you need this anyway)
- 3 or 6mil plastic punched w/fine holes for the *breather ply* (this is optional)

For the cling wrap, I located some 30" x 1000' industrial "pallet stretch wrap" (not shrink wrap) from Global Industrial which is the same exact polyethylene material as Saran wrap, but slightly thicker. This worked out to about $23/roll and should allow me to build 3 planes.

Tool #1: The Vacuum Pump

The first thing you need is a pump to remove the air from your part, creating a vacuum, and putting the weight of the atmosphere to work for you. My first reaction was to get one with "more power", but you really don't want this unless you intend to do full-blown vacuum bagging. A low pressure system is much more tolerant to an "amateur setup" and the supplies used with this technique in particular. Toolmen, this is one place where more power is NOT better.

Nick and I spent a few days sending eBay links back and forth before we settled on a linear piston vacuum pump from Medo (we each acquired one of their air compressor pumps, which has a vacuum/input port). These are used in medical devices and fish tanks, have relatively low pressure, consume as much power as a 40-watt light bulb, are self-cooling, and are built to operate for extended periods of time.

Nick kindly sent me some connectors, but I chose to make things difficult by upgrading and building this box enclosure. Putting the pump on a board would serve the same purpose, but I just wanted to dust off some old woodworking skills. The parts list for the final product is as follows:

- Medo linear piston pump: $56 from eBay
- Miscellaneous parts & connectors: ~$20
- Canabalized computer chord: Free

Note that the top cover is for show only in these pics -- I have not yet cut vent holes and when running the pump I leave the cover off to keep things cool.

Tool #2: The Mold

By 'mold', all that is meant in this case is a very flat surface to which you will vacuum bag your parts (the flat ones at least). You can actually get away with not making a proper mold for the flat parts, but you'll have to weigh them down on a flat surface to ensure they do not bend. However, that just sounds silly if you're going to get this far -- just make the mold from the following materials:

- A flat 4' x 4' piece of 3/4" Birch plywood: $? (I forgot)
- Polyurethane: $? (I had some lying around)
- Mold release wax (similar to car wax, but very tough): ~$13 for a can
- PVA (Polyvinyl Alcohol, and rather optional): ~$15 for a quart

Here you can see I'm going a bit over the top with the wax and PVA, compared to the Cozy Girrrl's technique.

Get the flattest and smoothest piece of Birch ply you can find, and sand it even smoother using fine sandpaper. My piece is actually quite used, with saw and scratch marks all over the place. Paint a thin coat of polyurethane on top and let dry thoroughly. Sand with very fine sandpaper, and put another coat on. Do this for a total of 4 coats of urethane, moving from sandpaper to steel wool along the way. Let dry an extra day, and then wax with 5 coats of mold release wax. Let this dry (overnight or for 24 hours if you can).

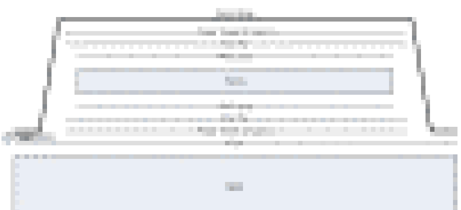
To go totally vacuum-bagging-crazy (this is optional), spray a thin film of PVA on the surface of your waxed board. The PVA is slightly viscous, but can be diluted with water if your spray comes out too thick. The purpose of the PVA is to keep the wax from bonding with the part, thereby contaminating the layup and inhibiting bonding of future layups. Here's the mold (without PVA), and a test piece of PVA after it has dried.

PVA dries into a thin film, acting as a barrier between the part and the mold, and easily allowing any stray epoxy to easily separate from the mold. PVA is also water soluble, meaning that it can be washed off rather easily from a cured layup if need be. Note: I have substituted a layer of polyethylene film ("Saran wrap") for PVA with perfect success. PVA is much better, but appears to be unnecessary for all parts.

The Procedure

The first thing you need to do is understand how all the layers need to be setup on your mold. This illustration shows what is necessary for a 2-sided layup:



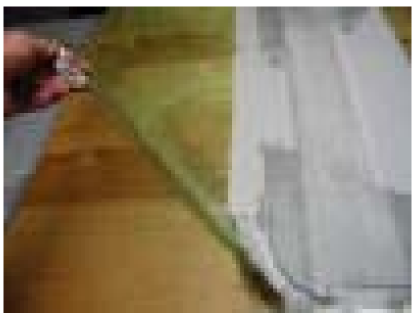
Here's how I did the 2-sided layup (if you want to do a 1-sided layup, omit steps 2-6):

1. Prepare your mold by cleaning it and putting down PVA or Saran wrap.
2. Place two layers of paper towels on the mold where your part will be bagged.
3. Micro-slurry your foam (do side #1 on separate work surface, side #2 will be on the mold).
4. Place the glass and wet it out, NOT worrying about air bubbles in the layup.
5. Add the peel ply just so it sticks to place.
6. Flip the wet side onto the paper towels waiting on the mold.
7. Layup the other side (repeat steps 3-5)
8. Add 2 layers of paper towels on top.
9. Cover with the stretch film and make as smooth and sealed as you can, NOT worrying about air bubbles under the film.
10. Wrap the tip of the vacuum hose in a protective wad of paper towel.
11. Insert the hose somewhere away from the epoxy, but next to a paper towel.
12. Turn on the pump, and press your finger around the edges to facilitate a seal.

Leave the pump on through the initial cure cycle. After cure, just pop off the part from the mold. You can see the value of the PVA in the following pictures. A foundation layer of carefully placed stretch wrap (no folds, wrinkles, or bubbles is nearly impossible though) still could be used as a substitute, but the PVA is so much easier.

Here's the part coming out (off) of the mold and after removing all the bagging supplies:

To get ready for the next session, just do the following:

1. Clean your mold of any remaining PVA with warm soap and water.
2. After every 6 or so parts, add another layer of mold release wax (do this after your first session).
3. Spray down a new PVA layer.

This might seem like a lot of extra work, but when I look at the benefits it's hard not to want to do this everywhere I possibly can:

- Saves time by not having to chase and stipple air bubbles in the layup **at all!**
- Saves more time by not needing to wet-out the peel ply as carefully as you normally would as excess will be absorbed into the paper towels
- Perfect application of peel ply -- no spots where the peel ply didn't make good contact.
- Lighter than normal parts at same or better strength.
- "Set and forget"

I am quite satisfied that this has worked out so well. What was once a mystery to me is now just another tool. This technique isn't for everything, but so far it has worked wonders with my flat parts.

GENERAL-

Tip - Tracking Progress

(Rick Maddy): As I progress through the construction of my plane I use a highlighter to mark what I have done. I use this as a sanity check too. When doing a specific task I read the plans a couple of times. After doing that task I take the highlighter and highlight the text of the task I just did. This allows me to confirm what I just did - before the epoxy dries, and it allows me to quickly see where I am in the plans.