# PEAK OF FLIGHT NEWSLETTER

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# Fiberglassing Inside Body Tubes: Part 1

By Dave Juliano

For those new to High Power rocketry (and even some mid-power builds), the lack of steps provided by some manufacturers may be intimidating. If they're not, maybe they should be! The forces involved with high power rocketry can be enormous, and if you are like most sane rocketeers, you hope your project lives to fly another day. For many, this involves fiberglassing the cardboard airframes that ship with many basic high power kits. Apogee has many articles on this topic, and there are also many great videos, so I won't be covering that here, but the techniques developed with that skill are applied here, so if you haven't tried to fiberglass the exterior of a tube, get a few under your belt before you try this: fiberglassing the inside of a tube.

Why would you want to do this? Why not just 'glass the outside? Well, for a few reasons that we'll get into in a moment, but note that the reasons I provide are for tube-finned rockets only. The techniques I describe will be incredibly difficult on the inside of a tube with an aspect ratio of more than 2:1 (Length by width). The model I'm demonstrating this on is a LOC Precision Cyclotron. Unfortunately, I understand now that I may have been lucky enough to get one of the few remaining kits: the new owners of LOC are interested in bringing it back, but need to "figure out a few things first!", and I can tell you, LOC kits are great, but this one has a few difficult spots.

I like to study other people's efforts when building models, and attempt to improve upon either shortcomings that they've identified with either a kit design or construction instructions (where available). This kit has some great reviews online, but one thing that is shared by all is that the landings are hard on the tube fins. It comes in tail-first like most rockets, but due to the sheer size of the fins, they are easily dented, crimped or, if it's hard enough of a landing, crushed. I want to fly something more than once, and when building a high power rocket with epoxy (like you should!), it's very difficult to pop a damaged part off and try again.

Laminating a layer of fiberglass to an otherwise weak tube with epoxy is a great way of enhancing strength in all dimensions, without adding a whole lot of weight. However, there are some tradeoffs: it does add weight, which you want to minimize if you plan to be safe or hit high altitudes, but adding weight in the aft of a rocket is particularly problematic! It can, if overdone, move the center of gravity (CG) too far to the rear, potentially moving it behind your center of pressure (CP); the one surefire way of ensuring your rocket is a danger to those watching it fly. Thankfully, Tube Fins have a ton of surface area, compared to regular fins, so the CP is almost astonishingly far back, but maintaining an acceptable margin of safety is vitally important and, as always, building for as low of a mass as you can while still getting the strength you need is the right way to go. It increases safety and flight performance and decreases material cost as well as flight cost, since you can fly lower-powered and less expensive motors to get the same level of performance.

So back to one of the original questions: if laminating fiberglass improves strength, and is relatively easy to do on the outside, why bother laminating the inner diameter? It gives you three distinct advantages:

It doesn't change the outside diameter (OD) of the fins. With tube fin designs, the tubes are almost always touching in three places. A fin will touch its two neighbors, and also the airframe. If you increase the OD, you'll find that the tubes now form a larger diameter "circle", leaving a sizable gap for your airframe contact point. This is another weak spot, so it's vital that this bond is strong. The best way to get a good bond is through a close physical fit. To this end, if you reinforce the outside of a tube fin and then try to build the kit using the instructions provided, like they are with the Cyclotron, you'll be in for a nasty surprise. The pairs of fins will build up just fine, but when you go to adhere them to the tube, the last set will simply not fit. I can't imagine a more frustrating experience!

When you're building a tube-finned rocket, the inner surface of the fin becomes a fantastic and often striking surface to paint. If you're like most of us, the paint job is part of the pride of the rocket. Seeing one with large spirals can be a disappointment. However, filling inner spirals of tubing can be quite challenging, as they tend to be much deeper than those on the outside and sanding is much more difficult, being on an inside radius. Fiberglassing the tube gets rid of those visible spirals entirely. If done well, the surface is like a mirror. You'll see I didn't quite get there myself!

Finally, the cosmetics and buildability of the kit notwithstanding, remember the primary reason for the reinforcement: we want the tubes to be stronger to survive hard landings. For those that fly on grass or other types of soft-fields, it may not be a big issue, but here in the west, it's desert hardpan.

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Even a slightly rough landing will do damage. Reinforcing the inside gives just as much additional strength as doing the outside.

So, now that we've covered the benefits, time to cover the materials and process:

You'll need:

1. Fiberglass cloth. I used 4oz weave, which is very easy to find and easy to work with.
2. Laminating Epoxy Resin. Do not try this with an epoxy meant for construction, since it will be too thick to use. This is why it's important to have a few exterior laminations under your belt first. I'm going to assume you have and will be omitting a few of the more common steps.
3. Foam brushes. Make sure they're long enough to reach more than half-way into the tube. My build had fins 5.5" long, so the standard brushes at any hardware store were perfect, and I found the best success with 1.5" wide brushes. Reusing these brushes will lead to heartache and failure, so be prepared to lose at least one brush per fin.
4. Standard Laminating Gear, such as mixing dishes, stir (popsicle or craft) sticks, a gram balance, disposable gloves (nitrile are easy to find, cheap, and safe), paper towels, denatured alcohol (to clean up drips), and a well-covered work surface. Laminating is quite fun, once you get the hang of it, but it is almost always a messy process.
5. Balloons. Get a bag or two of regular latex balloons, 9" diameter and 15" diameter. I bought two bags of each, and used the 9" for the laminations, but am glad I had the bigger ones for later, more on that in Part 2.

To begin, give the tubing a good sand with 80 grit paper on both inner and outer surfaces. Really scuff it up.

This improves the bond between the glass laminate and the tube and will make finishing later much easier.

1. To prepare your cloth, you can either go the "smart way" and calculate the inner circumference of the tube (the good old c=pi*d, but be sure to use the inner diameter), allowing for a slight overlap (½" is what I went for. Less would work, but makes the layup more challenging), or the "easy way": roll up and mark a sheet of printer paper after smoothing it around the inner circumference, again adding for some overlap, using the marked or cut paper as a template once unrolled. Don't go crazy on the overlap of the width, or you'll have a harder time with bunching and wrinkles, as well as the possibility of an unsightly bump. You'll also want to add additional length. The balloon, once inflated, is going to want to either pull the laminate through or push it back out. If you go too short, you'll end up with bare spots. With this technique, the excess is cut off, so I went with an extra full inch on both sides. My cloth ended up being 7.5"x 10" (5.5" long tube + 2" of excess, 1" per side, and 3.14*3 +0.5 for the overlap). Cut the material to the best of your ability, ensuring that there aren't a lot of loose threads (toes).
2. Carefully lay this cut material aside on a clean surface. I wasn't as careful as I should've been, and trapped a large bit of something in one of the laminations...oh well, lesson learned!

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3. To get an idea of how much resin you'll need, a quick trick is to weigh one of your cloth rectangles and multiply by 4. This will depend on both your laminating resin as well as your cloth. I've done a few laminations, and know that this will give me enough to work with, with enough left over that I'm not kicking myself (nor wasting a ton). Put on two pairs of gloves, and follow your resin manufacturer's instructions to measure the right amounts of resin and hardener, and mix it well (**Figure 1**).

**Figure 1: Fin and mixed epoxy.**

**Figure 2: Epoxied inner surface.**

4. With one of the brushes, begin to wet the inside of your first fin (**Figure 2**). I marked a line on the outside of the tube using a piece of angle aluminum, just like you would to draw a fin mount line. It ended up not being terribly useful, so feel free to skip this step. We can do it later, and with sufficient extra length on the cloth, if it goes on a bit crooked, it will still overlap and form a complete skin inside the fin.

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**Figure 3: Folded cloth in thirds**

**Figure 4: Cloth laid into epoxy as a bundle.**

**Figure 5: Half-way pressed into epoxy.**

5. Once you've got a good layer of resin, pull off the outer set of gloves so you have fresh clean gloves, and fold one of your glass fabric rectangles in thirds (**Figure 3**), ensuring that you're leaving the dimension of the length of the tube unchanged. For example, I laid out my rectangle so the long dimension was in front of me and the shorter dimension away from me.
6. Now, pick up this "cigar" of cloth, and lay it into the wet epoxy in the tube (**Figure 4**).
7. Begin to unroll the bundle, smoothing the surface in one direction (**Figure 5**). Using a long clean stick, press the cloth into the resin. Continue this in the same direction until you reach one of the free ends. At this point, you have about half a bundle still roughly rolled, and half laid out into the wet epoxy. Keep working the unrolled half into the resin, ensuring that there aren't wrinkles or big air voids, working the cloth into the resin. It probably won't fully wet out, but that's okay, we'll get to that.

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**Figure 6: Additional epoxy applied to the edge, before the rest is laid out.**

8. Now that the one free edge is firmly down, go back the other way (**Figure 6**), repeating the process of pressing and smoothing until you find the overlap. On my first fin, I just continued to push the cloth down and found that the first layer of the overlap soaked up all the resin and left the bit overlapping dry and harder to work with. On the second fin, I stopped here, and grabbed the brush and put another layer of resin down on top of the first edge, and then smoothed the second end into the fresh layer of resin. This made it a lot easier.
9. At this point, you've got your fiberglass cloth laid into the layer of resin and no wrinkles. If you do, keep working the material. Also, look for big gaps and ensure that the cloth hasn't pulled away from the inner surface It's easy to "wind" the cloth up just a bit, pulling a portion away from the wall. This adds no strength, so be careful, and ensure that the full surface of the cloth is married to the wet tube. At this point, you have more epoxy in your dish if you measured correctly, and

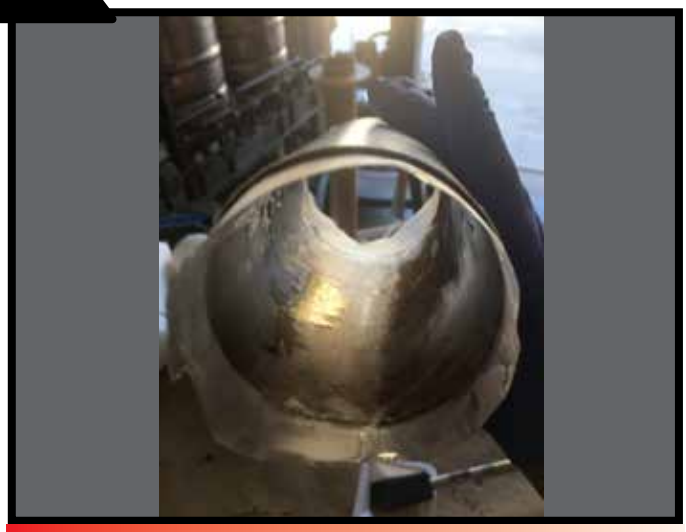

**Figure 7: Cloth fully wetted out.**

a very wet foam brush. These things suck up a ton of resin, and even get longer and quite floppy. Grab that brush and go back over the glass, wetting it out completely (**Figure 7**). The epoxy will be quite slippery, and you'll find the cloth wanting to move around. Keep it in place to the best of your ability, ensuring again that it remains married to the inner surface, and that you're not introducing wrinkles. It's not as hard as I'm making it sound, but it is important and can't be fixed later.

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10. Once satisfied, take a look at the overhanging cloth on both ends of the tube (**Figure 8**). Make sure that it's roughly even and that the cloth is also fully wetted out. Take a few seconds and dab some more resin to the free-hanging cloth. It will be removed later, but having it wet will make the trim-up much easier later.

**Figure 8: Getting ready for the balloon. Notice the cloth overhanging in the tube.**

11. Now comes the magic, which you probably already predicted by seeing balloons as part of the materials list. Get yourself a fresh pair of gloves, grab one of your balloons, and, holding the tube vertically in one hand, hold the balloon in the other so it hangs down more than half-way through. In my case with a 9" balloon, I had to have my nose almost in the tube. If your cloth is overhanging too long, you're going to get resin on your face, which isn't safe. Use a bigger balloon if this is the case. If it's too close to the top of the tube, it won't inflate evenly, and you'll find all your hard work of laying up a nice laminate pull itself out as the balloon inflates. Once relatively confident of the placement, gently begin inflating the balloon. You want to try to force it out of the far end of the tube forming a bulb. At this point, you can move the tube a bit away from your face, giving the balloon space to begin to inflate on the end closest to your face. Stop here a second, pinching the balloon shut. Inspect your progress: you want the balloon roughly symmetrical, but it won't be perfect. Key details to confirm are that the balloon is pressing the excess material to the tube wall and flaring it out slightly on both sides, and that excess material is visible on both ends. If it's not, it may have shifted inside. I had this happen a few times, and you'll lose the benefit of the laminate. If this happens, slowly release the air. If you just let it go, the laminate may stick to the balloon, pull away from the wall, and you'll have a lot of fixing ahead of you. A slow release tends to leave the cloth on the wall. Reposition your fabric, put on fresh gloves, grab a fresh balloon, and try again, making corrections based on what happened (hold the balloon deeper into the tube or not as deep). If things look good this time, or if you're satisfied with your first attempt, tie off the balloon (**Figure 9**), and find a way of setting it aside. The balloon will press out a lot of excess epoxy, and depending on how you hang or lay it down, it will flow. If you really wetted the cloth out well, quite a bit of resin will be squeezed out. This is what we want! It ensures optimal resin to cloth ratio and keeps the weight down. Leaving it one place will cause a surprising amount of epoxy to flow to the low spot. Be prepared to clean this up periodically as it cures using the alcohol. This length of time will depend on the cure rate of your chosen resin and the weather you're experiencing: hot dry weather sets it faster, while cold or damp weather will extend the cure time significantly.

**Figure 9: Balloon filled and cloth wet on both sides. Note it's not equal, but doesn't have to be.**

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12. Once you've got your first fin done, you can move on to the next… if you have the space and nerves to keep going. There's no shame in doing these one at a time! If you do try to do more than one at a time, do not reuse your weigh boat, mixing stick or brush. Set those aside. You can throw them out, but sometimes the brush and boat can give you a sense of the cure progress without having to manhandle the now-curing balloon-filled fin. Grab a fresh set, and go back to the beginning of the process.

For my build, I did this 6 times. I did the first fin one day to check my technique, and then the remaining 5 in one shot the following day.

Don't wait until the epoxy cures fully. You want the green or "leather" stage, where the epoxy is set but not yet fully cured. The wetted cloth that hangs out is still flexible, but not at all wet or sticky. At this point, the cloth won't move, so grab your favorite Xacto and pop the balloon. It'll make a cool sound, and you'll probably notice that the end you popped disappeared, but the other end now looks like a drum. With freshly gloved hands, grab the balloon and pull it away from the inner wall, removing the balloon remains. If the glass is at the right texture, you can easily trim the excess away from the ends, using the tube itself as a cutting guide. The longer you wait, the harder this gets. If you let it get a full cure, you'll need a saw, so don't wait that long! Going too soon means that the cutting action can pull the cloth away from the wall since it's not cured enough to bond well.

At this point a few things should become apparent: the inner surface of the tube now looks very smooth! If you see air pockets or small voids in the surface, you can apply fresh epoxy and do the balloon thing again or, if only the weave of the cloth is all that is visible in a few small areas, you can touch it up later with spot putty. If you have big swaths of dry cloth, it means you didn't wet it out enough, and this tube should be a learning experience since you won't be able to save it. When laminating external surfaces, there are a few techniques that ensure you reach a smooth surface. But, ironically, using a balloon makes this far easier than any external layup, so sit back and enjoy the optimal ratio of resin to glass that you just obtained using a child's toy! This also gives the epoxy time to set up fully, before moving on to Part 2 (minimum of 24 hours in most cases). Once fully cured, go ahead and sand the edge square. This may require a power tool, but no matter what tool you use, make sure you're wearing the right PPE as fiberglass fibers are bad for your lungs and skin. A few seconds on my benchtop belt sander left me quite pleased!

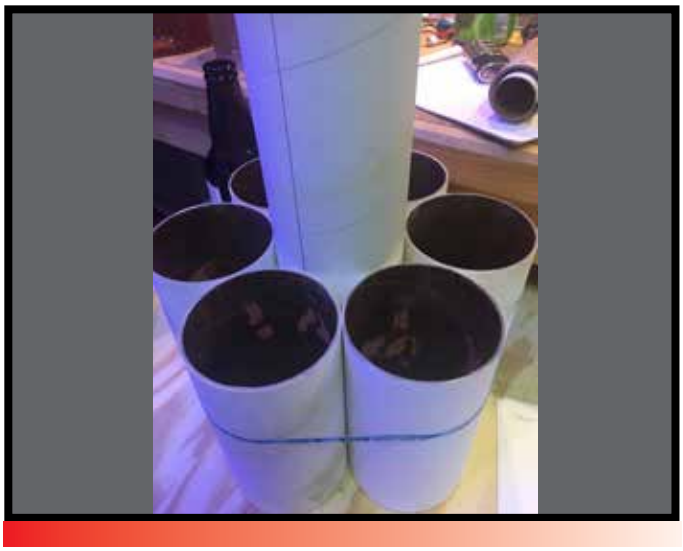

**Figure 10 – Finished fins with spot putty touching up minor imperfections, mocked up on the airframe, not yet sanded.**

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If you've done this one tube at a time, take a moment and gently squish an unlaminated tube versus the one you just laminated. The difference will be astounding.

### *Conclusion*

This article takes care of the two of the benefits: increased strength and a finished, glass-like smooth surface. Check out Part 2 for how to get the last benefit, a striking color contrast, while still maintaining easy and strong assembly!

### *About the Author:*

Dave Juliano is a Born Again Rocketeer who got back into the hobby with his own kids after attending a local club launch a few years ago. He's currently a Level 2 certified flier and enjoys the build process the most. His first and still favorite rocket is Estes Big Bertha, and now proudly flies three sizes, with a High Power upscale planned. He and his family live near Tucson, AZ, and fly with the Southern Arizona Rocketry Association (SARA), but not as often as they would like.

**Figure 11: Author Dave Juliano**

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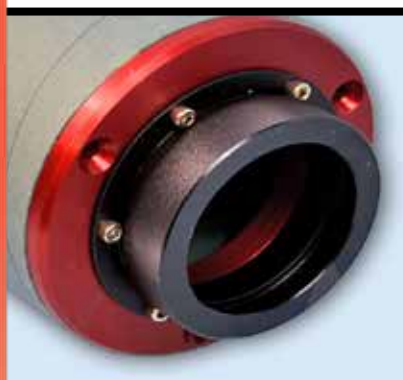

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