PEAK OF FLIGHT NEWSLETTER

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GLUE SELECTION AND APPLICATION TECHNIQUE

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PEAK OF FLIGHT

Glue Selection and Application Technique

By Phil Woolfson

As an avid rocket builder and as a life-long builder of many things, I begin each project by deciding how best to fasten its parts together, so that I can end up with a strong and long-lasting result. There are a great many adhesives available, and for any given assembly, a small subset of those adhesives will typically yield the best results. In addition to glue choices, I have found that by using certain techniques, you can avoid assembly problems and wind up with a great rocket, one that will be as enjoyable to fly as it is to build.

This guide applies to the most popular style of rockets, those made with balsa fins, a rolled paper tube and (typically) a plastic nose cone. In this basic construction, we are dealing with porous, semi-permeable and non-permeable materials, and we must select the proper glues for each. There are a number of glues used in rocket building, and in your build you may select one or more depending on the steps needed to build your individual rocket. Let's look at the pros and cons of some of the most popular glues:

Most Used Adhesives

- **Yellow Glue:**
  Elmer's Woodworking Glue or Titebond II

  Pros: Excellent strength, fast initial setup, safe, easy to use, fairly inexpensive. Great for all wood to wood, wood to paper.

  Cons: Not for plastic

- **Marine or Industrial epoxy:**
  West System, Total Boat, Ever Coat

  Pros: Incredibly strong, versatile, multiple viscosity possible, great for all assembly of High Power and Low Power kits. Will adhere to smooth surfaces.

  Cons: Expensive, complicated to use, requires many components, short pot life, can have strong odor and some components are hazardous, requires ventilation.

- **5 Minute Epoxy**

  Pros: great for fillets.

  Cons: can be messy to apply

- **White Glue:**
  Elmer's School Glue

  Pros: Good additive to soaking water for water slide decals, non-toxic.

  Cons: Less strong than yellow glue for assembly

- **CA adhesive:**

  Pros: Fast setting, great for certain applications like body wraps and fin skinning. Dries very hard.
  Note: for body wraps, you must use a low odor AC so as not to damage the plastic.

  Cons: Bonds skin instantly, can be brittle for structural use.

- **Model Glue:**

  Pros: Excellent for gluing plastic assemblies together.

  Cons: Shelf life. Only for assembling styrene

Less Useful Adhesives

- **Gorilla Glue:**

  Not really useful for rocket building. It requires moisture to set and requires a lot of clamping pressure to keep from separating the materials as it sets up. It expands as it sets so it will leave excessive residue. It is really

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meant for exterior construction use. It is strong and waterproof, but it's not a best choice for our hobby.

- **Construction Adhesive, Silicone, Contact Adhesives:**

  These are not designed for strong, rigid connections that we want when assembling rockets. Heavy and tend to be messy. Hard to remove from surfaces and skin.

- **Hot Glue:**
  Hot glue is not structural and can separate easily from materials. Not trustworthy for structural connections.

Tips for Gluing

While some building techniques apply specifically to various glues, others work well for a variety of adhesives. These are methods that I have found to make assembly easier and provide satisfying results.

Motor mounts

I typically begin a rocket by assembling the motor mount. The motor mount is responsible for keeping the motor stable throughout various phases of the flight. This includes the liftoff phase, where the mount must keep the motor from traveling up through the rocket, which is never good, as well as the deployment phase (on single deployment rockets) where the mount is responsible for holding the motor in place so that the ejection gasses can push the recovery system up and out of the top end.

FIGURE 1: GLUE THE TUBE SLIDE THE RING

Gluing this assembly can be easy and effective as long as you keep a few things in mind. First, let's examine the construction of body tubes. On most low power rockets, the material used for the body tube and the material used to construct the motor mount are similar. They are essentially a wrapped paper tube and are often somewhat slick on the outside. For these tubes, light sanding will improve adhesion, particularly when woodworking glue is used.

When filling the grooves in the main body tube, you'll be sanding it. You may not think to sand the tube for the motor mount, as it will not be seen and you are not likely to paint it, but sanding the motor mount tube prior to gluing it will make for a better connection. You also have the option to use epoxy for this, and some people prefer epoxy as it does have typically greater strength than the yellow glue.

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One benefit to using epoxy is that it will adhere better to a smooth surface, another is that it tends to be more heat resistant.

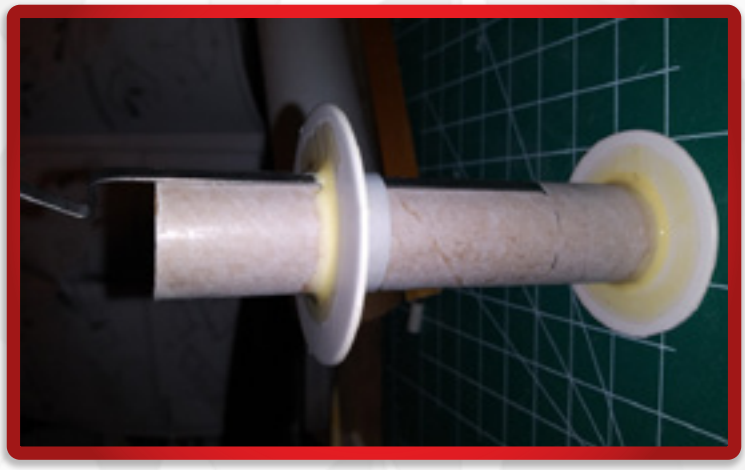

FIGURE 2: MOTOR MOUNT

Yellow glue, on the other hand, is a bit easier to work with, less toxic, and is quite a bit stronger than the paper tube and rings that you are connecting. It does not need to be mixed, so there is no pot life to be concerned with. Pot life refers to the length of time that a two-part mixture has, once mixed, before it begins to harden. Epoxy that hardens before it is used must be discarded.

If you opt for yellow glue to assemble you motor mount, you should begin by gathering all of the components and seeing which ones have shiny mating surfaces or the surfaces where the glue is to be applied. These areas should be scuffed – that is lightly sanded with fine sandpaper, such as either 220 or 320 grit, until they take on a matte finish. Wipe them down, and you are ready to assemble your motor mount. It is a good practice to carefully measure and mark your mount according to any instructions provided. Depending on the relative diameter of your motor mount and body tube, you may have either rings or discs to install onto the tube. If you have discs, you may want to make sure that they are on perfectly straight once glued into place. This can be done using anything square and holding it up to the tube and against the disk. For rings, this really isn't needed.

Best results can be achieved by first marking just under where the ring/disk will be installed and mark them all at the same time. Then, starting at one end, put a small line of glue above the mark, and then slide the ring onto the glue, wiping off any excess. Repeat for any remaining parts, check to be sue that they are square and then allow

FIGURE 3: GLUING INSIDE TUBE

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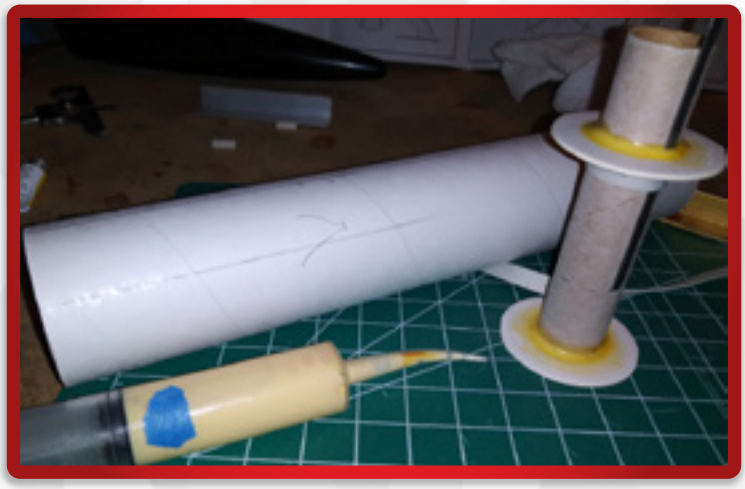

FIGURE 4: TAPE MARKS GLUE DEPTH

to dry. If you are using flat centering discs, adding fillets will add strength. If using yellow glue, it works best to build up your fillets in layers to prevent getting too much moisture into the tube at one time. Also, it is neater and gives you more control. If on the other hand, you have decided to use epoxy, this is not as much an issue.

By gluing carefully, you can get the best adhesion with the least amount of weight, as you can avoid excess glue that isn't actually adding strength.

When you glue the motor mount into the body tube, measure where the rings are going to make contact in the body tube and apply a ring of glue onto those areas, then slide the motor mount assembly into the tube where the glue has been applied. It is important to keep going once you begin, because if you pause while installing the motor mount, it could become stuck where you don't want it, so take a moment and plan this step carefully.

If using epoxy for this step, you have a bit more time to get the mount installed, but in either case, it is always a best practice to put the glue on the tube, whether on the inside or the outside of the work, than to put the glue on the rings. It is also a good idea to have some sort of applicator.

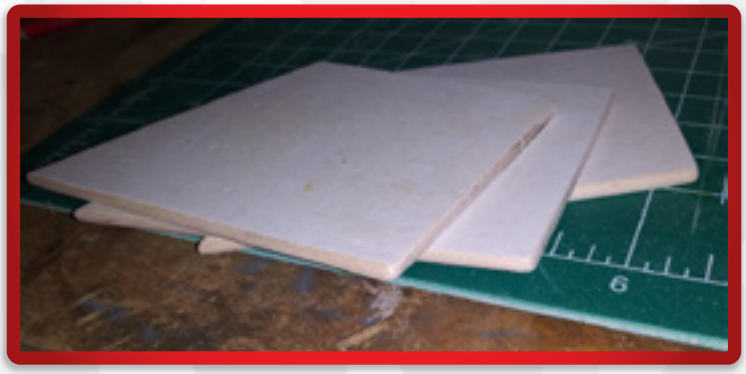

FIGURE 5: FINS READY

Fins

Fins receive considerable aerodynamic forces in ascent and often take most of the impact in landing. It is important that they are attached properly, with the two main considerations being the grain direction and the method of attachment. If you look at a fin as it is ready to install onto the rocket, you will notice that the grain of most wood fins, being made from balsa, is fairly straight.

If you were to mount a fin so that the grain runs parallel to the body tube, it would have very little strength, because thin balsa like that which is typically used for fins on a low power rocket will easily break along the grain unless it is reinforced. And just how do you reinforce the balsa?

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FIGURE 6: GLUE AMOUNT FOR PAPERING

Fins should always be cut so that the grain runs away from the body tube. This way, when the fin is attached, the tube serves to bridge across the grain, reinforcing it. This helps to make your rocket sturdier and helps to increase the likelihood that it may be flown, recovered, and flown again. While we are talking about reinforcing your fins, there is another technique that you may wish to add.

Papering Fins *(optional – advanced technique)*

Gluing a layer of paper over each face of the fin can add a great deal of strength to your rocket. This is because once you add this skin to your fins, you are basically not only making them into something that is more like plywood, which is much stronger and more stable than a single piece of balsa, also if done correctly, you are also decreasing the amount of prep you would need to achieve a very smooth paint job, as you have less grain to deal with.

You could use either printer paper or tracing paper to cover your fins. You can use either yellow glue, epoxy, or CA adhesive. Each has advantages and disadvantages. Yellow glue has a lot of moisture so it is very important to use the least amount that will work, otherwise you may not end up with a smooth surface. CA may bleed through the paper, as can epoxy so you'll want to use wax paper to keep the fin from sticking to the table. Again, use the least amount of glue possible to minimize cleanup. While there are a variety of ways to hold the paper in place as the glue sets up, all you need to get started is a flat surface to work on, a flat item to place on top, and something to weigh it down, or a clamp.

Using these simple tools, you'll get a flat fin, and you may then dress the edges as you like, rounded, tapered, etc.

A few general good practices for this technique: Always glue up both sides at one time. If you do not, it is guaranteed that your fin will end up concave on the first papered side. As the glue sets up, it has a tendency to cause the paper to shrink. As long as you do both sides at once, the fin should set evenly. Make sure that there are no dry spots. Still use the least amount of glue possible. We want to keep the paper smooth, and make sure it sticks thoroughly. Give the assembly at least 24-48 hours to dry, depending upon the temperature. Most adhesives take longer to dry when it is cooler.

Epoxies can be a bit trickier. You want epoxy to be thin enough to spread easily, but if you are going to thin it with a solvent, you want it to gas off a bit before applying

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the paper but not so long as it starts to set up. If mixed properly, it will set up, but too much solvent could affect the surface of the paper.

If you do this properly, your surfaces should require little to no sanding. If you end up sanding through the paper on either side, you won't get the desired results. If you think this is something that you would like to try on your rocket, it's always a great idea to practice on a piece of scrap first and make sure that you can get it to work. If it does, and you are happy with the results of the test piece, then you may wish to try it on your rocket. Now, this is an optional step, and you can certainly build a great rocket without it. If you are building a rocket whose fins extend past the tail and wish to be able to use a smaller chute for closer recoveries, this might be something you want to try.

FIGURE 7: GLUE ON FIN EDGE

Attaching the fins

Before you attach the fins to your rocket, you'll want to install your motor mount and fill the spiral in the body tube. This makes overall assembly easier, and you now have a sanded body tube upon which to install the fins. Most kits come with a marking guide to determine where around the body tube the fins must be placed. I prefer a fine point mechanical pencil to mark my body tubes, for greater accuracy you can use a door frame to trace the lines up the tube, or even get a narrow piece of aluminum angle and use that. The object is to make sure that the lines you draw to place the fins (and launch lugs) run perfectly parallel to the body tube.

The body tubes that are used for the majority of LP rockets are rolled from paper so when selecting your adhesive, you must consider that you are gluing that fin to the outermost layer, and that the joint can only be as strong as the attachment between layers. You may choose again between yellow glue and epoxy, but keep in mind that while the epoxy might offer a stronger joint, it won't really result in a stronger rocket most of the time. This is because a good quality yellow glue is already much stronger than either the tube or the fin.

I prefer yellow glue for the attachment part of the process because it sets much faster, can be done without clamping in many cases, does not need to be mixed, no pot life to worry about and is just easier. For filleting, however, you might prefer epoxy if it is thick enough, as you may be able to apply your fillets in one pass. Consider however that if you must thicken the epoxy yourself, the additives could be very harmful to work with without the proper safety equipment and training. If you are using epoxy for

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your fillets, you may want to sand a narrow strip of balsa to shape for the desired fillet size, that way you can just draw it across your epoxy while it is not yet setting up to define the shape of your fillet. When you are done, just clean the stick with some solvent to preserve it for further use.

If you fillet with yellow glue, you may want to build your fillets up using a few layers of glue. Your fingers are fine for forming the fillet, as the glue is not harmful and can be easily washed off. You might make as many as five or more passes, each one blending the fin to the body tube just a bit more.

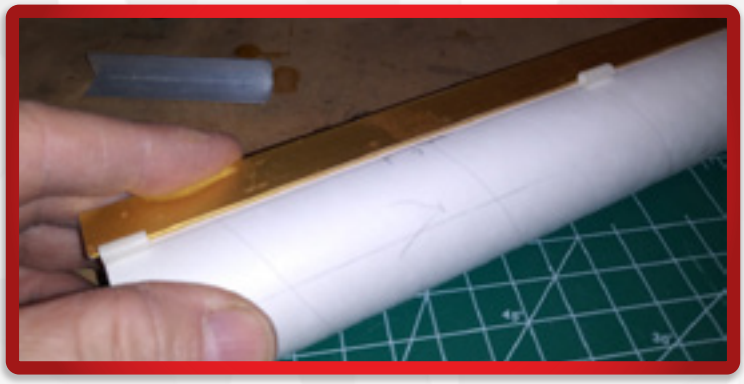

FIGURE 8: LUG ALIGNMENT

Launch Lug

The launch lug can be attached in pretty much the same way as the fins. If you are using two launch lugs, you may wish to use a straight edge, such as the doorway trim, or piece of aluminum angle or other tool you may have to align them. If using the door, you may want to install the lugs before the fins. It is a good idea to lightly sand the launch lug prior to installation, and you want to make certain that no glue gets into the interior of the launch lug, as that could impede the rocket from leaving the launch pad.

FIGURE 9: RESULTS

Nosecones

Most nose cones today are made of plastic, and they may be made of either one or two parts. Most plastic nose cones have a built-in anchor for the recovery system, and it is typical to fasten the shock cord by tying and gluing the knot, so that it cannot slip when it is under load. Whether your rocket uses a shock cord or an elastic (rubber band) style cord, it is advisable to fasten the cord using a knot that is going to be strong enough for your particular rocket. If you are building a very lightweight rocket, a couple of half hitches should do just fine. If the rocket is heavier, you may wish to incorporate a bowline, which is a common and very strong knot which is often used by sailors, because it is designed not to work loose under tension. Don't overestimate this, however.

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Once you have you the knot secured to the nosecone, you may ask if you should secure it with glue, and I would recommend that you do, because you don't want it to slip, and because it is good to be able to trim the free end as close as possible to the knot to avid it from interfering with the deployment of the recovery system. You have a couple of options here if you are using elastic as a shock cord, you would use either yellow glue or CA adhesive. You want only a very small amount, and it is most effective to glue the area where the free end comes from the knot. If you are using a rubber shock cord, a small drop of CA adhesive will do a nice job of keeping the knot in place.

You do not want to use a lot of glue in either case, because you want to maintain flexibility in the knot, and to allow the knot to slide along its attachment point at the nose cone, offering a bit of strain relief.

If using a two-piece nose cone, then you will want to use the correct glue to assemble the nose cone. CA adhesives may be one choice, but you should bear in mind that these adhesives are not truly integrated into the plastic parts they are used to attach. Rather, you are creating a sandwich of sorts, fairly strong, but can tend to be brittle. You should bear in mind that the nose cone is subjected to various stresses throughout flight and recovery, and so the stronger the better, right?

It is for this reason that I prefer to use a model glue for this application. Model glues melt the plastic slightly, and so the result is that the two parts are actually welded together when the glue is dry. When I glue plastic, especially in a nosecone, I prefer to apply the glue to the inner surface (the main part of the nosecone) and then slip the lower piece into it. You need only a small amount of glue, just enough to get a slight, even coating of glue inside the nosecone, and you want to use something other than the tube to apply it. Various applicators are available for many glues and will allow you to get the right amount of glue just where you want it. Too little glue may not give sufficient strength, while too much may cause a number of other problems.

Any time you glue one item into another, you want to insert the item being installed in a smooth single motion, in order to prevent the item getting stuck where you don't want it. In the case of a nosecone cap, it's a good practice to turn it slightly as you are inserting it into the glued area. This will help to assure that the glue spreads evenly and that the adhesion is consistent. It is best to immediately wipe off any excess glue that may have come out of the joint, using a paper towel. Do not use your fingers to do this, as the glue may be not all that easy to remove from your fingers. It is after all made to stick stuff together.

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FIGURE 10: SHOCK CORD ASSEMBLY

FIGURE 11: SHOCK CORD INSTALLED

Shock cord to body tube

There are a couple of options for fastening the shock cord to the body tube. The option you choose can be influenced by the diameter of the body tube, and each choice has its benefits.

Many kits today come with a paper anchor for the shock cord. This angled anchor folds in thirds, with the shock cord glued and folded inside of it. It makes for a solid connection between the shock cord and the body tube. These can work well for any but the thinnest of tubes, and the installation is fairly straightforward. You fold the shock cord into the paper anchor, using a fairly generous amount of yellow glue, give it a few minutes to begin to set up, and then, while it is still soft, glue the assembly into the body tube. You want it to be far enough in to leave space for the nosecone, and you can hold it in place with any type of a spring clamp that is long enough to fit in. You want to wipe off any excess glue, trying to leave a smooth transition between the assembly and the body tube.

The other option you have is to, starting about ½" below the body tube, cut two parallel slits about 3/8" around the tube (parallel to the top of the tube) and about ¼" or so apart. Push in on the area between these cuts and glue your shock chord into the resulting flap which is created. This will leave a minor dimple that can be filled with yellow glue, usually taking a few coats. The advantage of this method is that it leaves a smoother area inside the body tube for the recovery system to deploy and weighs less once done. These work great for the smallest rockets with 13mm tubes.

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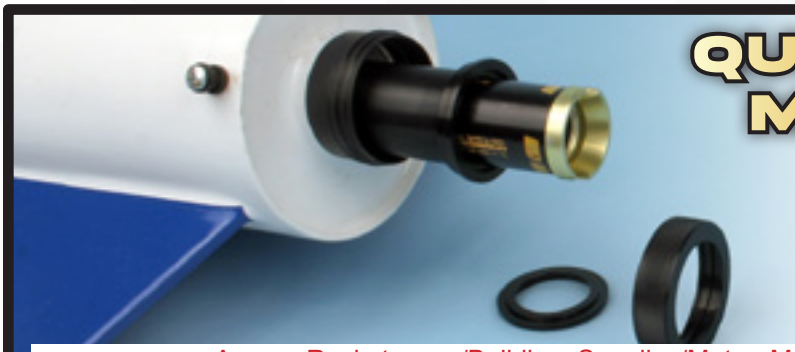

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Now that you have seen some ways to make your rocket building easier and more successful, why not get that rocket you have been wanting to build, but might have thought would be tricky? I hope that these tips will make it easy and fun!

About the author

Phil Woolfson is a master craftsman, techie, and born-again rocketeer. Upon getting back into the hobby about twelve years ago, he quickly discovered that despite his considerable tool collection, he still builds rockets using only a few simple tools. For that reason, he finds that the hobby is still just as relaxing and enjoyable for me today as it was back in the late sixties.

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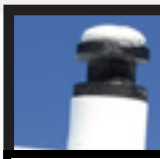

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