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Tips and Tricks
for Aircraft Homebuilders

First Edition, Bend, Oregon, USA

http://www.caro-engineering.com

ISBN 0-9752984-8-8

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Table of Contents

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Getting Started

Planning the Work

Read all the build manuals until you understand them before starting to build. To work efficiently, have a building plan. Do not just follow the instructions step by step from the manuals or drawings, but figure out where you can do several jobs from different manuals at the same time - sometimes the tasks are related. Stick to the plan and always have a primary, secondary and tertiary job list for every visit to the workshop. Then, if you have time or glue etc left over, it can be used productively. If you have a very small final job, it may be quicker to do it at the end of other work rather than starting fresh next time. For example if you have a little bit of filler available at the end of a job you can use it for some finishing work elsewhere. Don't stand in the workshop and look at it! Work on it at every opportunity if you want to finish it.

Make a list of everything you can think of that you need to do to build this plane. Date each item on the list as it is completed, but leave it on the list. When a roadblock interferes with the current task at hand, a quick reference to the "To Do" list will get the project moving again, because the list can be used to pull yourself away from the task at hand.

Incomplete items: At any given point in the project, but especially when systems are being installed in the airframe, there are usually a number of unfinished tasks going on at any time. Keep a "To Do" list and do not mark anything off it until that task is torqed, safety wired, double checked... etc. Keep the full list and date each item when it is complete. If you have to remove a bolt or take off a safety wire, take the date off of the completed task.

Keep a daily log of time on task. Just a short note of what was being done. Then when frustration sets in or it feels like you are not getting anywhere, a look at the log and "To Do" list will give you the reassurance that there is progress being made.

Try to do *something* on the project every day - even if it is only for a few minutes.

If people come to visit, after a few minute tour, get back to work while talking to them. If they insist on staying, put them to work.

Take a lot of pictures, of your own project as well as of other builder's projects and airplanes in general. You do not have to sort them but you can learn a lot on a rainy day. Digital photos cost nothing these days.

Building Time

Once you start building, you will find out what works best for you. Some people are most effective working about a 3-4 hour building session a day, but maybe not every day. Others may be used to doing 10 hours straight or just one hour in the evening on a regular basis. Each builder has a particular set of constraints to work with and effective working hours differ from builder to builder. It is really important to know your working habit and limits.

When kit plane factory quotes you what it calls 'build time', they usually mean time you spend working on the plane. It does not include what builders call 'head scratching' time. This is time we all spend looking at the manual, watching the video, calling factory support, and going through the Aircraft Spruce and Specialty catalog. Take time to think about what needs to be done next. Read ahead and see how each process will come together in the end. Then mentally plan out the work for the next session and have some rough idea of what you are going to do in what order. If necessary, order supplies and tools you might need ahead of time. By getting the planning out of the way, you can concentrate on getting the work done and use the limited shop time effectively.

- Arrange your work so that you do a task which requires curing or drying time at the end of your building session. Then you are less likely to touch it by accident or get dirt on it.
- Finish one task and give yourself some time to study the next one before jumping in.
- Keep up a regular building schedule, but do not get so carried away that you neglect everything else in your life. Balance building with other aspects.
- Don't build when you are tired, you are much more likely to make mistakes, which you will discover the next day and waste time redoing it.

Get Advice Early

It is always better to learn from other's mistakes rather than having to make them yourself. So read this paragraph and decide for yourself. One builder described a lesson he had to learn the hard way.

The seatback is the very first part he attempted to build of his airplane. It is a flat, moderately sized composite layup that is a good first project to let you learn on. The builder reports he had to re-do the part due to the fact that he really did not get up to speed on the peel-ply process and working out the bubbles before he started. As a result, his first part ended up with too many defects and he had to cut it up. While this might at first seem sad, it was an excellent lesson on many levels. It got him involved with other builders in the area because he immediately knew that the first piece was NOT how he wanted his project to go. A visit from another builder, a lesson in the best ways to learn the skill, consistent products and some new material from the supplier later, and he had a seatback that was excellent!

ADVICE - Get help early to aid in your confidence and consistency. The remainder of the parts this builder made turned out great because of this first lesson.

Understand the Concept of Your Kit

If you are building a mature kit that is known for its exact nature and user-friendliness, perhaps following the directions and drawings will be all it takes. However, if you decide to build an early kit or an immature kit, you should understand that you might have to "build to fit". That means that there are some parts you receive that are likely to change and that you need to do your constructions around them. There may be errors in the instructions or drawings. Do not blindly start making parts because these may never fit together. Build defensively, cross-check and never assume that components will just fit together.

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Shop and Tools

Heating the Shop

If you plan on working in winter as well as summer, you should think about how you want to heat the shop. Depending on the size and insulation, you may need anything from 6000 W to 2 kW. If you do not want to heat a large space, you can partition the space you need to work in and just keep it warm. If you spend time irregularly in the shop, it will hardly be worth it to keep it warm all the time. Then you should select a heater which can heat it up in a short time. Here are the methods used by some builders:

- Used oil fired hot water furnace. It was piped to a car radiator with a fan blowing through it. It is fed by a 55 gallon oil drum behind the garage that the oil company fills when they fill my house tank. Hot air comes out of the radiator at about 140°F.

- An unvented oil heater works well and burns very clean. CO levels are well within the acceptable range when running the heater. Because it only burns cleanly when it is at its operating temperature, there may be some smell when it is lighted and warming up. You absolutely have to take it outside before turning it off. I neglected to do that once and it took weeks to get rid of the smell.
- Hot air furnace (the ones from mobile homes are particularly compact).
- Wall mounted vent-less propane heater or natural gas convection heater, which can be purchased from McMaster Carr (60,000 BTU/hour output). A convection heater is more suitable to heat the entire volume of air of your shop evenly as opposed to a radiant heater which primarily heats objects in its path.
- Circulating hot water heat in the floor of the shop. Heat source is 30 gallons domestic water heater about 30,000 BTU, propane fuel. Circulation temperature typically about 85°F. 500 ft of 3/4 inch polybutylene tube in floor in two counter-circulating loops. Each loop goes out to two of the perimeter walls first. A small circulation pump runs continuously, drawing under 1 Amp.

Air Compressor

For most projects it is somewhere between nice to have to absolutely essential to have an air compressor. Many tools are powered by compressed air, it can be used to blow dust of a surface and it is needed for spray painting. The size of your compressed air storage tank is as important as the compressor itself. It really depends on what you are using it for, but in general, larger is better. The more volume you have available, the less often will the compressor have to come on. Because the compressor is noisy, it is desirable for it to either run infrequently or have it located far away from where you are working. For work requiring a lot of air like sandblasting, a compressor and tank suitable for operating tools is inadequate. An air compressor is an important part of your shop. Get a good one, not the smallest, cheapest one which may cause you headaches and cost you more in the long run. The same applies to hoses and fittings. Rubber hoses age and eventually leak or blow out (hopefully after your project is finished). Learn about the options first and evaluate them before you put your money on the table.

Vacuum Pump for Free

If you already own an air compressor, you can convert it to a vacuum pump for vacuum bagging composite layups. Remove the air intake filter. Use threaded pipe about 3 inches long, cover the

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threads with Teflon tape and screw it into the cylinder head air intake. Then take a wooden dowel about 1.5 inches in diameter, 3 inches long and drill a hole into it length wise about the size of the little attachments you clip compressor tools to (about 1/4 inch) to act as an adapter. Then screw this adapter in. Clean out any dust or chips to prevent them from entering the compressor. Buy a vacuum gauge (for auto brakes for example) and connect it inline. Slide the dowel into the threaded pipe and wrap the whole thing with duct tape to prevent leaks. After attaching a hose, turn the compressor on and watch it pulling vacuum. The theoretical value of the vacuum is 30 inches of mercury (inHg), but you can be satisfied if you get over 28 inHg. The compressor will still function like a compressor. When you need to pull vacuum, just move the hose to the other attachment. You may want to remove the oil fill plug so it does not suck oil into the cylinder.

A different approach consists of removing and modifying the reed valve setup in the pump head, and then installing it so that it sucks instead of blows. As such, you do not have to redo any plumbing and the tank now acts as a vacuum plenum, which you can close off from the hose with a simple valve. Then, when the laminate is done and bagged, all you do is open the valve so that you get an instant vacuum with a high rate flow. The pump then keeps the vacuum magnitude in the tank.

Machine Set Up

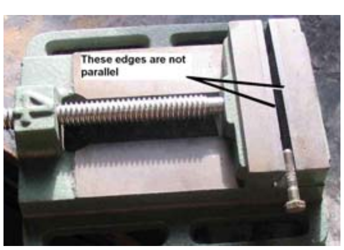
Many machines have features for set up for a specific task. Examples would be the angle of a drill press table or sander, stops or guides on a band or table saw, stops or bend radius on a brake. This can help you accomplish a certain job with more precision or for repeated operations. Once you have set the machine up, check how it performs with a piece of scrap material. Measure it to verify this is really what you wanted. Often you will find that a further adjustment is needed because of flexing of support, machine, blade or spring-back.

Magnets as Clamps

Have you ever had to reach around corners, way down into hard to access spaces where you needed to clamp a part? Consider magnets as clamping devices. You need two of them, one on the outside and one on the inside to clamp two pieces together. The thicker the parts, the lower is the clamping force because magnetic force rapidly diminishes with distance. For some really serious clamping force, use super strong rare earth magnets. Be careful! Neodymium alloy magnets are strong enough to be dangerous to work around. Big ones can easily break or crush fingers if they take off and snap together.

Clamping Small Parts in a Vise

Sometimes it is necessary to clamp a small part in a vise on one end. Unfortunately the edges of the vise do not stay parallel and the part is not held securely. When pressure is applied to the part, in which you wanted to drill a hole, it will rotate down. To avoid this problem, simply insert a second part of the same thickness at the other end, this will keep the clamping edges parallel.

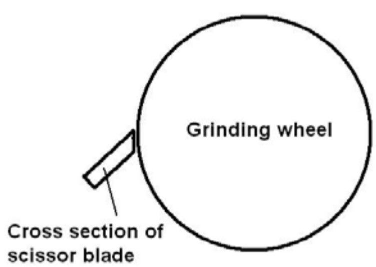


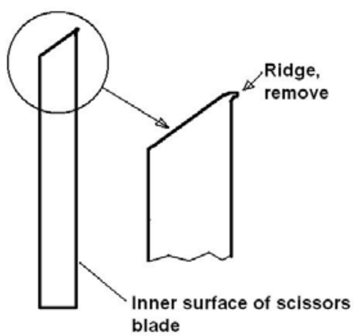
Scale in a Bag

An electronic scale is the most useful tool for measuring resin in the correct proportions. Unfortunately it seems to be impossible to pour resin into a cup on the scale without spilling some. I put the scale in a plastic bag to protect it. I can push the buttons and read the display through it. When it becomes too sticky, I replace the bag.

Procedure to Sharpen Scissors

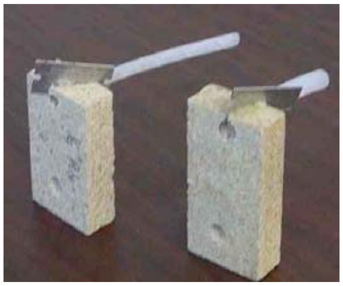
Scissors used for cutting fabric (glass, carbon etc.) work fine for a while. But because the fabric material is very hard, the blades dull quickly. The results are frayed fibers, uneven cuts and blisters on your fingers from the hard work, especially if Kevlar is involved. Sharp scissors cut easily and cleanly. Unless you are able to sharpen your scissors frequently, cutting fabric can quickly become a frustrating job. To sharpen scissors, you will need a grinding wheel, which can also be used to sharpen drill bits and other things. Open the scissors wide and hold one blade against the rotating wheel at the angle shown in the sketch. Start as close to the hinge of the scissors as possible. Slowly draw the blade across the wheel towards its tip while maintaining the same angle. You should just see the sparks coming over the top of the cutting edge. If they stay below the edge, you are not reaching the edge. Look at the edge; it should be at the same angle the full length of the blade. The old surface should have been ground away. If any of the old surface at the cutting edge remains, repeat the process. Once you have sharpened both blades and close the scissors for the first time, close them by pushing the blades apart with your hand so that they do not touch until the blades are fully closed. Then open them while pressing the blades together. This removes the slight ridge on the cutting edge which is the result of the grinding. This can also be done with fine sandpaper or a stone drawn over the inside of the blade. If you do not remove this ridge, the scissors will not cut well and dull very quickly. Now the scissors are ready to use.





Spiral Tubing Cutters

Spiral tubing can be used to keep wire bundles together or as anti-chafe covering for tubing. While you can buy spiral tubing in various sizes, you could also make it yourself if you have surplus regular tubing available. To cut the tubing, for example polyethylene, into a spiral, you need to make a very simple little tool. Take a scrap of wood and drill a hole near the edge that is slightly larger than the tubing you wish to cut. Saw a thin kerf in the edge of the wood, to intersect the hole at an angle, bond a razor blade into the slot such that it protrudes into the slot just enough to cut through the wall of the tubing and the tool is completed. To make spiral tubing, start feeding tubing into the hole with a twisting motion while pulling it out the other side. If you have different diameter tubing, make a tool for each size. The angle of the razor slot establishes the spacing of the spiral cut. You will have to experiment a bit to get what you want.



Drill Press

Maybe you can build your airplane with only a hand drill. But I found that a bench model drill press is very useful. A drill press is especially valuable for cutting large, accurate holes. For small holes, a high speed hand drill works fine. When you are shopping for a cheap one, watch for a few things. The table should not flex down when you put a lot of pressure drilling something hard. The speed should be adjustable. This is typically done by moving the drive belt from one pair of pulleys to another. The table on cheap models slides up or down for adjustment. This is fine if you do not mind the extra work. It is more convenient if the table can be cranked up and down with a hand crank.

Depth Stop for Drill Press

The depth stop on an inexpensive drill press can be so awkward and time consuming to adjust that it is seldom used. If it requires winding two nuts up and down, you are probably thinking it is not worth the effort. The picture shows an alternative approach which you can build yourself, which allows fast and easy adjustments of the stop. The concept is the same as the cotter used to lock a lathe tailstock. It takes only a fraction of a turn to lock or unlock and is very secure when locked. You may find that you use the depth stop far more than anticipated when you have this modification.

Construction is simple and you can use whatever material you have available. You will need a rod to replace the original threaded rod. A rectangular metal block is used as the stop block body. A cotter is made from 3/8 inch round (about 3/16 inch longer than the stop block body) by end drilling for a 10-32 tap, clearance drilling just over half the length, then tapping.

The stop block is pilot drilled to provide the intersecting holes when drilled to size, where the hole for the stop rod is positioned so the block will be about 1/16 inch from the scale of the drill press. The pilot for the 3/8 inch hole is placed so the center clearance hole will have about a 0.050 inch wall in the bottom of the cotter. The cross-holes are drilled to size, carefully, (shaft hole first) because of the interrupted cut part way through. The shaft is put in place and drill shanks are used to try in the 3/8 inch hole to measure the clearance; this shank size is subtracted from 0.375 inch to find the depth of the cotter. The 3/8 inch round is side milled with a 15/64 inch cutter at the center to the appropriate depth for the cotter, then cut in half at the bottom of the cotter with a 0.015 inch slitting saw. As the knob you can use any knob you may have available. It is drilled for a press fit on the head of a 10-32 socket head bolt. Cross drill the stop rod but if you have a suitable nut, a longer thread would be another way to lock it in place. With the rod in place and the cotter positioned to match the hole for the rod, run the stop block onto the rod and tighten the knurled knob to lock the block to the rod.

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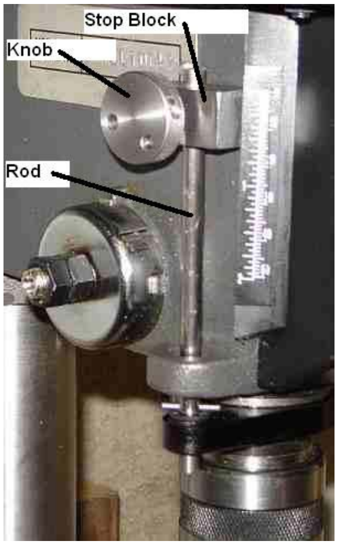
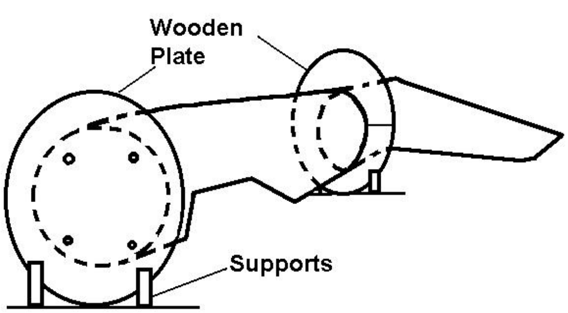


When not in use, the stop block is positioned so the top edge can be used with the scale for depth readout. To use as a depth stop, loosen the knob and lower the drill to the desired depth, push the stop block down against the contact and tighten the knob to lock the cotter. It takes little torque to lock it solidly. Alternatively, to drill to a depth, lower the drill point against the item to be drilled and put a spacer equal to the desired depth between the stop block and its contact point, push the stop down against this spacer and tighten; remove the spacer and the depth is set.

Considerations for a Fuselage Turning Jig

A fuselage turning jig enables you to rotate the fuselage by yourself so you can work on it at different angles. Depending on the size of the fuselage, it may or may not be practical to build such a jig. Consider the height of your shop first. With the turning axis level and the fuselage upside down, with the vertical tail pointed down, how high would the fuselage belly be? Can you still reach it to work on it? Will it still fit in your shop? Would it be sufficient to turn the fuselage sideways?

Once you have determined how far the fuselage will be turned, examine the fuselage for hard points to attach it to a jig. In front, the engine mount hard points are probably the most suitable ones. On the tail this might be more difficult. Does the tail end have hard points for the attachment of the horizontal tail? If not, the best solution is usually to fit the jig around the thinnest part of the fuselage itself, at the location of a bulkhead so that the skin is not overstressed.



A very simple jig consists of round pieces of plywood. The fuselage can be rolled around on the floor to any angle only limited by the vertical tail. It is low enough to easily work on. The height is determined by the diameter of the wooden plates. Support legs which are bolted on, hold the fuselage at the desired angle.

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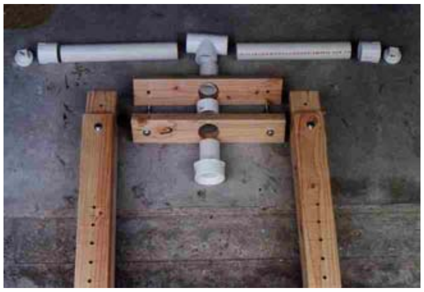
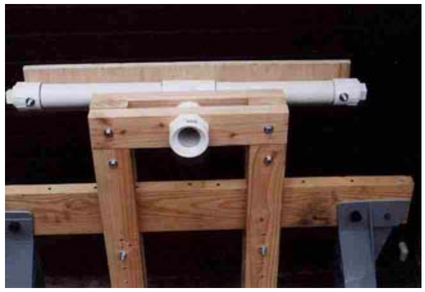
If your fuselage is small and needs to be raised up to work on it, consider the following jig. The support frame is spaced to fit on a saw horse. The pipes can be metal, or plastic if the fuselage is light enough. The pictures show a turning jig constructed using 2-1/2 inch PVC plumbing pipe and fittings. These are assembled and glued together with a framework of wooden boards. The two vertical legs are made to slip down on either side of the sawhorse. There is a spacer used to lock the pieces together and keep the jig from sliding too far down on the sawhorse. The holes are used for a nut and bolt which can be tightened to lock the jig at any desired position.

The tail end of the fuselage can simply be supported on a saw horse.


Another possibility is buying an engine stand and fabricating some 1/4 inch steel angle to fit the engine mounting holes on the firewall. This stand allows you to move the fuselage around the shop and you can rotate it when working inside or on the bottom of the fuselage.

Consider if you really have to build and attach the vertical tail before you have done most of the work on the fuselage like gear, etc. Once you build the vertical tail, rotating the fuselage becomes much more difficult.

Wing Turning Jig

When you prepare to paint a wing, keep in mind that for best results it is important that the stream of paint remain continuous as you move across the surface area. The problem that comes up is how to keep that stream of paint continuous as you move from the top to the bottom of the wing. A solution which has worked well for some builders is described here.

Begin by constructing two round wooden discs about 24 inches (or a size appropriate to your wing) in diameter and cut them in half. Using a band saw, notch each piece of the half round to fit the dimensions of the spar. After you place the two half rounds over the spar, use steel plates drilled with 4 holes to bolt the two half rounds together. This way, a wheel is placed on either side of the centerline of the wing spar as shown in the left sketch.

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