Chapter 1 Introduction to the Lancair ES FastBuild Kit

1.1 Introduction

The purpose of this chapter is to familiarize you with the use of this manual, the general philosophy behind its layout, how to set up your shop and what supplies you will need. You should also read the recommended books to familiarize yourself with glassworking if you are a newcomer to fiberglass construction techniques.

Always refer to the *Glossary* on page G.1 for definitions of unfamiliar terms.

1.2 Recommended Reading and Background Information

This manual provides detailed step-by-step instructions for assembling the Lancair ES Kit. Hands-on experience with fiberglass construction techniques and various hand tools is assumed. If you do not have this background knowledge, we recommend that you study the following texts.

Composite Materials Practice Kit

This kit contains various materials with which to practice and develop your fiberglass construction technique. It also contains a copy of Burt Rutan's *Moldless Composite Sandwich Homebuilt Aircraft Construction* book described below. This kit is recommended for all newcomers to fiberglass construction and is a good refresher for everyone else.

Moldless Composite Sandwich Homebuilt Aircraft Construction by Burt Rutan

Though the hot-wire shaping technique covered by this book is not used on the Lancair, this book has a great deal of other excellent, basic fiberglass construction information. Highly recommended.

Building Rutan Composites Video tape by Burt Rutan

Although it covers some techniques not used on the Lancair, it shows you how the experts handle fiberglass construction. Highly recommended.

Composite Construction for Homebuilt Aircraft by Jack Lambie

This book is an additional source of useful construction information and goes into the theory of aircraft design as well. Jack's Chapter 9, *Safety in Working With Composite Construction*, is particularly worth reading. This book would be a useful addition to the above.

Kitplane Construction by Ron Wenttaja

This is a resourceful book with information on metal, wood, and composites.

The above publications, practice kit and video tape are available from:

Aircraft Spruce and Specialty Company

Address:	225 Airport Circle Corona, CA 91720
Toll-free order line:	(877) 477-7823
Customer service:	(800) 861-3192
Fax:	(909) 372-0555
Email:	info@aircraft-spruce.com

The following recommended books largely describe aspects of aircraft construction other than working with fiberglass:

Firewall Forward by Tony Bingelis

This book is filled with vital information about engine installation. You'll need this when you're getting ready to install the engine.

The Sportplane Builder by Tony Bingelis

This book has useful information on aircraft construction in general such as electrical systems, instrumentation and fuel systems. The chapter entitled *You and the FAA* gives important information on the procedures that you will need to follow during construction in order to get your homebuilt's airworthiness certificate.

These two books can be obtained from:

EAA Aviation Foundation

Address:	Whittman Airfield Oshkosh, WI 59403-3065
Phone:	(920) 426-4800
Internet:	www.eaa.org

1.3 The Manuals, Blueprints and the ES CD

Please read this manual! We encourage you to read this manual and then use it as your reference tool as you build your airplane. In this age of computers that are user friendly, cars that provide a warning light for every change in status, many people are out of the habit of reading manuals. That philosophy will not work here. While there really aren't any complex steps to building this aircraft, there are many that must not be overlooked. So, please do read this manual.

Each chapter should be read entirely and understood before beginning the work it describes. The equipment and supplies called for in each chapter should be on hand and ready for use.

1.3.A Manual Layout

For ease of use and understanding, this assembly manual is laid out in a logical progression of assembly steps. This manual is organized as follows:

Chapter 1 – Provides an overview of the shop requirements and necessary tools to build your homebuilt airplane.

Chapter 2 – Describes safety considerations for building, general building procedures and how to prepare and join parts.

Chapter 3 and all following chapters contain the actual assembly instructions. The chapters are presented in the order your plane should be built. Assembly instructions are in a sequence that either is a convenient construction order or is necessary due to the kit design.

Chapter Organization

Each assembly chapter is organized in the same sequence.

1. Introduction – Briefly describes the work that will be completed in this chapter, and special construction requirements and if a pre-fit is necessary.
2. Parts List – Provides a complete list of the parts used in the construction procedures in the chapter. Parts lists may not match a kit. A parts list can include all or part of a kit plus other hardware from the H or K kit lists.
3. Construction procedures – this section is divided into specific areas of assembly. Each division is defined by an alphabetic prefix: A, B, C, etc.
4. Graphics, including drawings and photographs – each graphic is numbered within an alphabetic prefix: A.1, A.2, A.3, B.1, B.2, etc.

Symbols

The following symbols are used in the manual.

Click on this symbol to view the photograph of the procedure that has just been described.

Click on this symbol to view a series of photographs.

This symbol indicates a pre-fit is required.

This symbol indicates there is a detail view of the area covered by the magnifying glass.

Revisions

Occasionally revisions to the manuals may be necessary. Updates are posted on the Lancair web page. When updates are available, you need to immediately replace all outdated pages with the revised pages. Discard the outdated pages.

The lower right corner of each manual page contains a revision date. The final edition of this manual will have a zero followed by the date printed, for example, Rev. 0–06/12/2005. All subsequent revisions will have the revision number followed by the date of that revision. All revisions include a *List of Revisions* page for each chapter with updated pages When you receive a *List of Revisions* page, you will need to inserted it in front of the first page of each revised chapter.

1.3.B Blueprints

The blueprints included with this ES manual can be considered tools in the contribution they make in the building of your airplane. They are mechanical drawings which present a picture of the parts and assemblies you need to complete. But they are only useful if you can read them. We suggest you spend the necessary time to become familiar with the blueprints prior to building the specific portion of your airplane that they address.

A list of blueprints for the ES Super Fastbuild Kit are included at the beginning of the Parts List section of each chapter. The lists contain only the blueprints that are provided after the completion of the two week builder assist program.

1.3.C The ES CD

The CD included with the manual contains an electronic version of the manual that you can view or print from your computer. In addition the CD manual provides the following:

- Includes color photographs of various construction processes and specific assembly techniques.
- Ability to search the entire manual for a specific word or phrase.
- Includes a linked table of contents and index.
- All drawings and photographs are organized in a slideshow presentation, in the same order as the manual's chapters.

CD Tips

The manual on the CD is in a PDF format. This means that Adobe Acrobat Reader is required for viewing and printing the manual. If you do not have Adobe Acrobat Reader on your computer, download the latest free version of the Reader from www.adobe.com or www.downloads.com.

Using Adobe Acrobat

When you have the Reader installed, you can double-click on any file ending with PDF to view it on your screen.

To use the ES CD, insert it in your CD drive and double-click on the MainMenu.pdf. Select one of the menu items to use a feature on the CD. Please read the insert that is included with the CD to learn how to navigate through the manual, search the manual, or view only photos from a specific chapter.

1.4 Setting up your Shop

This section contains the following topics:

- Shop size considerations
- Temperature
- Building shop tables, a jackstand and cradles

Introduction

Your work area needs to be well lit, clean and uncluttered. It needs to have at least one large table to cut on and work with the fiberglass. Since parts will be placed on the floor occasionally, the floor needs to be cleaned and free of oil, grease and dirt. A dirty floor can contaminate parts.

1.4.A Shop Size

The minimum size for your shop floor should be approximately 20 ft. by 30 feet. This will accommodate the building of your Lancair. Figure 1.4.B.1provides an overview of the ES dimensions.

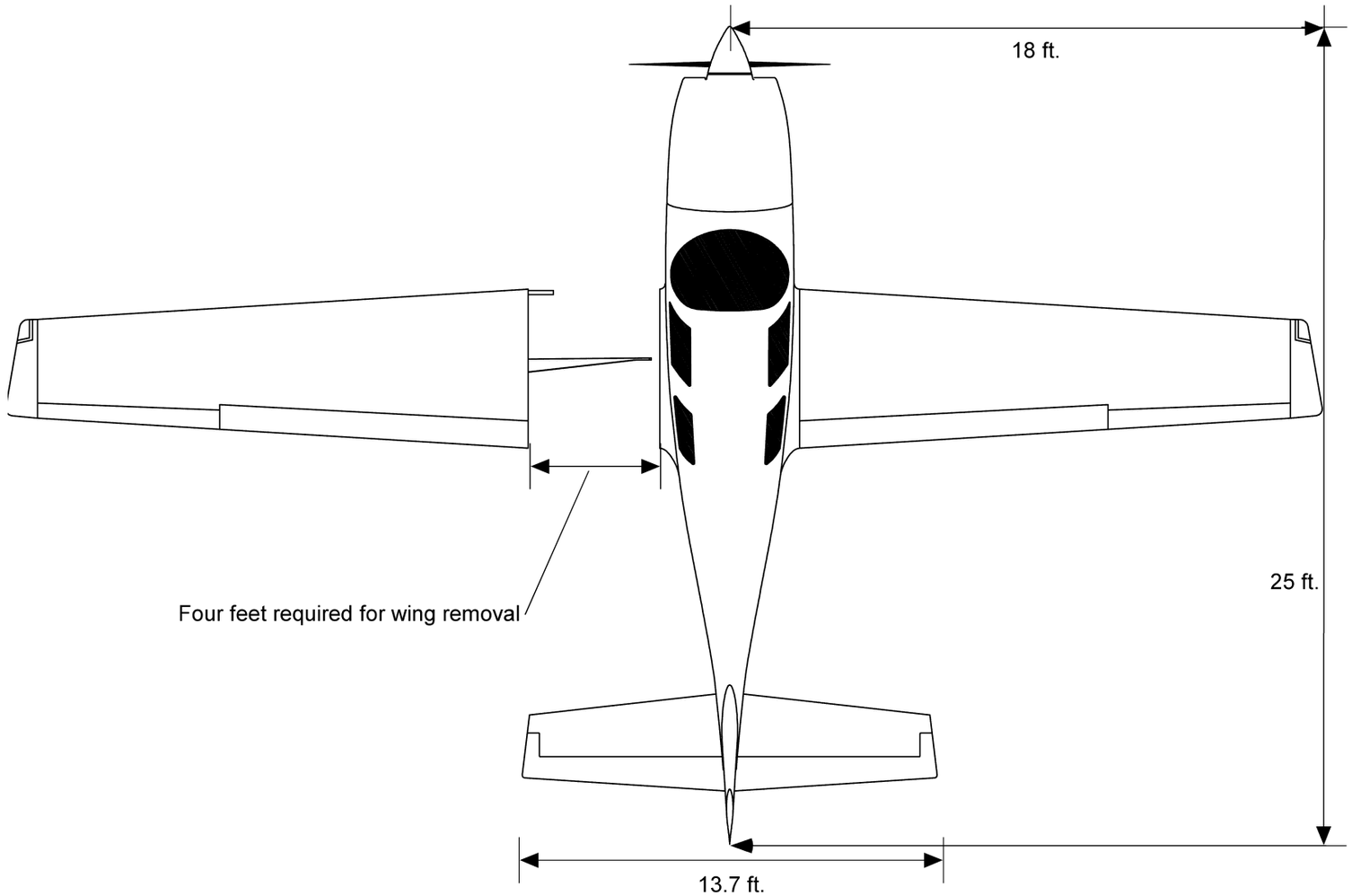
Since the wings are pre-fit to the wing fairings and then removed for the remainder of the building process, it is not necessary to have a shop that will accommodate the finished dimensions with the wings on. You can temporarily move your plane outside to work with the wings.

Tip: Remember that removing the wing requires approximately four extra feet beyond the wing tip.

1.4.B Temperature Control

If you plan to work in your shop when the outside temperature is less than 70°F, a heat source may be necessary. When working with fiberglass adhesive or resin at low temperatures, wetting out the fiberglass becomes difficult. The ideal shop temperature is between 68° and 78°F.

Figure 1.4.B.1 Shop floor area



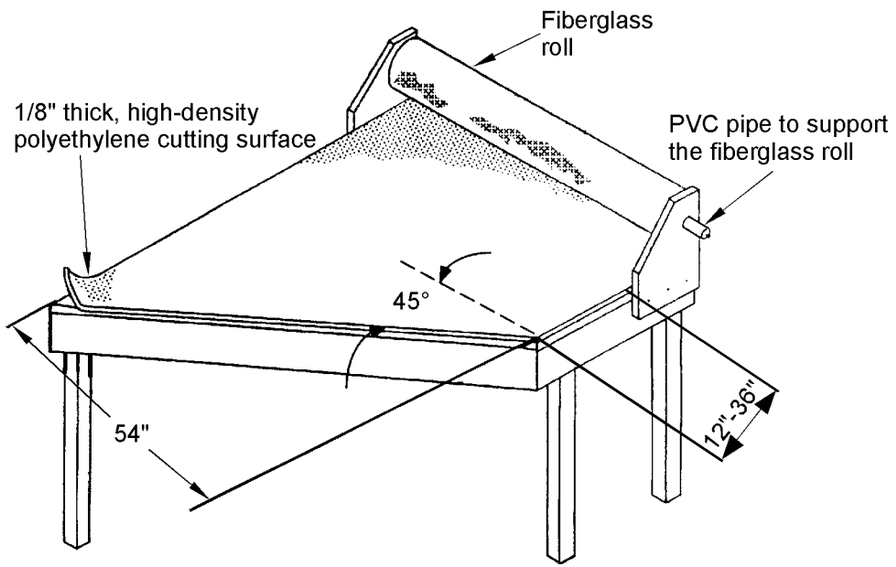
1.4.C Cutting and Layup Tables

Cutting Table

One of the focal points of any composite shop is the fiberglass cutting table. Those of us who previously built composite planes without a cutting table can't believe we were so naive. We recommend building a cutting table in your shop!

At one end of the cutting table mount the fiberglass roll so you can unwind the cloth onto the table. You need to be able to unroll at least four feet of cloth onto the flat cutting surface. A PVC or any type of pipe can be used as a roller for the cloth roll. Mount the pipe through two plywood supports nailed to the sides of your table.

Figure 1.4.C.1 Fiberglass cutting table



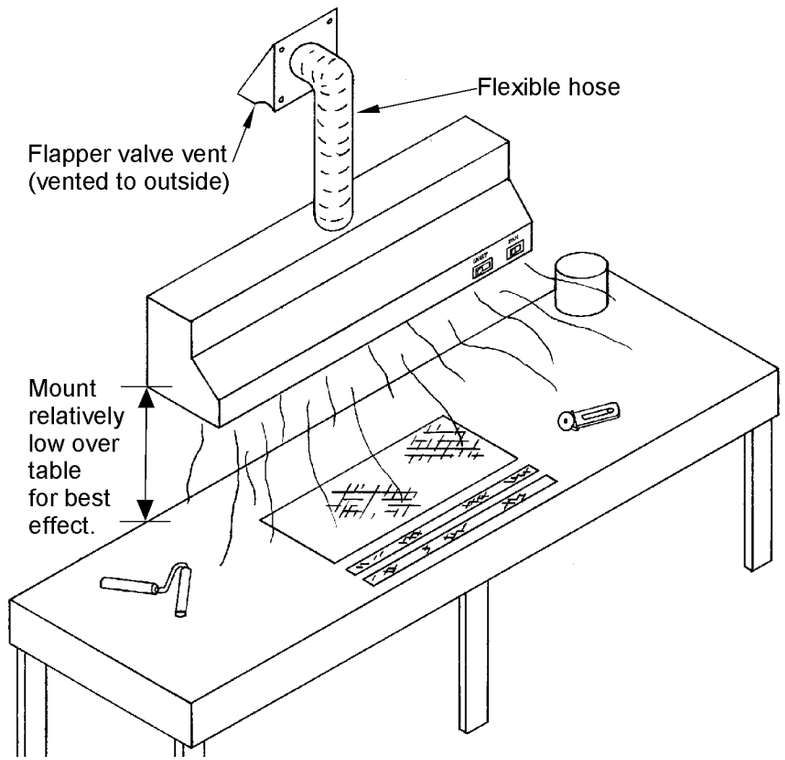
The cutting surface should be a hard plastic such as an 1/8" thick, high density polyethylene (HDPE). Some home supply stores have similar sheets of this material called tileboards for use as shower liners. Also check a plastic supply store. After you have been using the cutting surface for awhile, you may not achieve clean cuts. Simply flip the plastic sheet over and use the other side.

When the cutting table is not in use, it's a good idea to at least cover the fiberglass roll with plastic to keep dust from settling on it.

Layup Table

A layup table is handy when it is time to start your wet layups. Construct a table about 3' by 8' in size, and mount the exhaust hood low over the table surface. Use the same type of hard plastic surface you installed on the cutting table.

Figure 1.4.C.2 Layup table



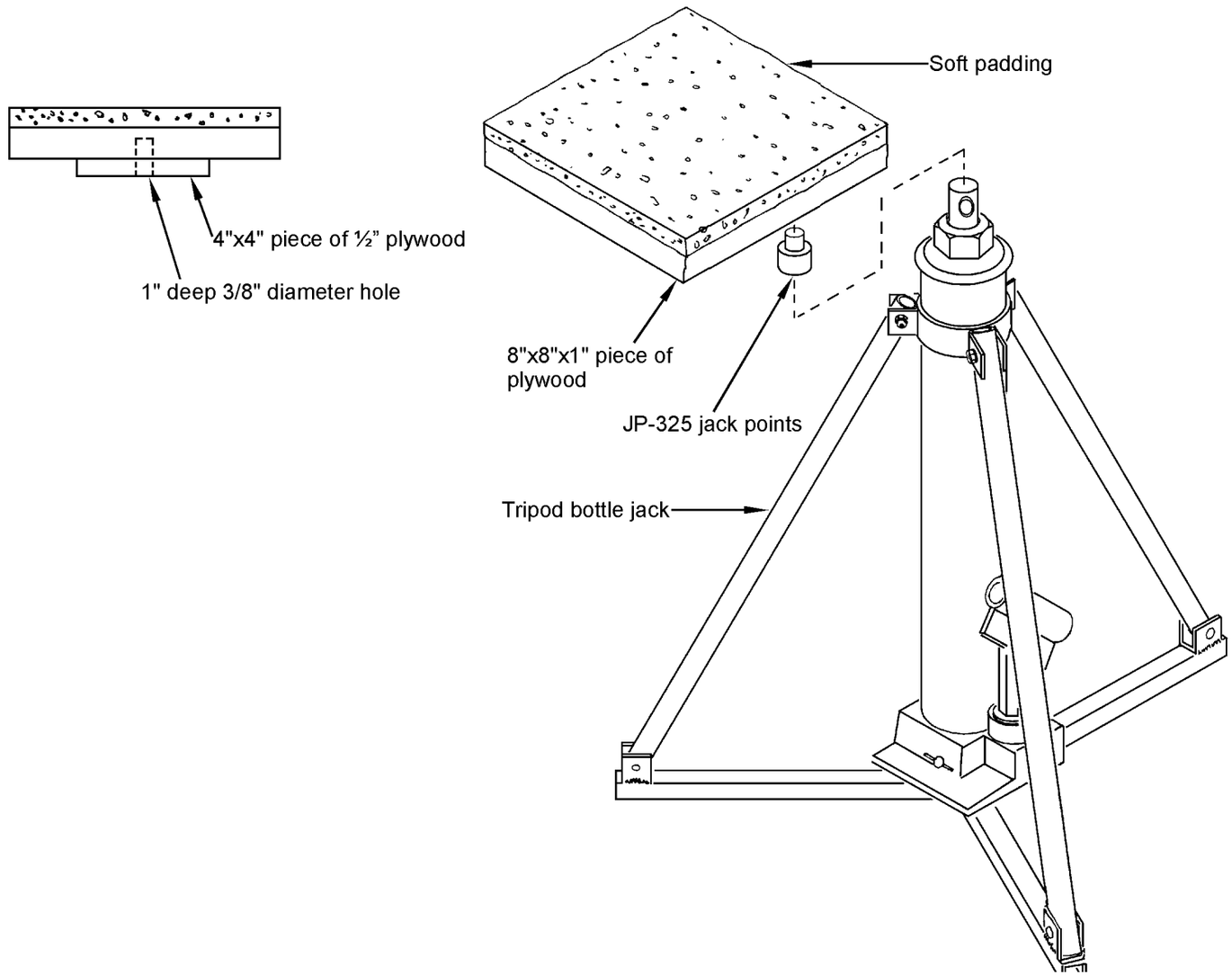
1.4.D Making a Useful Jack Stand

The jack stand is ideal for lifting the wings and a number of other tasks including checking the weight and balance. In addition the ES fuselage bottom may have optional jackpoints.

Steps...

1. Cut two pieces of plywood, one 8”x 8” and the other 4”x 4”.
2. Glue the two pieces of plywood together with the 4”x 4” centered on the larger piece.
3. Drill a 1” deep and 3/8” diameter hole in the center of the 4”x 4” piece.
4. Install the JP-325 jack point in the hole.
5. Glue soft padding on the top of the 8” x 8” piece of plywood.
6. Insert the Jack port on the jack stand.

Figure 1.4.D.1 Jack stand



1.5 Shop Tools and Supplies

This section contains the following topics:

- Tool suppliers
- Descriptions of basic shop tools
- Descriptions of specialized shop tools
- Shop supplies

In addition, Appendix E *Tools* on page E.1 contains a shopping list of the tools listed in this section and also a list of the tools that we supply during the builder assist program. We recommend that you obtain all of these tools for your shop.

Introduction

The tools and supplies described in this section are extremely useful in your shop. They are not mandatory but we highly recommend all of these tools. The tools we feel are most important are included in the Appendix E *Tools* on page E.1.

Since you may not be familiar with all of the tools, we have included a description of each.

Tools and supplies that are available through Kit Components, Inc. (KCI) can be ordered from:

Kit Components, Inc.

Address:	2244 Airport Way Redmond, OR 97756
Phone:	541-923-2244
Email:	kci@lancair.com

Other locations for buying tools and aircraft supplies are:

Aircraft Spruce & Specialty Co.

Address:	225 Airport Circle Corona, CA 92880-2527
Phone:	1-877-4-SPRUCE
Email:	info@aircraftspruce.com

1.5.A Basic Tools

Saber saw (jig saw)

This saw is very handy for cutting out large or complex shapes from prepreg material. You can use a manual saw but it won't be fun. Always have plenty of sharp blades and change them often. Dull blades create rough edges and create more sanding/smoothing work later in the building process. We use carbide-tipped blades exclusively for the composite cutting.

Electric or cordless drill motor

Most of the material you drill on a glass kit is fairly soft and thin and should require no more than a small drill motor with at least a 3/8" chuck. We recommend a variable speed over a two speed. Also buy one with a 1/2" chuck. When you drill plastic parts they must be drilled at a very slow speed that is below the range of all single and most two-speed drill motors.

Drill press

One of the most useful tools is the drill press. It is a necessity for precision drilling. It can be used in drilling out broken bolts, and it can cut holes using a fly-cutting tip.

Drill bits (numbered and fractional)

It takes a lot of cheap drill bits to make a lousy hole that one good bit could have made quickly and perfectly. We recommend that you buy a good set of numbered drill bits. Lettered drills are also handy like the "E" (.250") or the “D” (.246") with a reamer.

Carpenter's levels (2 and 4 foot lengths)

Levels are indispensable in a good shop and essential for building straight. Buy good aluminum levels. Make sure they have straight edges and then round the sharp ends a bit so you won't gouge any holes into your precious prepared surfaces.

Carpenter's square

Buy this when you get the carpenter's levels and for the same reason. Don't round the ends, just be careful.

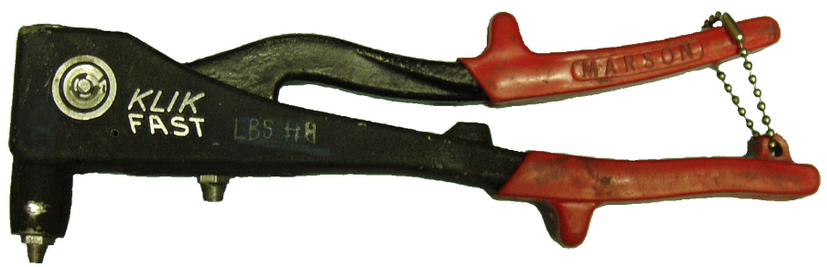
Clamps

You will need a number of the following types of clamps.

- Spring clamps –Buy a number of these including three or four large ones and about a dozen that you can use with one hand while you try to hold six other parts in exactly the proper position.
- Vise grip clamps – These are useful for forcing pieces together. Never use these on any fiberglass, prepreg, or carbon composite parts. They grip with enough force to do great damage to these parts, which may not be visible to the naked eye. Buy several of these.
- C clamps – Buy an assortment of these and three or four in each size. Again, use caution when applying these to any glass parts. Tighten slowly and only until just snug.

Pop rivet tool

When you clamp parts together and drill the holes you'll insert pop rivets. The best method to do this is with a pop rivet tool. It should come with three extra tips for use with all four common sizes of pop rivets, 3/32", 1/8", 5/32", and 3/16"



Rotary sander (rotary or orbital type)

This tool definitely makes it easier to sand and smooth rough edges. A good orbital sander with a trapper bag will keep particles out of the air and your clothing and your lungs.

Reamer

A reamer or ream is a tool for enlarging holes. For hand tools the drive will usually be a square drive, intended for use with the same type of wrench used to turn a tap for the cutting of screw threads. They should only be used to remove small amounts of material. This ensures a long life for the reamer and a superior finish to the hole.

1.5.B Specialized Tools

We refer to the following tools as specialized shop tools because it makes it a little easier to overlook their higher price tags. Again, the tools listed are not mandatory for your shop but we have found them extremely useful. The tools we think are the most important are included on the shopping list.

Angle grinder

This is a powerful tool that can help you to custom fit your ribs and bulkheads quickly. Be very careful though, if the high speed grinder surface gets away from you, it can quickly customize everything in the general vicinity.

Air grinder

These come with a fantastic array of special bits and we can't imagine building a composite aircraft without a air grinder tool. You'll use this tool more than any other in your growing tool collection.

Tip: If you do not have an air compressor, consider getting a Dremel tool. The Dremel works similar to the air grinder tool but it is not as powerful.

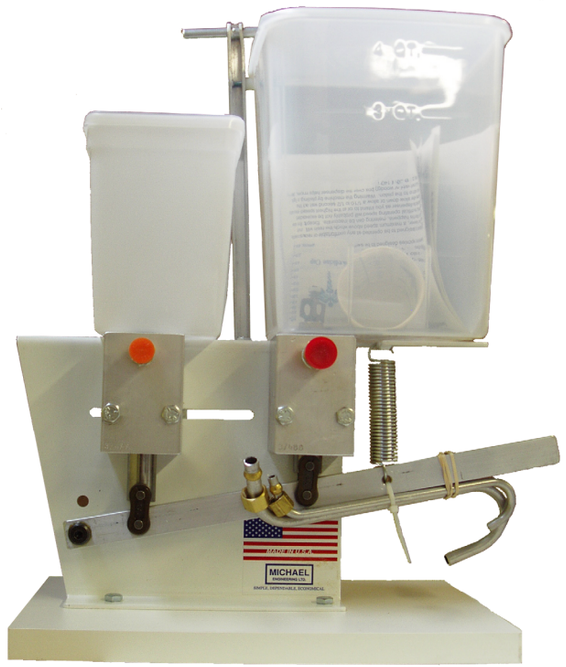
Tungsten carbide bits for Dremel tool

The Dremel bit can easily cut prepreg. Prepreg is very easy to work with except that it eats power tool blades/bits for breakfast. Dremel's tungsten carbide cutters come in various shapes and sizes and are your best bet. Some of the Dremel part numbers to look for are 9931 through 9936. The carbide bits last a long time as long as you don't use them on aluminum or Kevlar™, which tend to gum them up. They are expensive and we paid about $12.00 for a single bit. For availability check hobby stores, hardware stores, Sears, and the KCI catalog. There is also a wide range of bits for cutting, grinding, buffing, polishing, etc., for use with the Dremel. If these bits are available, get one of each. You can make a holder for the bits out of a piece of 2x4 with drilled holes for holding the bits.

Epoxy pump (Sticky Stuff dispenser)

An epoxy pump pays for itself in saved epoxy. With every pump of the handle you will receive the proper amount of resin and hardener without needing to weigh or measure. With practice you'll know the proper number of pumps needed for the size of the lamination you are completing. We offer this item in our KCI catalog and highly recommend its use. Many builders use a lightbulb heated box over their epoxy pumps to keep the epoxy warm and thin. This is fine and we do the same. If you don’t plan to use the pump for a week or so, turn off the lightbulb. Otherwise the volatiles in the epoxy can evaporate out and cause faulty curing or no curing at all.

If you are using the pump every night you don’t need to worry about evaporation and you can leave the lightbulb on. Use no higher than a 25 watt bulb in your box.



Rotary cutter and blades (Pizza Cutter)

Use a rotary blade to cut fiberglass cloth quickly and cleanly. Scissors do not cut cleanly and should not be used on fiberglass. The rotary cutter and blades are available through the KCI catalog. Always purchase extra blades. We suggest getting the aluminum rotary cutter (G-T-01001) for fiberglass work since it tends to last much longer and stands up to acetone. It you get

two rotary cutters, one can be used for dry fiberglass cloth cuts and the other for cutting wetted out cloth.

Rivet squeezer

A rivet squeezer will save you hours when you are installing rivets.

Cleco™ pliers and bits

You will need a Cleco™ pliers tool and about 50 of the 1/8” Cleco bits (copper). A Cleco tool is simply a special pair of pliers used to fasten together the sheet metal. Clecos are a sheet metal fastening device used extensively in the aircraft industry. Clecos and Cleco pliers are available from aircraft supply stores or catalogs (ours included).

Digital level

A digital level has an LCD readout instead of a bubble. On some digital levels the center pops out to become a small, six inch level that's extremely handy for measuring control surface throws, seat back angles, firewall angles, engine thrust lines, etc., all with an accuracy of 1/10th of a degree.

KCI carries a digital level. It is a great tool but always remember to re-calibrate the level module when you turn it on, otherwise you could be off by a couple of degrees.

Air compressor

This tool is useful in any shop. You will find many uses for it during the construction of your airplane, particularly when you want to remove sanding residue from surfaces and during the painting prep. steps.

Tubing bender

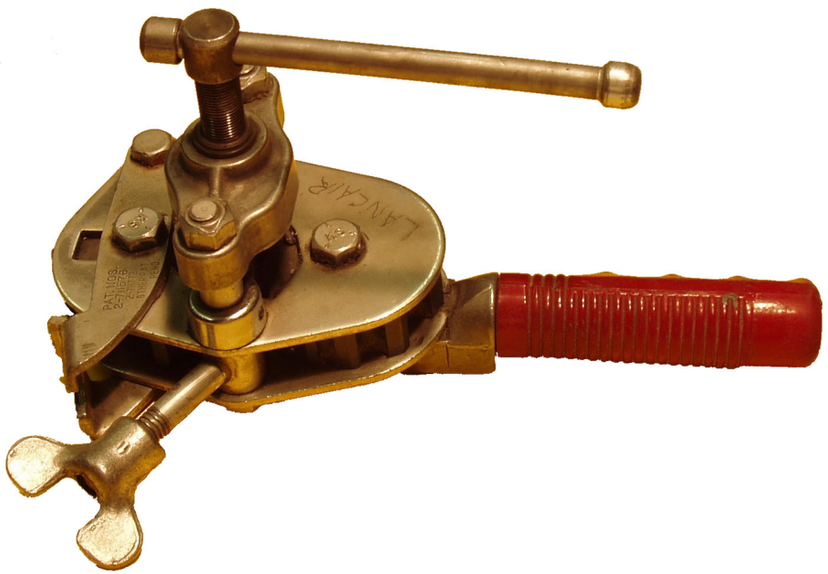
You will need a tubing bender for 1/4” O.D. aluminum tubing.

Tubing cutter

A tubing cutter is the standard and the best tool for cutting aluminum tubing to the correct length.

37° flaring tool

Make sure your flaring tool is for 37° and that it work with 1/4” O.D. aluminum tubing. Keep this with your tubing bender. You won't need it often, but when you do nothing else will work. Don't use automotive type flaring tools as they have a different flaring angle.



Deburring tool

Utilizes a simple twist-of-the-wrist action for deburring holes and radii. The curved blade automatically follows all contours.

Surveyor transit

If you like gadgets this one is fun, although a water level will work just as well for less money. A surveyor transit can save you an hour or two in setup time and is usually available for rent from surveyor/construction suppliers. It is like the water level because it still takes two people to use it effectively. It will allow you to quickly level the fuselage, wings, horizontal stabs and jigs.

Water level

This is an inexpensive and simple method for checking wing washout, horizontal stabilizer position and other big jobs on the airframe. We use 1/4" inch I.D., clear tubing that is available at the hardware store. We also recommend dying the water with food coloring to make the water level in the tube easier to read.

Plumb bob

A small plumb bob is necessary for vertical measurements. Multiple plumb bobs are useful for aligning.

1" Makita belt sander

This belt sander along with an assortment of different grit belts will come in handy before you finish your kit.

Heat gun

The heat gun can help warm parts you want to bond, straighten a warped part and a lot of other jobs. It can also destroy parts if you are not careful! The heat gun is a well-used tool in our shop, not only for heating parts, but for gently heating to cure epoxy, shrinking heat-shrink tubing on electrical connections, etc.

1.5.C Supplies

Safety glasses or goggles

Wearing eye protection is important when you are working on a composite aircraft. A splash-resistant goggle works best to prevent dust from entering your eyes and the goggles.

1 mil thick plastic drop cloths

You will need a lot of 1 mil thick drop cloths. You can get them at most hardware stores and they are great for covering things. You will also use them in the preparation of BID tapes and other fiberglass layups. Thinner drop clothes are not as easy to handle and thicker ones are too hard to work.

Paper towels

Buy paper towels by the case if you have the storage space. Always keep at least three or four rolls on hand. You'll be using paper towels for cleaning up drips as well as using them for absorbing excess resin.

Tongue depressors

We supply tongue depressors with your kit. There should be enough to complete the project with a few left over. You will use the depressors as mixing sticks for the epoxy you pump from your epoxy dispenser.

We also use modified tongue depressors for many tasks. A square-end version is used to spread micro radii. Also a tapered-end version is used as shims when pre-fitting airplane parts. The following picture is of a square-end tongue depressor.

Brushes

Brushes are supplied with your kit. You will use these for stippling and soaking up excess resin. You will need to cut the bristles to half length on some of the brushes. The brushes can be cleaned in acetone and reused.

2" side paint roller or wallpaper roller

Another simple but handy tool is the roller. We recommend a small 1-1/2" wide paint roller (without the furry paint sleeve), and a larger 3" wide roller for pushing the air bubbles out from under laminates. Try sliding a length of PVC tubing onto the paint roller to get a smooth, hard-

rolling surface. Common paint rollers work okay but we made a solid aluminum roller that works even better. Wallpaper rollers are also good for this application.

Rubber squeegees

The auto parts store should carry plastic Bondo™ smoothing paddles. There should be three of four different sizes in a package. These work well for removing excess epoxy and air out of layups, applying and smoothing out micro, and any number of other items. The paddles clean up easily and they should last the entire project.

Sandpaper and sanding blocks

Purchase several sanding blocks and a lot of 40-grit sandpaper. Nearly every time you apply epoxy or BID tapes to a piece, you will have to rough it up with 40-grit first. Get this size for your belt sander and your sanding blocks. Get a couple of sheets of other grits but nothing rougher than 40. We suggest 80 and 120-grit and even finner for finishing.

3M Production Paper Sheets are the best we've seen for preparing fiberglass and carbon fiber. The are 2-3/4" x 17-1/2" and are meant for longboard sanders. If cut in half, they fit perfectly into most rubber hand sanding blocks. 3M calls this sandpaper "The Green Corps" and the paper is green. Auto body supply and auto paint stores should carry this item.

Cardboard

We recommend using cardboard for rib or web templates. Create cardboard templates to use as a pattern for prepreg.

Cotton flox

Cotton flox is finely chopped cotton fibers which appear nearly as fine as micro balloons. The difference is that flox is structurally stronger than micro when combined with epoxy.

Epoxy

During aircraft assembly two types of epoxy are used:

- Structural paste adhesive – used to structurally bond molded parts together. ~~We use Hysol 9360.~~
- Laminating resin – used to make fiberglass layups and is also mixed with flox or micro. ~~Jeffco 3102 is our laminating resin of choice.~~

These epoxies are not interchangeable. The instructions in this manual will specify which epoxy to use. Always follow the instructions. Make sure you use Lancair approved products. Most epoxies have a manufacturer's recommended shelf life of typically one year. In some cases this is quite conservative. However, the manufacturer’s recommendations should be followed.

Instant glue

Instant glue is included in your kit and is handy for many of the steps described in this manual. You can use it to temporarily tack almost any of the parts together. Use only a drop or two for any of the steps in this manual. You can use it to glue a piano hinge in place and for measuring where Clecos would get in the way. We keep this in stock.

Instant glue accelerator

This is the ultimate stuff for impatient people. This makes instant glue act even faster. A quick spray of this accelerator and the glue is set, right now. We keep this in stock.

Other Useful Supplies

- Rubber gloves
- Sawhorses