Chapter 2 Construction Materials and Processes

2.1 Introduction

The purpose of this chapter is to familiarize you with the construction materials and methods we will use throughout the manual. You may want to refer back to this chapter as you build your plane. There is a lot of information here that is difficult to absorb it in one reading. Building techniques in the 2.3 *Construction Processes* on page 2.8 section is explained in more detail in this chapter than it is at each and every spot in the manual where the technique is used.

Carefully read the next section 2.1.A *Building Safely*. It is extremely important that all safety considerations are carefully followed for safe handling of building materials and for the overall construction of your Lancair

2.1.A Building Safely

The following safety information is organized into this section so you can review it at one time. These safety suggestions and warning information appears frequently in this manual. We include this information so you are informed of the risks that are involved in building your homebuilt and the repercussions that can occur if the instructions in this manual are not followed.

Failure to follow these warnings and the others found throughout this manual could result in component failure and loss of aircraft control causing serious injury or death.

If you have any questions or doubts during construction of your kit about a construction procedure, do not continue until you have obtained the necessary information or skill. If you are not knowledgeable in fiberglass or other required construction techniques or tools, obtain that knowledge before starting your kit.

Kit Storage

After you unpack your kit and lay aside the premolded parts for a future use, they must be stored correctly. Try to store these parts in a position that won't produce any distorting forces. For example, store them supported in a position as close as possible to the actual use orientation.

The method you use to store your premolded fiberglass parts is extremely important. Care must be exercised when laying aside the premolded parts for a future use that may be months away. Try to store these parts in a position that won't produce any distorting forces. For example, store them supported in a position as close as possible to the actual use orientation.

Unlike fiberglass composite parts, the carbon fiber parts are stiffer and less prone to distortion. However it is still highly recommended that you carefully store these valuable parts.

All composite parts should be kept away from direct sunlight for any extended periods of time. An afternoon or a day of sunlight is acceptable but a week in direct sunlight is not.

Safety During Construction

Making changes to the aircraft during construction

No change to the aircraft design or specified construction procedures is permitted. Such changes may adversely effect the aircraft's structural integrity or air worthiness.

BIDs

Always follow the instructions provided for specific BID (bidirectional glass cloth) tapes or schedules. (Refer to the *Glossary* for a definition of each term.). If you increase the number of BID layers in your aircraft you are decreasing its strength. A heavier aircraft is quicker to build up G loads, has less payload, and is slower than the one built to spec.

All BID tapes must be cut on the bias at 45°. If you use BID tapes cut from cloth at 90°, they are only half as strong. Most commercially available BID tapes are cut at 90° and are unsuitable for structural areas such as ribs and bulkheads.

Removing the Peelply Protective Coating

Peelply is a non-structural fabric used in the manufacturing process to protect the inner surface.All peelply must be removed from bond surfaces to obtain a good bond. Bonding or laying fiberglass over peelply can result in structural failure.

All the premolded parts are shipped with a protective coating of peelply material on their inner surfaces. This material must be removed because it interferes with the bonding process. The peelply usually sticks out beyond the edge of a part in at least one area. This peelply piece looks like white cloth. The peelply is transparent where it lies on the surface of the part.

Most of the peelply has already been removed from your premolded parts. Peelply does provide some protection to parts and it may be left on until the part is needed in the assembly process. Then when you are ready you can remove the peelply.

Although removing peelply looks simple, it can cause serious injury if your hand slips and scrapes a sharp edge. Please be careful.

Steps.....

1. Grab the edge of the peelply where it extends beyond the edge of the part. Remove the peelply by pulling it by hand.

   It may take considerable force to pull off the peelply. As it is pulled off it usually tears off in odd-shaped pieces.
2. Use a utility knife to pick up a new edge of a peelply piece.

   Use the knife carefully so you do not cut into the glass of the parts.

The white cotton strips running in irregular directions on the surface of the peelply are required by the manufacturing process. These will come off with the peelply but more pulling force may be required.

WARNING: All peelply must be removed from bond surfaces to obtain a good bond. Bonding or laying fiberglass over peelply can result in structural failure.

Laminate

Laminate is a structure made by bonding together two or more layers of material with resin. It contains no core material.

Do NOT apply the laminate with the plastic side down. It will create a complete loss of structural integrity.

Cotter Pins

Two common errors occur with castle nut installation. The first is the castle nut is installed without a cotter pin, and the second is the cotter pins is bent incorrectly. Refer to *Installing Castle Nuts and Cotter Pins* on page 2.23 for the correct installation.

Adhesives and Epoxies

Always read the caution labels on all containers and cans of adhesives and epoxies.

WARNING: This epoxy is extremely irritating to the eyes and can cause permanent eye damage. May also cause skin irritation or sensitization reaction in certain individuals. Prevent eye and skin contact with epoxy materials. Avoid breathing vapors. Use only in well ventilated areas. Avoid inhalation or eye contact with dust from grinding or sanding of cured epoxy. Remove contaminated clothing and launder before reuse.

Mixing Adhesives

Check for the proper mixing ratios of the supplied structural adhesives and laminating resins. Failure to mix properly could result in bond failure.

The containers used to mix the adhesive cannot be wax coated. The wax coating could contaminate the adhesive and reduce the bond strength. In addition the mixing container must be free of dirt, grease and oil or any other similar contaminants.

Heaters and Fire Hazards

The epoxy cure time depends on the temperature during the cure period. Because of the fire hazards involved with most heaters, we do not recommend having a heater operating in the room that could cause a fire. Getting the room temperature above 77°F does help shorten cure times. But remember it will also shorten the pot life and working time of the adhesive.

Heat and Faulty Curing

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.

Solvents and Cleaning Parts

Failure to follow all cleaning steps can result in an eventual bond failure. Even surfaces which appear clean must be cleaned since some contaminants are not obvious.

Always follow the instructions provided on the caution label on the wax and silicon remover containers.

Cleaning Parts

The instructions throughout this manual recommend using cleaning agents. Acetone works best for cleaning most of the fiberglass, the carbon fiber parts and the joints.

Previously we recommended Methylene Chloride (MC) cleaner. It is excellent in its ability to remove impurities from surfaces. However, there has been controversy about its safety so we no longer use it.

Read and follow the safety directions of your cleaner.

WARNING: Wax and silicone remover is flammable and must be kept away from sparks, heat and open flames. It is harmful or fatal if swallowed. During use and until all vapors are gone: keep area well-ventilated and do not smoke. Extinguish all flames, pilot lights and heaters. Turn off stoves, electrical tools and appliances that could act as an ignition source. Vapor is harmful. Avoid breathing vapors and use only with adequate ventilation. Avoid skin and eye contact. Wear rubber gloves or suitable protective skin barrier. Wash hands if they come in contact with this liquid. If spilled on clothing, remove and launder before reusing.

2.2 Construction Materials

The following construction materials and processes are described to provide clarity as you build your airplane. Each of these procedures have been developed and tested at the Lancair factory. When it is necessary we make improvements to our build procedures.

You will use these procedures again and again during the building process. Refer back to these pages when you need to refresh your memory on the exact steps to complete a build procedure. Paying attention to these procedures ensures consistency in your building methods and develops pride for your finished product, your homebuilt airplane.

2.2.A Prepreg and Fiberglass

Honeycomb Prepreg Panels

The honeycomb prepreg panels that are used for the interior panels, shelving and several other pieces, are available in two types:

- 3/8" core + 2-BID per side (also known as 2-core-2)
- 1/4" core + 1-BID per side.

All BID ply schedules must remain the same when using prepreg panels. For example, if a part calls for 6-BID on one side and 2-BID on the other, the 2-BID honeycomb panel will require an additional 4-BID on the first side.

In addition, all attachment BID schedules must remain the same. For example, if the plans call for a 6-BID attachment, then 6 plies (wet layup) must be used. Typically a 1" contact on each surface is sufficient unless otherwise noted.

Cardboard Templates

Creating templates using cardboard for ribs or bulkheads can save time and money. The more complex the rib or bulkhead shape, the more a cardboard template will help. Making a mistake with a piece of cardboard is much cheaper than with a piece of prepreg.

BID Schedules

The BID schedule is the number of fiberglass layers bonding a structure together. If the manual calls for 2-BID, three or four must be better, right? Absolutely not! If you increase the number of BID layers in your aircraft you are decreasing its strength.

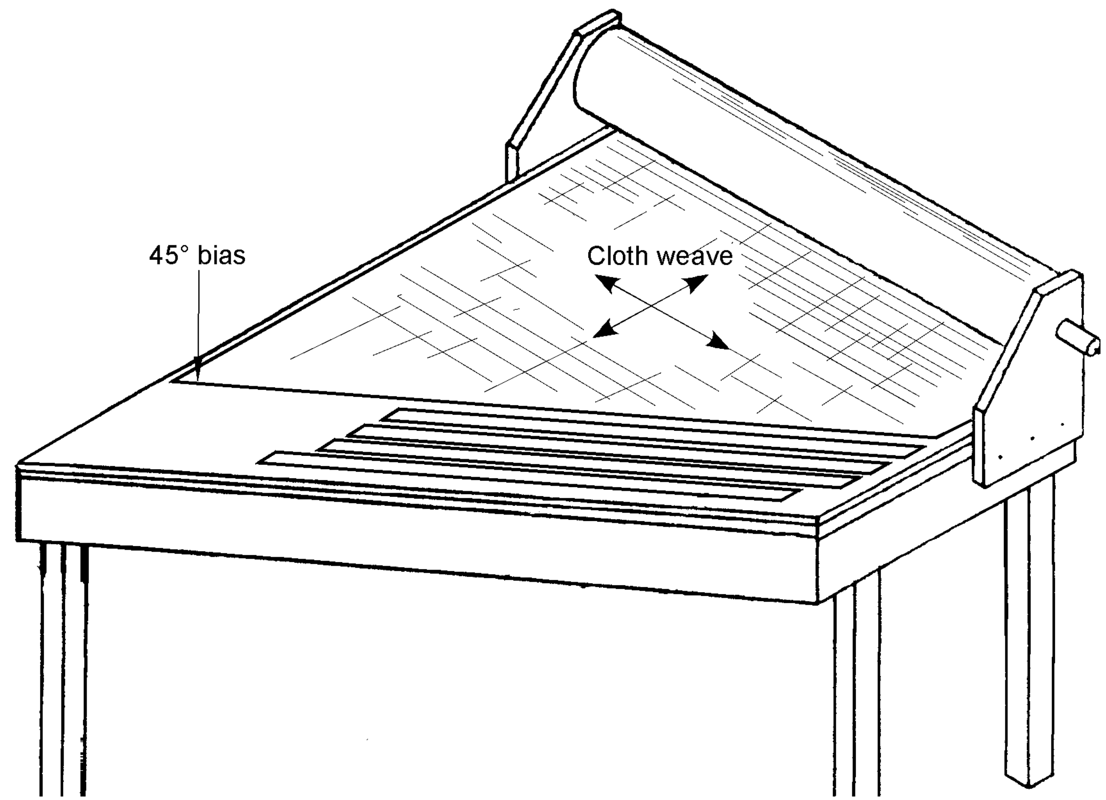
Cutting Fiberglass Cloth on the Bias

The bias is a cut, fold, or seam made diagonally, at 45° to the warp or fill threads of a fabric. Cutting on the bias is cutting the cloth so the fibers are on a 45° angle to the edge of the cloth. Most Lancair fiberglass parts are cut on the bias.

When you are cutting your cloth with the rollerblade, always pay attention to the specification for the bias for the part of the airplane you are glassing. The weave orientation arrows in this manual are provided so you can cut the cloth correctly.

Nearly every piece of fiberglass you apply will be cut on a 45° bias. There are very few fiberglass parts cut with the cloth weave of 0° on a Lancair plane.

Figure 2.2.A.1 Weave orientation



BID Tape Weave

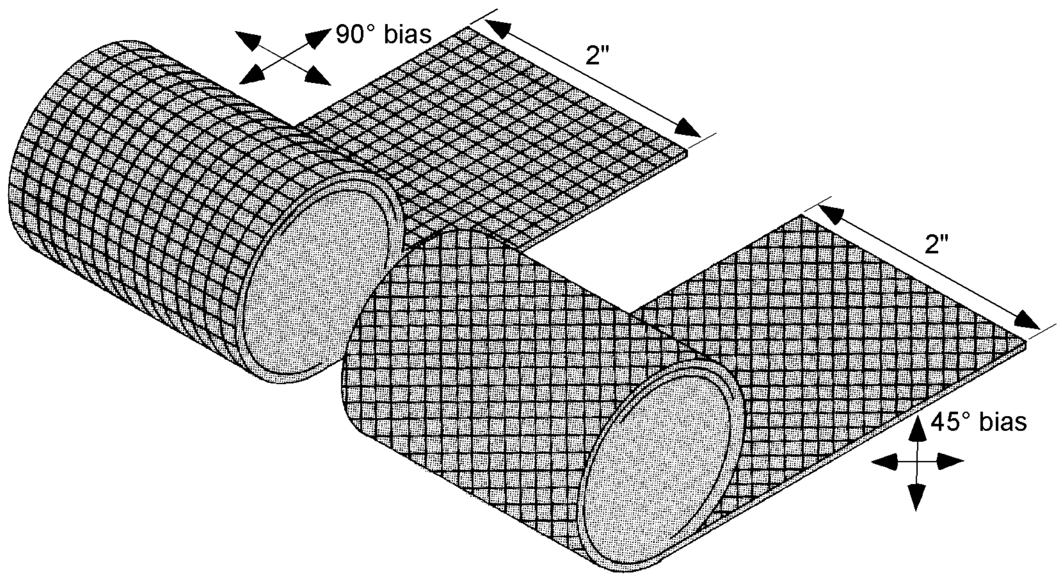
BID tapes are 2" wide, pre-cut fiberglass tape available through Aircraft Spruce. These BID tapes replace the need to cut your own BIDs out of the 50" wide roll of fiberglass provided in the kit. This is fine as long as the BID tapes were cut from the cloth on a 45° bias.

WARNING: If you use BID tapes cut from cloth at 90°, they are only half as strong. Most commercially available BID tapes are cut at 90° and are unsuitable for structural areas such as ribs and bulkheads.

The safest method to glass is to cut your BID tapes. At Lancair we cut 20 or 30 tapes at a time, all on a 45° bias. Then we carefully roll the tapes up so the 2” width does not shrink or expand. Then set them aside in a clean place to use as needed.

If you decide do buy pre-cut tapes, make sure they have a 45° cloth weave and are of the same strength of the fiberglass.

Figure 2.2.A.2 Different BID tape weaves



2.2.B Epoxy/Adhesive used in Aircraft Assembly

During aircraft assembly two types of epoxy are used. These two epoxies are used for very different tasks and are not interchangeable.

- 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. ~~We use Jeffco 3102.~~

Always follow the instructions in the manual for which type of epoxy to use. Other types of epoxies are available and can be used but you need to check with the Lancair factory before making any substitutions. Make sure you use Lancair approved products.

Most epoxies have a manufacturer's shelf life recommendation. We suggest that you follow this recommendation.

Structural Adhesive

The ~~Hysol 9360~~ structural adhesive is typically used for the following:

- Bonding body panels together
- Bonding dissimilar materials together

For example, it may be used to bond fiberglass body panels to window panels, fiberglass to carbon fiber, aluminum to another metal, fiberglass to aluminum, and so forth. It does not work well with some plastic materials.

~~Hysol~~ Structural adhesive is easily mixed in the proper ratio directly from the provided premeasured containers. The mix ratio is:

43:100 – 43 parts of Part B Hardner to 100 parts of Part A Resin

The pot life for structural adhesive ~~Hysol~~ is 12 to 15 minutes at 77°F. A 30 minute hardner is available when slower set times are required. This may be desirable in hot weather.

Wear work clothes since the adhesive may drip on you. Also check for adhesive in your hair or on your arms and wipe it off before it cures. A long sleeve shirt and long pants are highly recommended.

You can save time and money by buying the structural adhesive and the hardner in larger quantities and by using the epoxy pump described on page 1.10.

Curing Time

It is better to mix too much adhesive rather than too little. If you run out and must mix a second batch, the first batch may begin to thicken thus making it difficult to compress the seam properly and possibly reducing bond strength when it cures.

When you finish applying the structural adhesive leave any leftover adhesive in the corner of the container with a mixing stick in it. Since cure time varies with temperature, leaving a little adhesive in the container and positioning it near the part you have epoxied. This method allows the adhesive in the container to serve as a test for cure time.

After applying the adhesive you must wait at least 24 hours for the cure to set. Before you touch the parts, try to move the stick around in the adhesive container. If you can move it at all your adhesive is not completely cured. Wait another 24 hours and repeat. Handling parts before the curing is complete can reduce the bond strength and should be avoided.

The epoxy cure time depends on the temperature during the cure period. Because of the fire hazards involved with most heaters, we do not recommend having a heater running in the room that could cause a fire. Getting the room temperature above 77°F does help shorten cure times. But remember it will also shorten the pot life and working time of the adhesive.

Cure States

Three cure states exist that may be referred to during the course of construction. They are:

- fresh – no setup has taken place
- green or pre-cure – setup but still soft
- cure or post-cure – fully setup and hardened and bonding has occurred

Mixing ~~Hysol 9360~~ Structural Adhesive

Before you mix the adhesive all seams need to be cleaned and sanded as described on page 2.12 in and ready for fastening together. Also make sure you have practiced the steps in 2.3.C *Fastening Parts Together and the Double-bond Seam* on page 2.12 before starting.

Use the following steps to mix the ~~Hysol 9360~~ structural adhesive.

Steps.....

1. Read all instructions and information on the epoxy cans.

   The temperature of the adhesive ingredients and the surrounding room temperature must be 60°F or more.
2. Prepare all necessary equipment for mixing the adhesive.

   The 9360 adhesive has a working life of 30 minutes at 77°F. However, at higher temperatures or with a larger batch this working life is shorter.
3. Estimate the amount of adhesive that you need for the first seam and measure sufficient amounts of Part A Resin and Part B Hardner into the container and mix the adhesive.
4. Mix the two parts for at least two minutes using a mixing stick.

   Mix longer for larger batches. Occasionally scrape unmixed material from the sides of the container.

   WARNING: Improper mixing can speed or slow the cure time and decrease adhesive strength. Attention to the correct ratios in the mixing process is important.

Epoxy Resin

~~The Jeffco~~ Epoxy is typically used for the following:

- Making fiberglass layups,
- Mixing with flox or micro.

Just like the structural adhesive, the components of the epoxy resin come in premeasured containers.The mix ratio is:

26:100 – 26 parts of hardner to 100 parts of resin

The epoxy pumps on the market will pay for themselves since you'll waste less epoxy and have less chance of spills or improper mixes. We have one in our catalog that has performed well in our shop for years. Typically you will be using from one to six ounces at a time.

Epoxy working time can be as short as ten minutes if it is hot, so be sure everything is in place and ready to go before you begin mixing.

Just as you do with the structural adhesive, ~~Hysol~~ all the surfaces must be clean. Make sure you remove all oil, grease or other contaminants. Then slightly roughen them.

WARNING: Use care to mix your resins and adhesives according to the manufacturer's instructions for the particular system you are using. They are all different. An improper mix ration could result in improper bonding, or no bonding at all.

2.3 Construction Processes

This section covers the following topics:

- Preparing joints and joggles
- Drilling guidelines and bolt-hole tolerances for aluminum and fiberglass
- Fastening parts together and creating a double-bond seam
- Plastic layup
- Micro radii
- Building light
- Control systems
- Aluminum tubing
- Braided hose
- Painting

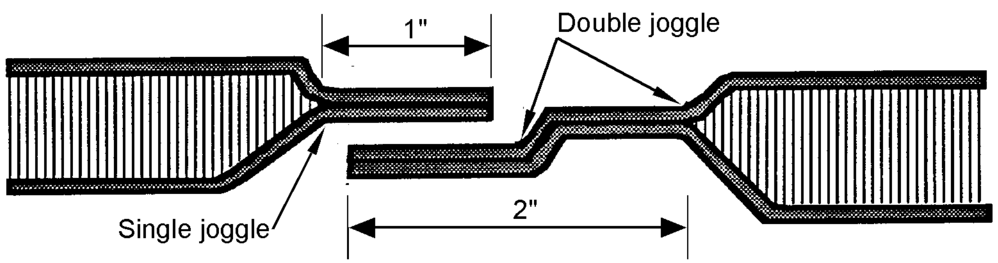
The following construction processes are described to provide clarity as you build your airplane. Each of these procedures have been developed and tested at the Lancair factory.

2.3.A Preparing Joints and Joggles

Adjoining parts are attached using a bonded, overlapping joint that is reinforced with fiberglass strips known as BID tapes. This joint is referred to as a joggle.

Figure 2.3.A.1 illustrates the overlaps prior to assembly. The dimensions shown in the figures are approximate. The edges of the supplied parts may have excess material. Prior to trimming, single joggle and double joggle surfaces can look similar. To obtain the dimensions illustrated in the figure below, you must trim the excess material.

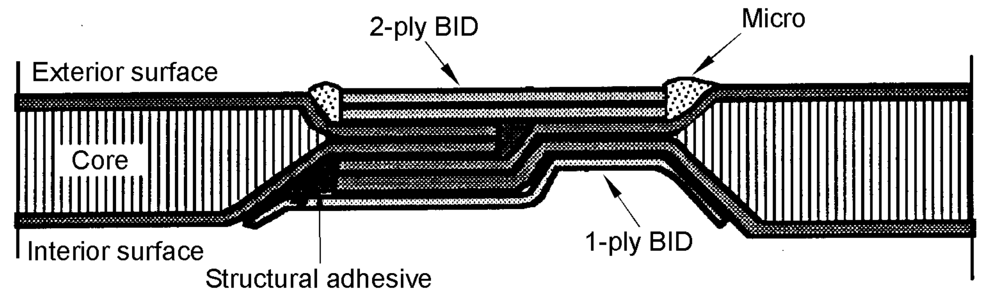
Figure 2.3.A.1 Single joggle and double joggle examples



WARNING: Edges of parts may be sharp. Handle with care by using gloves, or file and sand sharp edges.

Refer to Figure 2.3.A.2 for a view of a completed joggle joint.

Figure 2.3.A.2 Reinforced overlapping joint using BID tape



To view each type of joggle examine the front of the fuselage at the following locations:

- Single joggle – an example is forward of the firewall where the bottom cowl will meet the fuselage firewall joggle.
- Double joggle – an example is above and behind the firewall where the forward deck will mount.
-

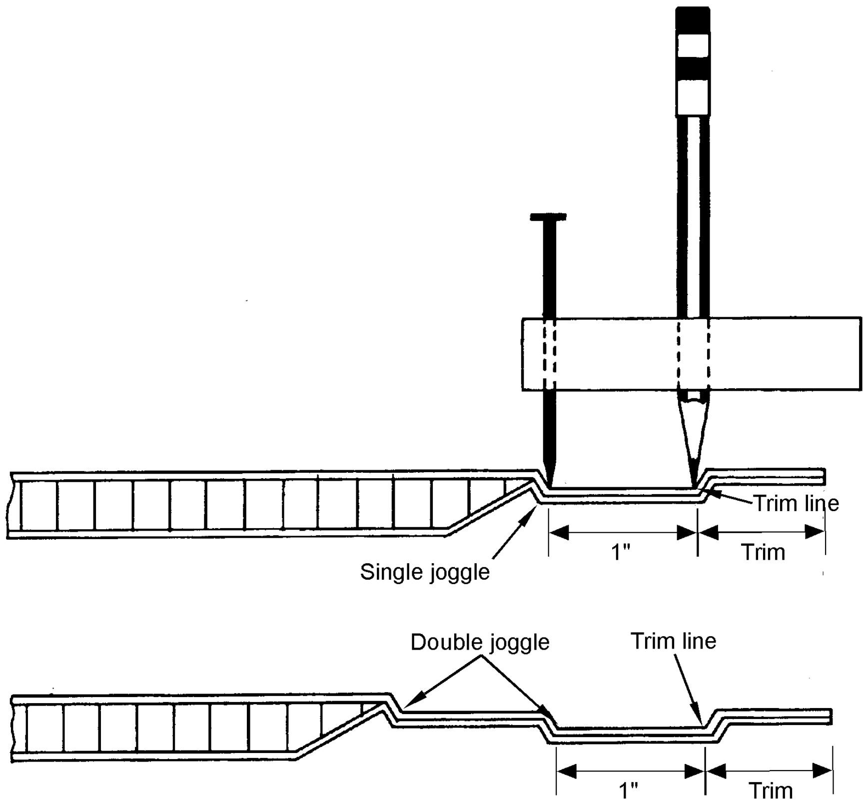
Trimming Joggles

Practice the following steps until you are proficient with trimming joggles.

Steps.....

1. Place the fuselage on a convenient working surface.
2. Make a marking tool from a piece of wood, a nail and a pencil.
   Make sure the nail tip is well rounded and has no sharp edges. You don't want the marking tool damaging the glass fibers. See Figure 2.3.A.3 for an example of the marking tool.
3. Mark a trim line using your marking tool on your single and double joggle surfaces as shown in Figure 2.3.A.3.

Figure 2.3.A.3 Marking the trim line



4. Cut along the trim line.

   See Figure 2.3.A.4 to view the trimming along the trim line. If necessary, trim additional material to obtain the correct, smooth edge. Sanding the edge may be useful to smooth the newly trimmed edge. See Figure 2.3.A.5 to view both an incorrectly and correctly trimmed edge.

This trimming procedure will be repeated each time you create a joggle during the building of your Lancair.

Figure 2.3.A.4 Trimming the joggle

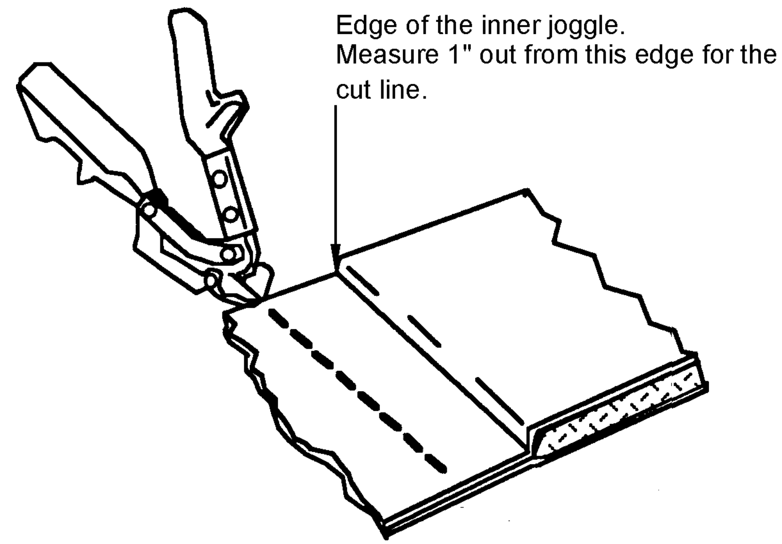
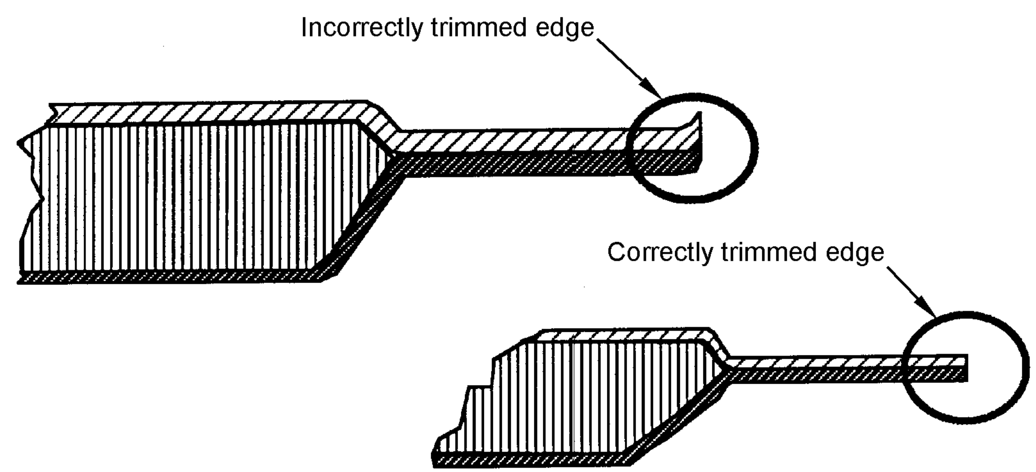


Figure 2.3.A.5 Trimmed edge examples



2.3.B Drilling, Bolt-hole Tolerances and Hardpoints

It will take some practice on your part to drill a close tolerance hole in aluminum and fiberglass. Through trial and error at the shop we have determined that the following drill combinations work well for various size screws and rivets.

The following lists contain the drills we commonly use for various bolts and rivets.

Rivets

- AN426 rivets (.097" diameter) – use a #40 drill
- 1/8" rivets (.125" diameter) – use a 1/8" or #30 (.1285") drill

Screws

- #6 screws (.137") – drill a tight #29 (.136) hole or a sloppy #28 (.1405")
- #8 screws (.161") – use a #20 (.161") or #21 (.159") drill (both work well)

Bolts

- AN3 bolts (3/16") – use, in addition to the obvious 3/16" drill, a #13 hole with reaming to get a tight fit (see the following section *Tolerances and Bolt Holes* for tolerance definitions). A #12 hole is sometimes too sloppy but can be used for unimportant, quick and dirty holes.
- AN4 bolts (1/4") – use 1/4" drill

Lettered drills are also handy like the "E" (.250") or the “D” (.246") with a reamer.

Drilling Technique

We recommend that when you are drilling you should step up to your final drill size. If you want a tight AN4 hole and you drill with a 1/4" drill, the hole will be loose and usually irregularly shaped. Instead step up to the final drill by first drilling a 3/16" hole, followed by a 7/32" hole, and finally a 1/4" hole.

The extra minute you spend changing the drill bits is well worth it. This is particularly true when you are drilling a hole that needs a close tolerance.

Tolerances and Bolt Holes

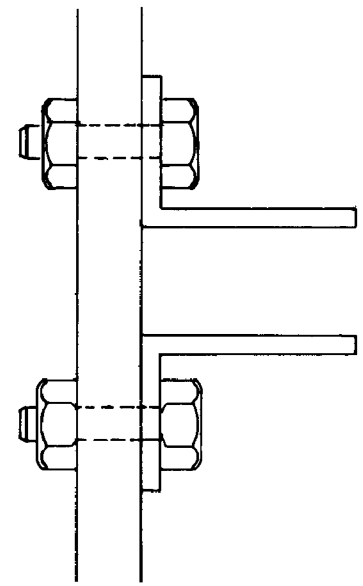
When a bolt is holding a bracket tightly against a bulkhead, rib, firewall, etc., you do not need to drill a .001" tolerance hole. This is because the clamping action of the bolt will keep the bracket from wearing a larger bolt hole. This applies to rod end bearings and bellcrank bearings that are mounted tight with elastic locknuts. In both of these situations the slop in the bearings are not dependent on the tolerance of the holes.

Loose tolerance

The definition of loose tolerance is a bolt hole that allows the bolt to vibrate. This action slowly enlarges the hole.

The two bolts in the following illustration simply hold two objects together. They are usually secured with elastic locknuts which are torqued down tightly. The possibility of excessive wear because of a loose tolerance hole is remote. This is the method of loose tolerance that we use in building a Lancair.

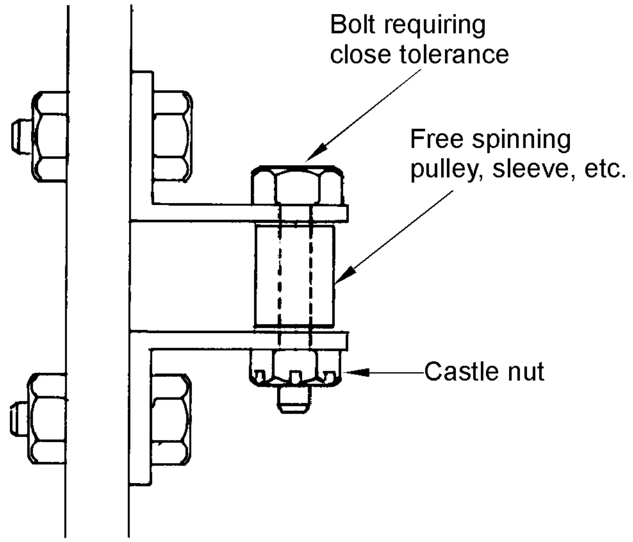
Figure 2.3.B.1 Bolt holes that accept loose tolerances



Close tolerance

Bolt holes that require a close tolerance are those where the bolt can rotate freely but without slop and the vibration that can enlarge a hole. When a castle nut and cotter pin are recommended, it means that the nut and bolt will not be tightened against a fixed object. Instead the object is allowed to float between the brackets. The Castle nut is simply snugged down and then secured with a cotter pin. This prevents binding on the spinning pulley or sleeve.

Figure 2.3.B.2 Bolt holes requiring tight tolerances



Drilling Alignment Holes

To achieve the proper overlap alignment during assembly, alignment holes are drilled for screws or Clecos. Then the screw or Cleco is placed in the hole to secure the parts in place during cure time.

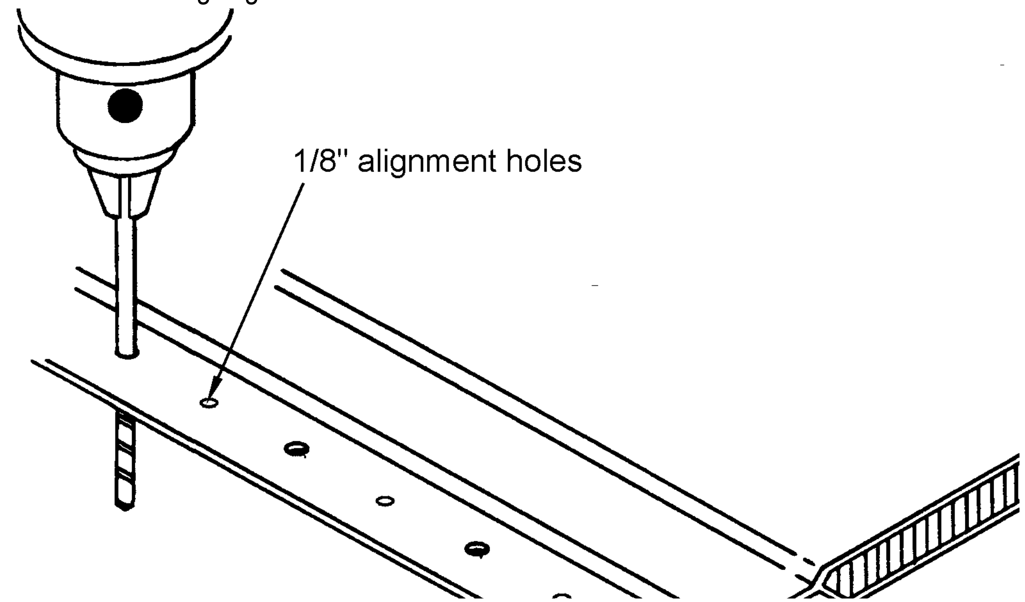
The following equipment is required:

- electric drill
- 1/8" drill bit

Steps.....

1. Using a 1/8" drill bit drill the alignment holes in the first part.
   Drill the holes as far apart as is practical.
2. Align the first and second parts. Now mark through the holes in the first part, making a small mark on the second part.
3. Drill the alignment holes in the second part.
4. Place the two parts together and insert screws or Clecos in the alignment holes to secure the two parts.
5. Drill 1/8" rivet holes between the alignment holes at 2" intervals along the seam edge.
6. Remove the Clecos.

Figure 2.3.B.3 Drilling alignment holes



Pop rivets will be inserted in these holes as a clamping device during the seam bonding process described in 2.3.C *Fastening Parts Together and the Double-bond Seam* on page 2.12. Once the bond is set the pop rivets are drilled out.

Hardpoints

A hardpoint is used to provide a solid surface for screwing parts together.

Steps.....

1. Draw a circle around a screw location with the screw centered in the middle. The diameter of the circle should be larger than the head of the screw.
2. Remove the inside laminate only, within the circle.
3. Remove a 1/4" (6 mm) of the core around the hole.
4. Fill the hole with flox.
5. Let the flox cure.
6. Install the screw.

2.3.C Fastening Parts Together and the Double-bond Seam

Parts that will be fastened together using epoxy or structural adhesive must be held tightly in position until the bonding material has set. Several methods of temporary positioning are available, but we recommend the pop rivet method described in *Drilling Alignment Holes* on page 2.11 as the best method. Then use the following steps to prepare the two parts you plan to join.

Before you start make sure you have read all the warning and caution labels on the containers and that you have reviewed the section on 2.1.A *Building Safely* on page 2.1 of this chapter.

Steps.....

1. Make sure you removed the peelply protective coating from all parts.
2. Trim all joggle surfaces as described in *Trimming Joggles* on page 2.8.
3. Drill the alignment holes as described in *Drilling Alignment Holes* on page 2.11.
4. Fasten the two parts together by installing a sheet metal screw or Cleco bits (see Figure 2.3.C.1) into the alignment holes.

   The tip of the Cleco is inserted into the alignment hole. When the pliers are released, the Cleco locks itself into the holes, tightly holding the parts together.

   This holds the parts in alignment while you drill holes approximately every 2" for pop rivets.
5. Drill the holes for the pop rivets.
6. Remove the Clecos or screws.
7. Clean the surfaces that you are going to bond.

   The surfaces to be bonded must now be cleaned since they may have become contaminated during handling and storage. Clean thoroughly with Acetone.

   - Dampen a cloth or towel with the wax and silicone remover. Wipe it along each surface that will be bonded together on each part. Do not rub or scrub the surface as that may work the contaminants into the surface.
   - Immediately follow with a dry cloth or towel to absorb the solvent and the contaminants it removes from the bonding surface.
   - Repeat this process until the seam on each part is clean.

   If at any time the cleaning or drying cloth shows any soiling, or the drying cloth becomes wet, replace it immediately with a fresh, clean cloth.

   WARNING: Failure to follow these cleaning steps can result in an eventual bond failure. Even surfaces which appear clean must be cleaned since some contaminants are not obvious.

   Always follow the instructions provided on the caution label on the wax and silicon remover containers.
8. If any obvious contaminants still remain the above process may be repeated with methylene chloride.
9. Lightly roughen all cleaned surfaces using a clean 80-grit abrasive paper until the surface shows a fine white powder. Remove the powder with a clean cloth or clean brush.
10. Prepare the bonding material (epoxy, epoxy/flox, epoxy/micro or structural adhesive) and apply it to one of the surfaces to be bonded.

Now you are ready to apply the adhesive on the seam of the first part that you have cleaned. Continue finishing the seam in 2.3.C *Fastening Parts Together and the Double-bond Seam* on page 2.12.

Finishing the Double-bond Seam

The following steps describe how two airplane pieces are joined together in a double-bond seam, which stiffens the joints by laying the fiberglass BID tapes over the bonded seams.

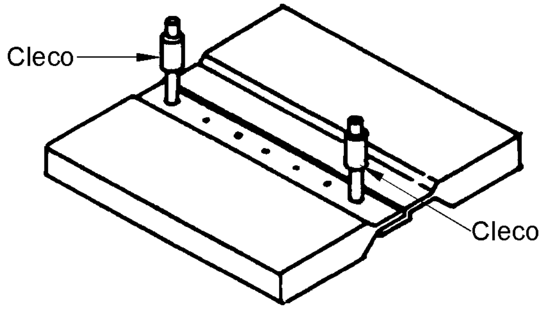
Steps.....

1. Using a wooden spatula, apply the structural adhesive beginning with the seam of the first part that you cleaned.
   - Spread an even layer of adhesive on the overlap surface of the part.
   - Now spread an even layer of adhesive on the overlap surface of the other part.
2. Overlap the two adhesive-coated surfaces and align the holes.
3. Insert a Cleco at each end of the two parts that need to be held together.

   This holds the two pieces in alignment as you complete the seam. If the seam is longer than 18” insert Clecos at regular intervals.

   The following illustration shows the two pieces that are going to be joined with a Cleco in each end hole.

Figure 2.3.C.1 Joining parts – inserting Clecos

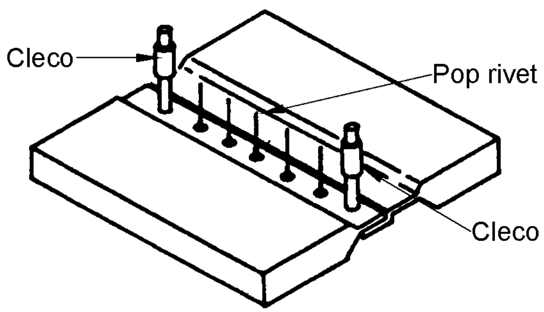


4. Insert the pop rivets into the remaining holes.

   Remember that these holes were drilled two inches apart for the length of the seam as described in *Drilling Alignment Holes* on page 2.11.

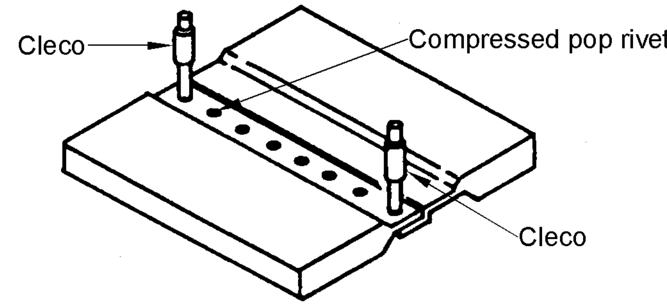
   The next illustration shows the pop rivets set into the remaining holes.

Figure 2.3.C.2 Joining parts – inserting pop rivets



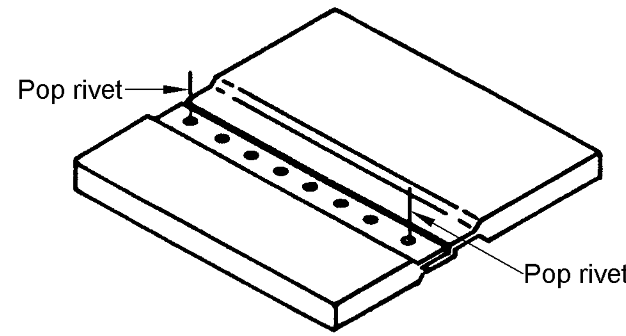
The following illustration shows the pop rivets after they have been compressed.

Figure 2.3.C.3 Joining parts – compressing pop rivets



5. Remove the two Clecos from the end holes and replace them with pop rivets.

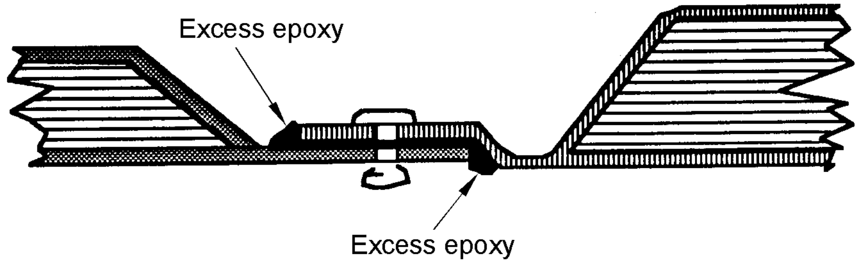
Figure 2.3.C.4 Joining parts – removing the Clecos



6. Scrape off any excess adhesive that squeezes out while it is still soft. Use a tong depressor for this task.

   See Figure 2.3.C.5 for locating the excess adhesive. Adhesive is more difficult to remove when it hardens.

Figure 2.3.C.5 Joining parts – removing excess adhesive and/or epoxy

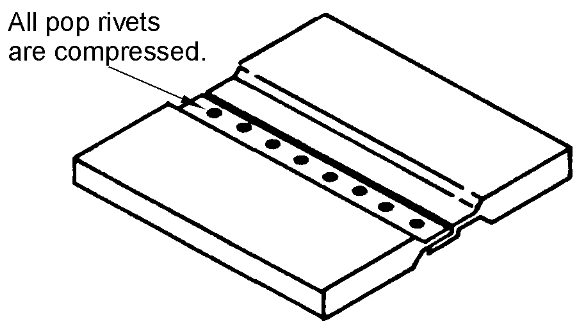


7. Use methylene chloride on a clean cloth to remove adhesive that smears on the fiberglass surface.

   If you used Clecos, clean any adhesive from the tool.
8. Wait for the adhesive to cure.

   Once the parts are solidly cured you can begin working with them again.

Figure 2.3.C.6 Joining parts – compressing end pop rivets

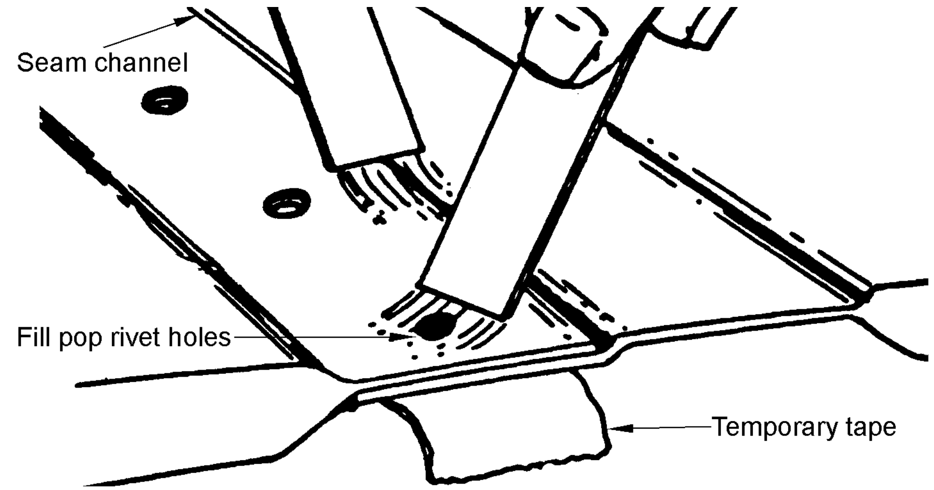


9. Drill out the rivets using a 1/8" drill, and remove any loose pieces.
10. Apply any type of tape temporarily to the underside of the seam.

    If you want to make the seam a little neater you can put a piece of tape over the back side of the seam. This covers the bottom of the rivet holes and helps contain the filler mix to make a smoother, neater finish. This method requires less epoxy and adds less weight, always something to consider throughout the construction process.
11. Fill the holes with a 50/50 mix of flox and micro.

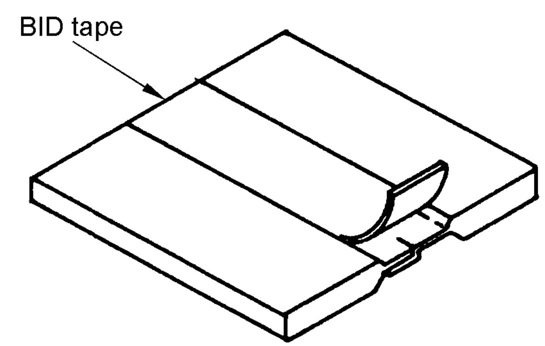
    Clean off any excess and let it harden.
12. Fill the seam channel with the mixture to bring it up to the level of the adjacent surfaces.

Figure 2.3.C.7 Joining parts – filling pop rivet holes



    This prepares the seam for the BID tape. You can proceed with the next step without waiting for this to cure.
13. Lay a BID tape over the top of the seam.

Figure 2.3.C.8 Joining parts – applying BID tape



14. Remove the temporary tape from the underside of the seam.

This completes the double-bond seam.

2.3.D The Plastic Layup

The method described in this section for wetting out cloth is simple and invaluable. Your project hours can be reduced by using this technique. First you create the plastic layup using the laminate method and then you learn to apply the laminate.

Creating the Plastic Layup

Use either the 1 mil plastic you bought with your supplies or regular household garbage bags. If you use the garbage bags, cut along the edges with a roller blade. Cut two sections of plastic bigger than the piece of fiberglass you are about to apply. Now you will see how easy the piece will be to handle with plastic on both sides.

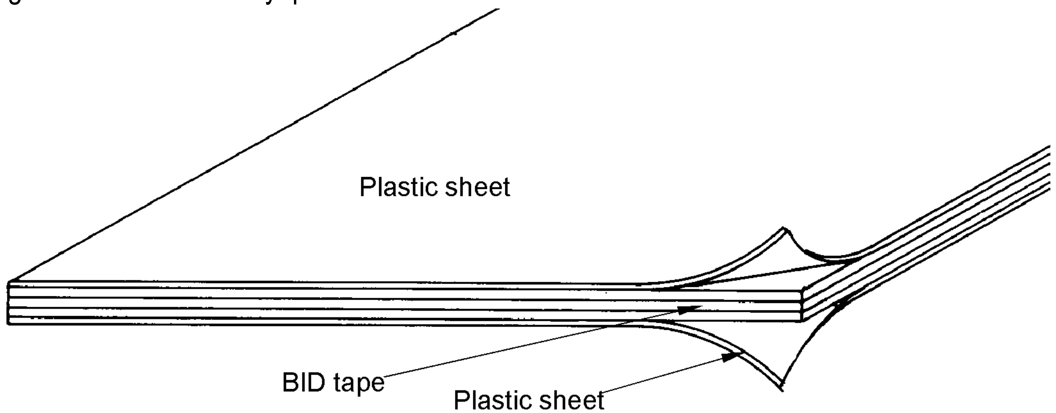
Steps.....

1. Tape one piece of the plastic to your fiberglass cutting table and lay the fiberglass piece (up to 4-BID thick) on the plastic.

   The cutting table provides an excellent surface for this technique.
2. Wet out the fiberglass cloth with plenty of epoxy.

   Gravity allows the epoxy to soak down through the layers of cloth and it is not necessary to stipple the BID with a brush.
3. Lay the other piece of plastic over the wetted-out cloth.

Figure 2.3.D.1 Plastic layup



4. Roll the air bubbles and excess epoxy out of the laminate.

   Always use a fair amount of pressure when rolling to achieve a good squeeze out of resin. See the next section, *Stippling and Applying the Plastic Laminate* for more information on rollers and rolling techniques.
5. Use the rollerblade to cut out the shape you need.
6. Remove the newly cut shape and peel the plastic off one side of the sandwich.
7. Lay the laminate in position on the surface you have prepared.

   Remember that the surface preparation includes sanding, cleaning, and painting on a light coat of epoxy.

   WARNING: Do NOT apply the laminate with the plastic side down. It will create a complete loss of structural integrity.

Stippling and Applying the Plastic Laminate

When you use the plastic layup method of wetting out your fiberglass, the following steps allow you to roll out the bubbles from between the plastic layers. This creates an air-free laminate.

Steps.....

1. Stipple or roll against the side of the laminate still covered by plastic.

   This squeezes the air bubbles from underneath the laminate.

Figure 2.3.D.2 Dry brush method of stippling

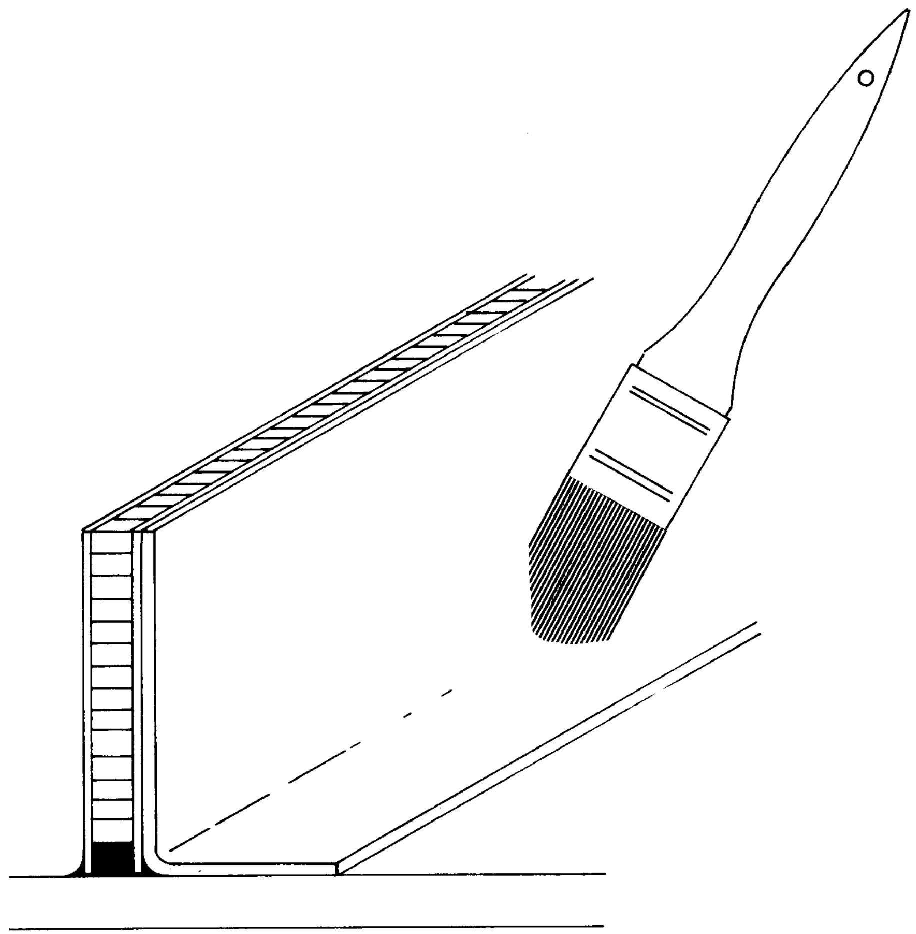
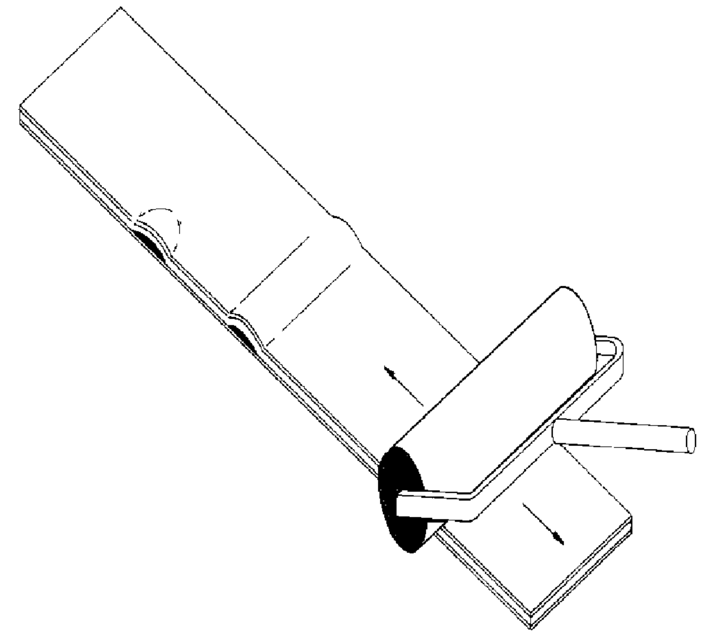


Figure 2.3.D.3 Roller method of stippling



2. Remove the remaining piece of plastic.
3. Stipple again if air bubbles were formed when you removed the plastic.
   Now you should have a bubble-free laminate with a good epoxy content.

2.3.E Micro Radii and Fiberglass Bridging

This section discusses the two methods that Lancair has developed for applying micro radii. Along with these methods you need to know the importance of avoiding fiberglass bridging. We use our modified tongue depressor that we developed in the late 1980s due to the demand for smaller micro radii. By sanding down the tongue depressor to a smaller radius, the micro joints on your ribs, bulkheads, etc., will look more professional. In addition this prevents the overfilling of joints which can add weight.

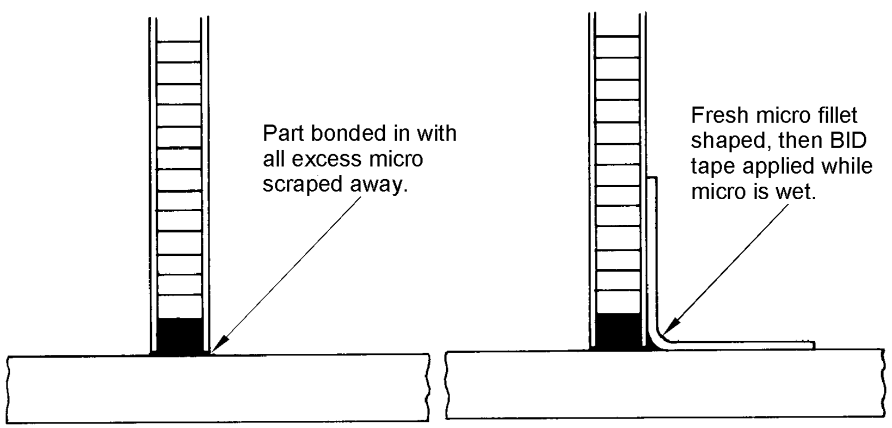
Micro Radii Methods

Either of the following methods can be used for applying micro radii and BID tapes. The second method is safer for preventing air bubbles.

Method One

This method bonds the rib/bulkhead and all the extra micro is scraped away leaving no radius. After the rib/bulkhead is cured in position, another batch of micro can be used to make the radius. The BID tapes are applied while this micro is still wet. This method makes the application of the micro radii easier because the part is already held firmly in position. Be cautious when the resin is painted onto the area where the BID tapes will be applied. The micro can sag and become runny. When this condition occurs it is easy to get air bubbles trapped underneath the BID tapes.

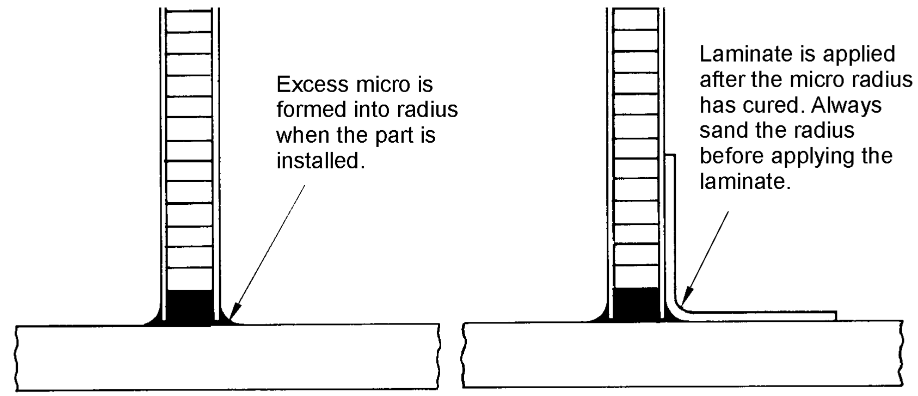
Figure 2.3.E.1 Method one for forming micro radii



Method Two

This method forms the micro radii when the rib/bulkhead is first installed. You must take care to hold the rib/bulkhead in its proper position while forming the radius with your modified tongue depressor. After curing, the BID tapes can be applied over a solid micro radii. This method helps eliminate air bubbles that form under the BID tapes because the resin that is used to saturate the tapes will not dissolve the micro. Plus, you can stipple the air bubbles out from under the BID tapes without destroying your radius. Be sure to sand the areas, including the micro radii, where the BID tapes will be applied.

Figure 2.3.E.2 Method two for forming micro radii



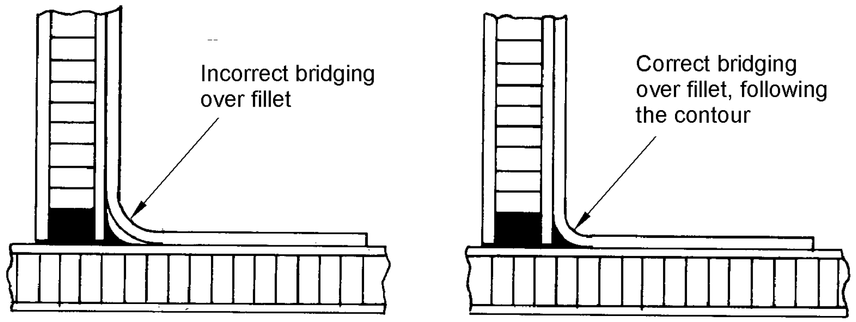
Tip: Do not be misled by thinking that more micro will make a joint stronger, in fact the opposite is true. Microballoons are not structural, so the more fiberglass tape you have bonding the actual part, the stronger the bond will be.

Avoiding Fiberglass Bridging

Fiberglass bridging must be avoided. We need to caution you that if you get carried away with smaller and smaller micro radii, the fiberglass will want to "bridge" over the microballoons and it will not bond properly.

Bridging is fairly easy to detect since the air is visible under the laminate. With a little practice your micro joints will look great.

Figure 2.3.E.3 Bridging fiberglass over a radius



2.3.F Building Light and Building Straight

Building Light

Your completed Lancair should not exceed the recommended design weight. A homebuilder's natural instinct is to consider any options that might make his plane stronger. But it is best if you follow the manual's instructions and not try to improvise.

The Lancair was stress analyzed and tested by Martin Hollmann, a leader in composite engineering. We've seen a Lancair with such a high empty weight that it is over gross as soon as the pilot steps into the cockpit, and with no fuel!

We recommend the following guidelines for building your plane. These will help keep your plane light.

- Follow the manual's instructions for BID layers.
- Always remove excess resin.

A frequent question asked by builders is "how much resin should I put on my laminates?" The worst enemy to a light, high performance airframe is too much resin.

Also, when the call for BID tapes is higher than two or three, you will save even more time and weight by wetting the cloth out on plastic.

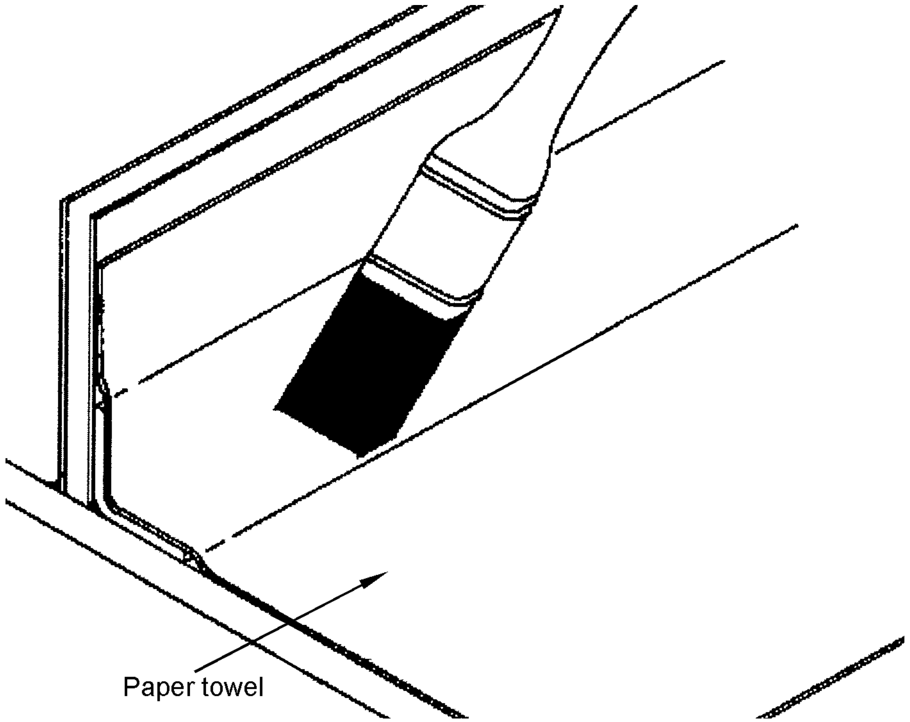
Removing excess resin

Another way to save weight is to throw out the peelply and use paper towels instead.

Steps.....

1. Pull off the plastic of a newly applied BID tape.
2. Place a paper towel directly on the wet glass and tamp it with a dry brush.
   The towel will soak up the excess resin and the tamping will help push out air bubbles.

Figure 2.3.F.1 Soaking up excess resin



3. Remove the paper towel when it is soaked.

   Look over the results. If the towel has pulled up or distorted the glass, tamp it again with the dry brush. Does the glass still look glossy, with an uneven resin content? Continue to tamp using a paper towel.

   As long as the laminate does not look white, which indicates it is too dry, there will be plenty of resin in the glass.

   WARNING: Always remove the paper towels before cure.

Building Straight

Keeping the airframe straight is important in a good flying aircraft. If your completed Lancair weighs in correctly, but it corkscrews through the air in giant barrel rolls when you let go of the stick, you haven't built a straight airplane. If you build your plane according to plans and following the advice given in the construction manual, your Lancair should fly straight and true when it is complete.

You need to realize that if one wing is a bit heavier, or a trailing edge is wavy, this is acceptable. Our prototypes never come out exactly straight and true. We don't expect homebuilders to create a perfect airplane but we do have some tips that might help.

A simple method of checking the straightness of an edge is using your eye. If an edge or surface looks straight to the eye, it is straight enough. Even minor discrepancies in wing tip washout can easily be detected by kneeling down ten feet in front of your Lancair, closing one eye, and align your other eye with the trailing edge tip. Sight one trailing edge tip above the high point of the wing, turn your head, and sight the other tip, comparing the two.

Straightening Trailing Edges

The trailing edges of your Lancair should be straight so the control surfaces can travel freely with a consistent gap. Then you check the straightness with your eye and the trailing edges aren't quite perfect. Now use the following steps to straighten any warped wing or tail trailing edges.

Steps.....

1. Heat the area with a heat gun until it's just too hot to touch.

   Be very careful not to burn or scorch the fiberglass or carbon fiber. Try heating an extra piece of prepreg material first, just to see how much heat is required to burn it.
2. Clamp a piece of straight wood or aluminum angle to the edge to keep it straight while cooling.

   Tip: Using wood is better because it cools slower than the aluminum and tends to prevent re-warping the edge. When heating the fiberglass don't burn the wood.

   If you use aluminum, heat the angle also. Otherwise the cold aluminum will cool the edge too quickly and the warp will remain. Heat at least an inch forward of the edge and don't discolor or burn the fiberglass.
3. If the warp still remains, locate a 1x2 or 2x4 board with the right curvature to warp the edge the opposite way when clamped tight.
4. Heat the edge and let it cool with the board clamped in position.

   With any luck, the part will spring into position with a nice and straight edge when the board is removed. Review the next two illustrations which demonstrate this method.
5. Remove the clamps when the skin has cooled completely.

Figure 2.3.F.2 Heating the trailing edge

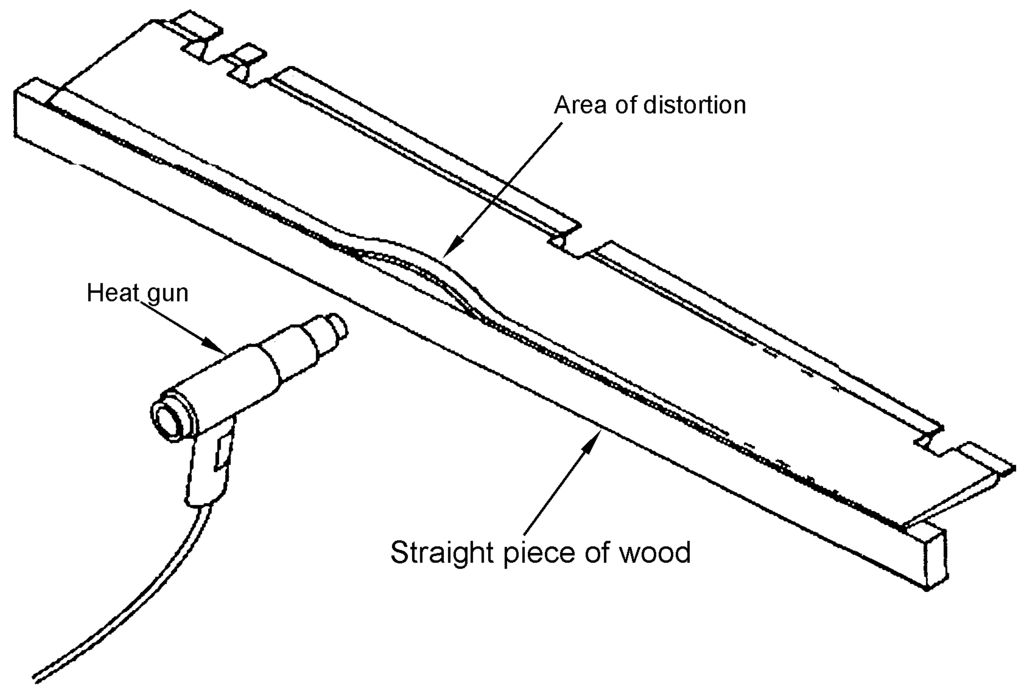
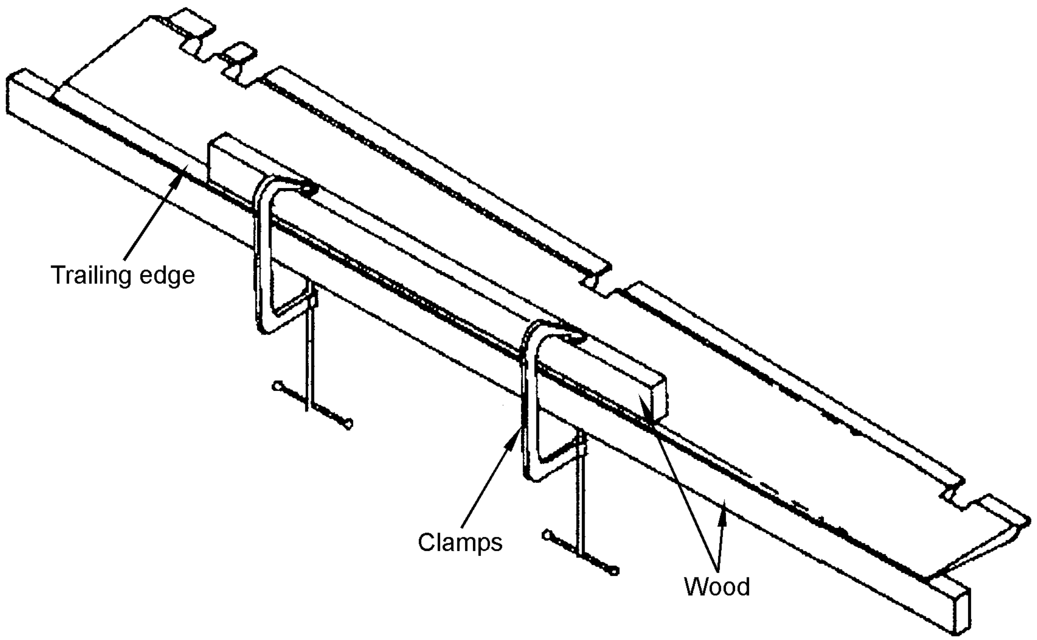


Figure 2.3.F.3 Clamping the trailing edge



2.3.G Control Systems

Control systems are any of the devices used to work the control surfaces such as the ailerons, elevator, and the rudder. The following list addresses specific areas you need to understand in order to build effective control systems.

- Working with pushrod ends
- Installing castle nuts and cotterpins
- Creating consistent control surface gaps

Working with Pushrod Ends

Pushrod ends are used in control system linkages.

View this picture to see a completed pushrod end.

Steps.....

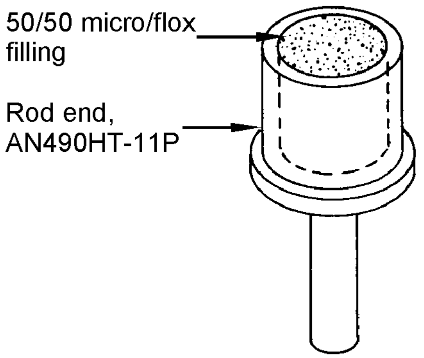
1. Cut the pushrod tube to the correct length.

   After cutting the pushrod tube to length, don't immediately rivet the rod end in position.
2. Test the pushrod tube length in the system (flap, aileron, elevator) by temporarily securing the rod ends to the pushrod with instant glue.

   Use only a few drops of glue to secure the rod end or the bond may become more than temporary. Don't cover the rod end with glue then slide it into the pushrod, the bond would be impossible to break free.
3. Break the rod ends free once you determine the tube is the proper length.
4. Clean the rod ends.
5. Fill the rod ends with a 50/50 micro/flox mixture and allow it to cure.

   This allows the drill to track straight through the rod end when it is drilled for the rivets. A solid rod end will also prevent rivets from buckling when they are set in place.

Figure 2.3.G.1 Filling rod ends with micro/flox mixture



6. Coat the rod ends with Loctite before sliding them into the pushrod tube.

   Only coat with Loctite on the very last time you slide the rod ends into the pushrod. This is right before riveting. The Loctite will prevent slippage or vibration wear.

7. Use a rivet gun to set the rivets which secure the rod end.

   Make sure you follow the *Rivet Rule* on page 2.22.

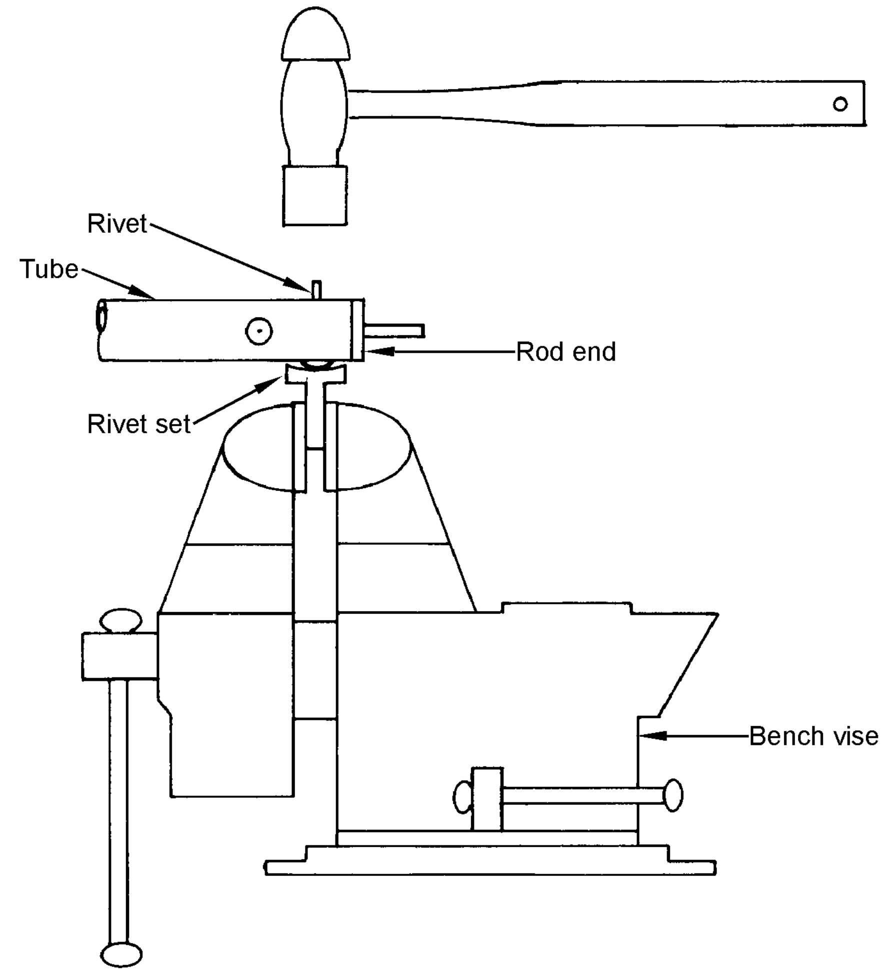
   A rivet gun is the best method of setting the rivets. In a pinch, we have used a hammer to lightly tap and expand the rivets. Refer to Figure 2.3.G.3. Hit the rivet lightly and accurately to avoid smashing the rivet end to one side.

   A rivet squeezer is not recommended for pushrod rivets because the rivets may buckle in the center of the pushrod.

Figure 2.3.G.2 Completed rod end

Rivet locations - Increase the distance from the end of the tube to the rivet (indicated by the arrow) to prevent rivet holes from interferring with the rod end

Figure 2.3.G.3 Setting the rivets in the rod end



Rivet Rule

The correct length of the protrusion is calculated as 1.5 times the diameter of the rivet. For example, a 1/8” rivet should extend 3/16” from the material being riveted.

Painting Pushrods

We recommend painting the pushrods with one coat of zinc chromate followed by one coat of color. This is how we paint them at the Lancair factory. Hardware store spray cans are fine for the color coat.

Installing Castle Nuts and Cotter Pins

Two common errors found during Lancair inspections are castle nuts without their cotter pins and cotter pins that are bent incorrectly.

The castle nut is a commonly used item in Lancair control systems. A castle nut is only used on drilled bolts and *must* be secured with a cotter pin. Castle nuts are usually snugged down, not tightened like an elastic locknut, and the cotter pin is used to prevent the nut from loosening.

The standard method of bending and securing cotter pins is shown in the illustration below.

- Longer cotter pin prong – The prong is bent over the top of the bolt and cut as shown in the illustration below.
- Shorter cotter pin prong – The prong is bent straight down.

Many homebuilders simply bend the two cotter prongs around the bolt and call it done. If the prongs are not cut to the proper length, the prongs could grab a stray piece of upholstery or wire and possibly jam the corresponding control system.

Figure 2.3.G.4 Side view of a properly pinned castle nut

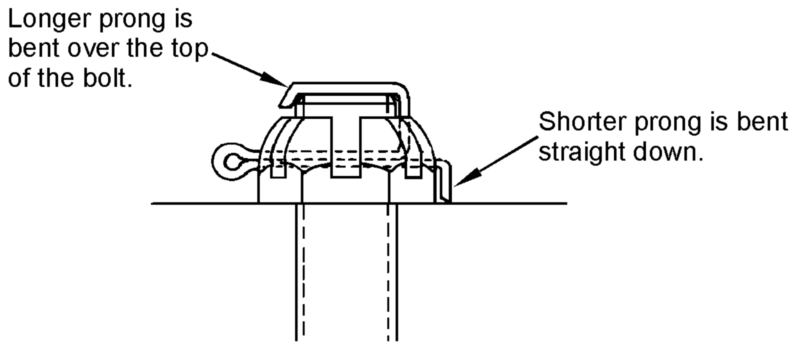
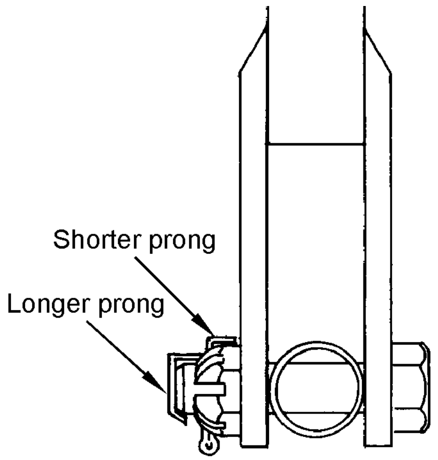


Figure 2.3.G.5 Top view of a properly pinned castle nut



Creating Consistent Control Surface Gaps

We define a consistent control surface gap as a space that a tongue depresser can fit into.

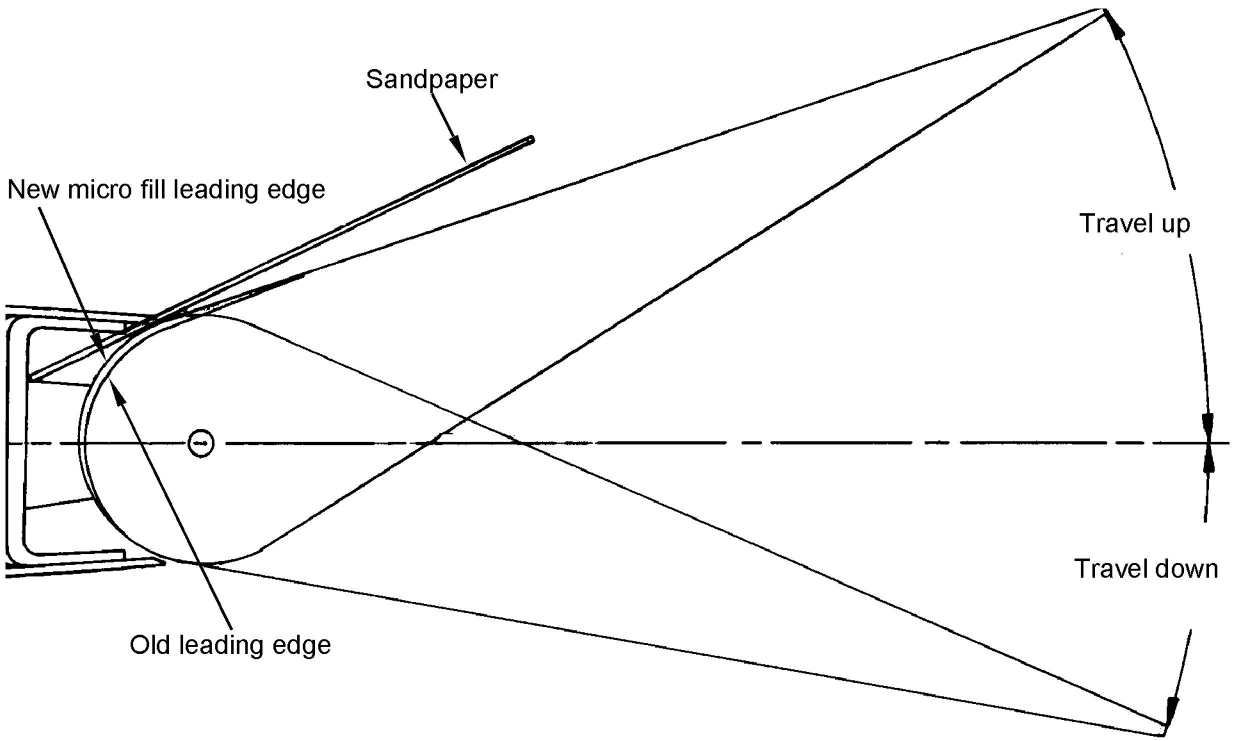
No matter how good the mold, the leading edges of the elevators, ailerons, flaps, and rudders never seem to fit the trailing edge of the wings and stabs just right. If you'd like to get a closer gap on your control surfaces, try this method.

For example, if you need to create a consistent control surface gap on your elevator, the following steps guide you through the process.

Steps.....

1. Mount the elevator to the horizontal stab and make sure there is at least a 1/16" gap between the elevator leading edge and the stab trailing edge.
2. Mark on the elevator where the gap is too great or fairly close and remove the elevator.
3. Add a micro layer, mixed thick, to the areas marked "too great" and shape a rough radius.

Figure 2.3.G.6 Gapping control surfaces



4. Allow the micro to cure. Then sand it so the elevator will just fit back into the stabilizer.
5. Sand the stab trailing edge straight, parallel to the hingeline.
6. Run one strip of sandpaper, 3M or Norton 40-grit longboard sheets work best, back and forth between the elevator and the stab, sanding the micro on the elevator.

   Another pair of hands is very helpful in this process to hold the elevator stable while you work the sandpaper. Have your helper raise or lower the elevator slightly when you feel the resistance on the sandpaper decrease.
7. Slowly work the elevator through its full range of travel.

   Now you should see a consistent gap between stab and elevator when the elevator is moved through its travel range.

2.3.H Working with Aluminum Tubing

Cutting, flaring and deburring aluminum tubing is a skill that will be required during the construction of your airplane. The following list addresses specific areas you need to understand in order to build aluminum lines.

- Cutting aluminum tubing
- Tube flaring

Cutting Aluminum Tubing

A tubing cutter is the best tool for cutting the aluminum tubing to length. We recommend a small cutter since it is much easier to work with.

1. Roll the cutter around the tubing. Tighten the handle slightly and roll it around the tubing again.

   Continue rolling the cutter until the tubing is cut.
2. Deburr the inside of the tubing using your deburring tool.

   After every cut the inside of the aluminum tubing must be deburred.

   WARNING: Deburr only what is necessary to achieve a smooth edge. Excess use of a deburring tool can remove too much material and potentially weaken the flared end.

For more information Tony Bingelis covers tubing cutting and deburring in his Sportplane Builder books and Sport Aviation columns. We recommended these books in 1.2 *Recommended Reading and Background Information* on page 1.2.

Tube Flaring

Tube flaring requires a specialized flaring tool and practice to learn how to use the tool. The flare in aluminum tubing must be clean to achieve a proper seal.

1. First deburr the tubing as described in the previous section.

   If the tubing is not deburred, the inside of the tubing could be scored when flaring and the tubing may not seal properly.
2. Grease the cone-shaped part of the flaring tool so it does not gouge the tubing.
3. Flare the tubing using your flaring tool.

   Do *not* over-flare the tubing. The expanding aluminum can crack. The cracks are visible if you look closely.

Continue to experiment and learn how to use your flaring tool. Again, refer to the books by Tony Bingelis for valuable information on these specialized tasks.

2.3.I Working with Braided Hose

Before you start working on the fuel lines, make sure you review these techniques for working with braided hose. You need to know how to cut the hose and how to install fittings on the ends of the hose.

Guidelines:

- The length of the hose is determined by measuring from the very tips of the flared ends of the fittings. Try to measure along a smooth arc between the fittings to avoid kinking the hose from over bending. Subtract about 1/2" (15 mm) from the measurement to find the actual hose length.
- There are no absolute rules in hose measurement.
- Try to avoid kinking the hose.

Cutting Braided Hose

1. Wrap the hose tightly with a couple of layers of electrical tap or metal aluminum tape. Center the tape on the planned cut line.
2. Use a large, sharp cold chisel to cut the hose by placing the hose on a thick piece of aluminum and hit the chisel with a hammer.

   This should create a clean cut. You can also use a bandsaw or a hacksaw.

Figure 2.3.I.1 Cutting braided steel hose

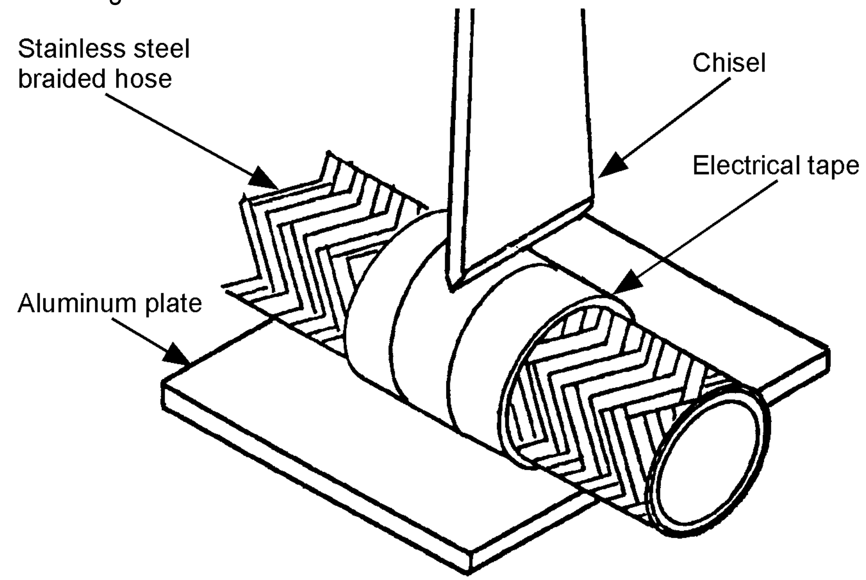
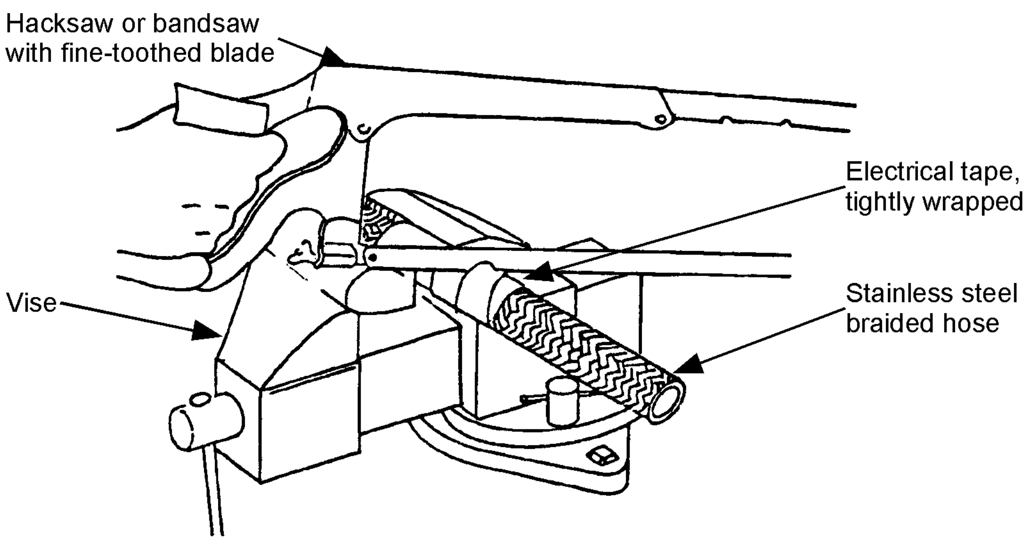


Figure 2.3.I.2 Cutting braided steel hose



Installing Fittings on Braided Hose

Most fuel and hydraulic hose-end fittings are installed in the same manner. The following steps will guide you through installing a Russell fitting on a hose for a fuel line.

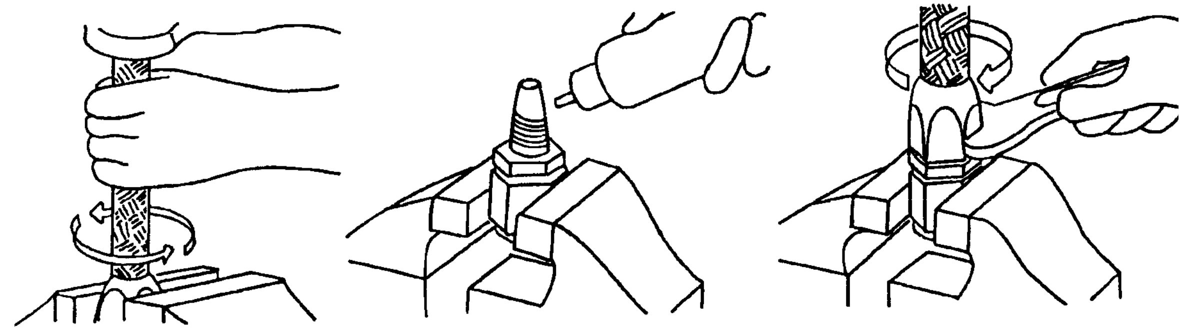
1. Unscrew the red socket from the nipple of the hose-end fitting.
2. Hold the socket in a vise and thread the hose counterclockwise into it. The hose will stop at the bottoming step of the socket.
3. Hold the nipple in a vise. Apply oil sparingly to the threads of the nipple and the socket.
4. Using your hands, start threading the socket and hose onto the nipple.
   Use your hands so you get proper alignment of the hose and the nipple.
5. Finish tightening the socket with a wrench until it reaches the nipple hex or when there is no more than 1/16" (2 mm) gap between the nipple and socket.

Sealing Compounds and Fuel LInes

Keep in mind the following recommendations as you work on the fuel lines.

- Do not use any type of sealing tape in the fuel system. Teflon tape has the potential for breaking loose and running into the engine.

Figure 2.3.I.3 Installing hose-end fittings



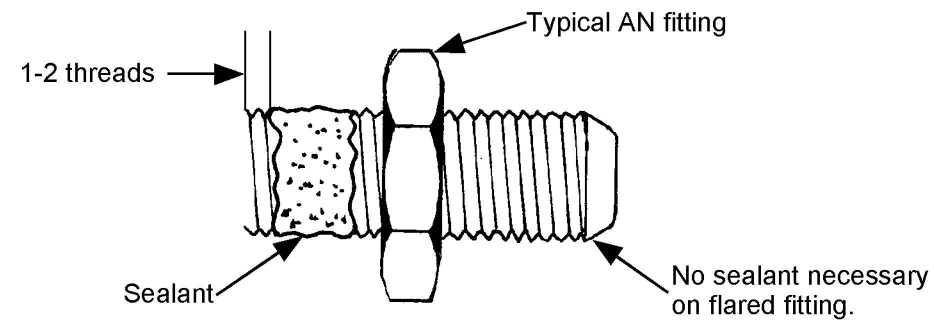
Twist the hose counterclockwise onto the socket until the hose bottoms out.

Clamp the nipple into the vise and apply oil sparingly to the threads of the nipple.

Thread the hose and the socket over the nipple until there is no more than 1/16" (2 mm) gap between the socket and the nipple.

- Flared-end fittings do not require any form of sealant.
- Pipe thread fittings should be sealed using a teflon based sealant paste. We recommend Loctite 592 Teflon sealant.
- When applying the sealant paste, start approximately. 1-2 threads back on the fitting to avoid contamination of the fuel.

Figure 2.3.I.4 Applying teflon paste to fittings



2.3.J Painting

These steps of cleaning and priming work well at the Lancair factory. We recommend this method of preparing your Lancair for its color coat.

Painting can be a tedious and sometimes toxic process. But if you take your time a good-looking paint job is fairly easy to produce.

Steps.....

1. Clean all surfaces.

   Clean all the bare fiberglass and/or carbon fiber surfaces to remove any contaminants that could affect your paint. You must clean before the initial sanding of your surfaces, and before each primer and color coat. We recommend DuPont Prep-Sol cleaner for this purpose.
2. Sand all surfaces with 80-grit.

   Scuff up the surfaces with 80-grit sandpaper. This is done so the primer can bond properly. Use a dual action sander to make short work of this step.
3. Apply a coat of primer.

   Again clean all the surfaces with Prep-Sol in preparation for the first primer coat. We recommend the polyester-based Featherfill primer as a first coat. Apply the Featherfill with a paint brush.

   Brushing on the first coat of primer fills the pinholes much better than spraying does. The goal of the Featherfill is to fill the weave of the material and the scattered pinholes. This first coat does not need to be attractive since most of it will be sanded off in the following steps.
4. Sand with 100-grit.

   Sand away most of the Featherfill using 100-grit sandpaper. Use a longboard sanding block or one of the sanding blocks that use a half sheet of sandpaper. If there are low spots in the surface, this is when you'll start to see them.
5. Blow off the surface with an air nozzle and clean again with Prep-Sol.
6. Paint with normal primer.

   We recommend any aircraft grade primers, including the following:

   - WLS primer
   - Superflite – has application and sanding properties

   Whatever brand you use, spray on a good, thick coat.
7. Sand down to 220-grit.

   Sand the primer smooth with the 220-grit. Wet sanding is recommended since the sandpaper is much more efficient when wet.

   This is where many homebuilders start to get impatient, sanding off coat after coat of primer. It does take a long time but only sand until the surface is smooth. You do not need to sand all the way through the primer coat you just applied.

   On the underside of your plane you may not want to apply any more primer if this coat has sanded smooth without sanding through. In this case, simply switch to 320-grit and finish the final sanding.
8. Fill any pinholes.

   Now is the best time to look for pinholes in your surfaces. Use the air nozzle to blow the dust off the smoothly sanded surface and out of the pinholes. Then fill the pinholes and chips with Evercoat polyester glazing putty. Use a putty knife or squeegee to force the putty into the pinholes. Lightly re-sand the pinhole-covered areas after filling.

   The lacquer glazing putties tend to shrink too much with age, as does Bondo.
9. Prime with normal primer.

   Again clean all the surfaces and spray on what should be the last coat of primer. Use the same brand of primer as the previous coat. Use your judgement to decide if you need a thinner or thicker primer coat. This coat is usually a thinner application. This primer coat should look evenly applied and very few sandpaper scratches should be visible.
10. Wet sand this last coat of primer with 360-grit.

    We do not recommend sanding with a 400-grit. It sands the surface too smoothly and the paint doesn't have anything to attach to.
11. Clean for color coat