



A Comprehensive **Guide to** **COMPOSITES**

Processes & Procedures
from the Professionals



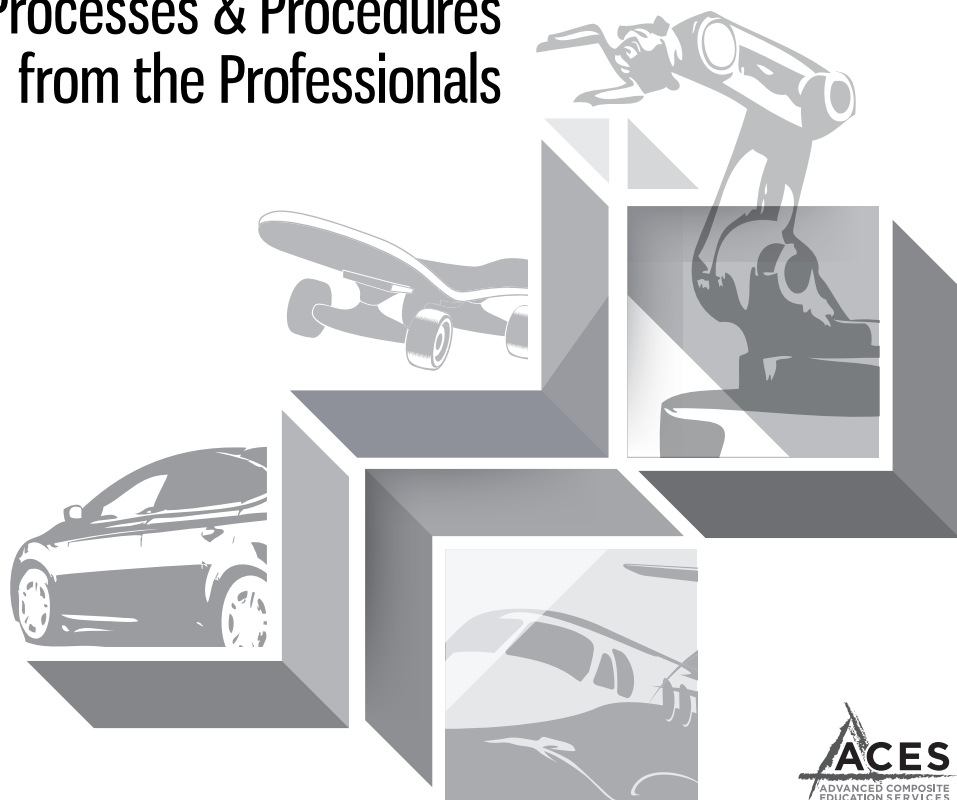
Kevin Fochtman

2ND EDITION



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Aviation Supplies & Academics, Inc.
Newcastle, Washington

*A Comprehensive Guide to Composites
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by Kevin Fochtman
Second Edition

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Fabrication



Objectives

- A. Laying up the part
- B. Applying the permanent vacuum bag
- C. The cure process
- D. Debugging the part
- E. Trimming the part

Laying Up the Part

This is the fun stuff, where we apply all of what we have learned thus far.

We have set up our shop to fabricate the composite parts of the future.

We have designed our part with the correct type of material, the right number of plies, at the right orientation to meet our part's needs whether they are structural needs or visual appeal.

We have planned out our processing schedule to support our engineering design.

We have acquired all of the materials, tooling, and equipment to fabricate the designed part.

Keep in mind that there are still many companies using wet lay-up as their primary process for the fabrication of composite parts. We will provide an example of the wet lay-up process and the prepreg lay-up process. These two processes are very similar in many ways. The main difference is that with the advanced composite, you will not need to measure and impregnate the fabric with the resin system.

The Wet Lay-Up

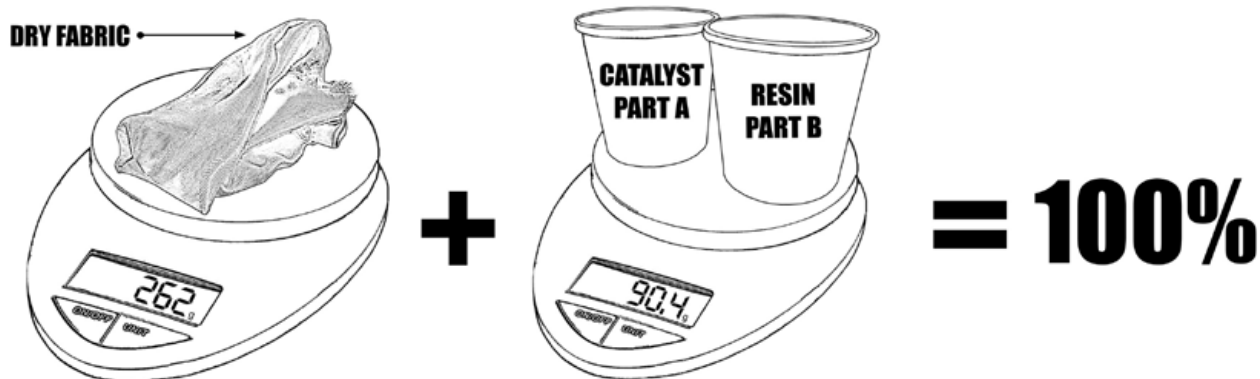
First—Prepare the material for lay-up by weighing the pre-determined quantity of dry fabric and the resin to be used. You will want a 40% resin to fiber content. For example if you have 262 grams of fabric you will want to weigh out 90.4 grams of your resin system. Not all resin systems are mixed at the same ratio. A resin system with a 1:1 mix ratio helps simplify the calculations,



Wet lay-up is used for non-structural parts that are not subjected to high stress or high temperatures.

but you may work with a resin system that uses a 4:1 ratio. Remember to deduct the weight of the mixing cups and keep your catalyst and resin in separate cups until you are ready to start the mixing process.

The 40% rule is not an exact formula for all resin systems and all types of fabrics available on the market, but is a general point of reference for your standard fiberglass and graphite fabrics used with epoxy resin systems.



Fabric and resin ratio defined

You are not ready to start the mixing process until you have your vacuum bagging materials and all of your vacuum probes and vacuum lines prepped and ready for application.

Pre-stage the work area—Do a dry run through the entire process prior to mixing the resin and catalyst together. Reviewing the process flow prior to mixing will save time and have a positive impact on the final product quality. Remember, once you have the resin mixed the clock is ticking. The time will depend on the resin system you use. Some resins have a longer work life than others. All it takes is a small forgettable item or issue to cause you to lose valuable time that is needed to process the material prior to the resin cure phase. Remember we want to apply the vacuum bag to evacuate any air, and compact material plies while the material is viscous.



Once the catalyst and resin are mixed, the clock is ticking. “Open Time” depends on your resin system.

Staged area check list:

1. Double check that your tool is clean and mold release or parting film has been applied.
2. Apply vacuum bagging sealant tape, and all bagging material (see Figure 17).
3. Have the vacuum probes and the probe pads nearby.
4. Have your vacuum source verified by making sure all connections are ready for use.
5. You will need extra gloves, solvent, and cleaning cloth available.
6. Place your scissors, sharp utility knife, and flash tape within arm’s reach.

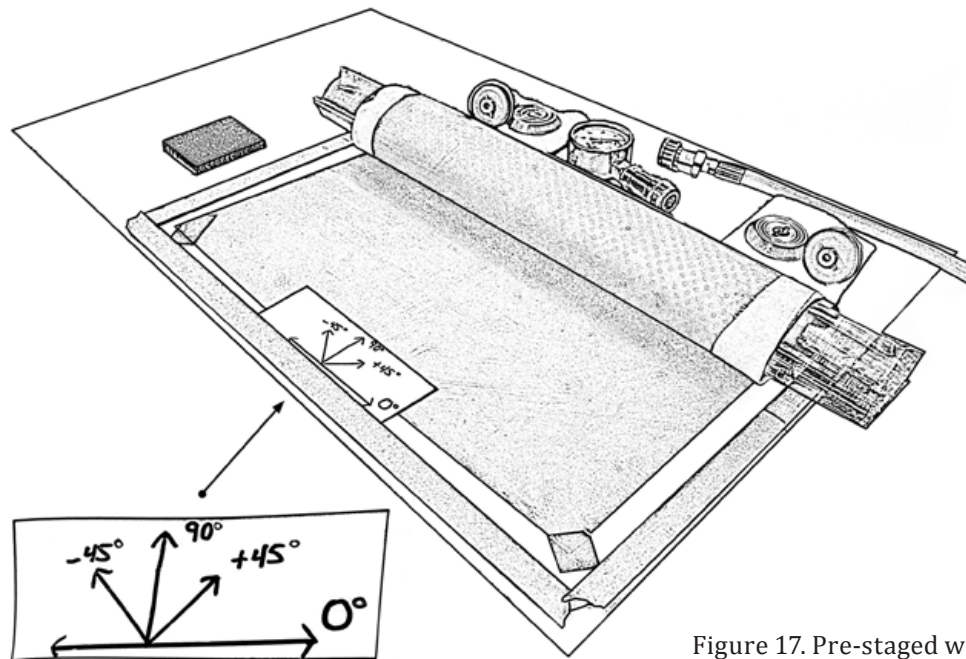


Figure 17. Pre-staged work area

7. Have a clean work area, place a disposable piece of chemically resistant plastic that you can get messy with resin and dispose of when finished. It is preferred that you perform all of your resin mixing and ply cutting on a chemically resistant table top for easy clean up.

Take note of the following information as you move through the process—This will help you gauge future projects.

1. Name of project
2. Short description of size and number of plies
3. Type of material being used, include resin system
4. Current room temperature
5. Minutes of work life/pot life—based on resin being used at current room temperature
6. Time of resin mixture
7. Time vacuum is applied
8. Final outcome, what would you do different next time?

Second—Place your dry fabric between two pieces of nylon bagging film. The top layer of bagging film will have your individual ply templates drawn on with a black fine point Sharpie pen. Each template will be placed and orientated to meet your ply-table orientation as previously engineered to meet your part's structural design.

Third—Mix your resin and catalyst thoroughly. After mixing part A with part B gently stir for one full minute, and then pour the mixed resin into Part A mixing cup and mix for an additional one full minute. Take care to scrape all unmixed resin and catalyst from the sides of the cups as

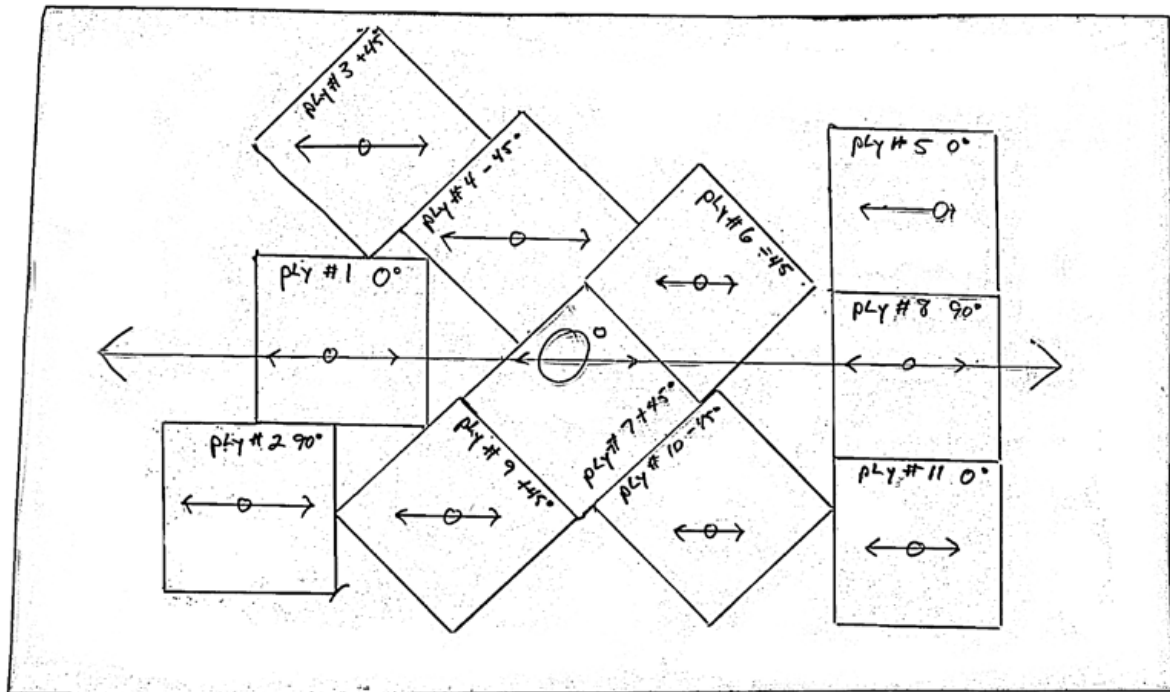


Figure 18. Nylon film with patterns

well as the stirring stick. Do not “whip” the resin during the mixing process; this will only induce additional unwanted air into the material.

Only use wax free/chemically resistant cups when mixing resins. Unfortunately cups are not just cups. If you choose to use a wax lined cup, the wax that you scrape off the side of the cup during the mixing process will mix in with the resin and result in foreign objects in the lay-up and possible dis-bonding between plies. If you use a styrofoam cup the resin will melt the cup causing a big mess.

Fourth—Pull back the top layer of nylon film and pour 90% of the resin directly in the center of the dry fabric. This should create a puddle of resin, do not drizzle the resin all over the fabric. Save the remaining 10% to touch up any dry areas that may exist after sweeping out the resin throughout the dry fabric.

Pull the top layer of nylon film over the dry fabric. As the resin saturates the fabric use your plastic sweep to pull/sweep the resin to the outside edges. Remember you want to start this process with light pressure. As you see the resin saturating the fabric and becoming more transparent you will see the undesirable air bubbles. By applying gradual pressure to your sweep, pull as much air as possible out of the fabric without pulling too much out, which can cause a resin starvation issue. We want even resin content without air, but if we have to choose we would choose air in the resin over resin-starved fabric. You will develop a talent for this as you gain more experience. The idea is to sweep the resin from the middle to the edges while the dry fabric is

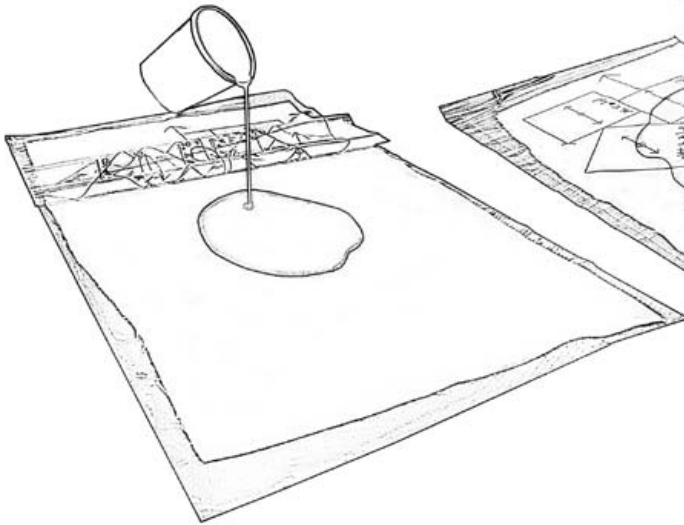


Figure 19. Apply resin to center of fabric

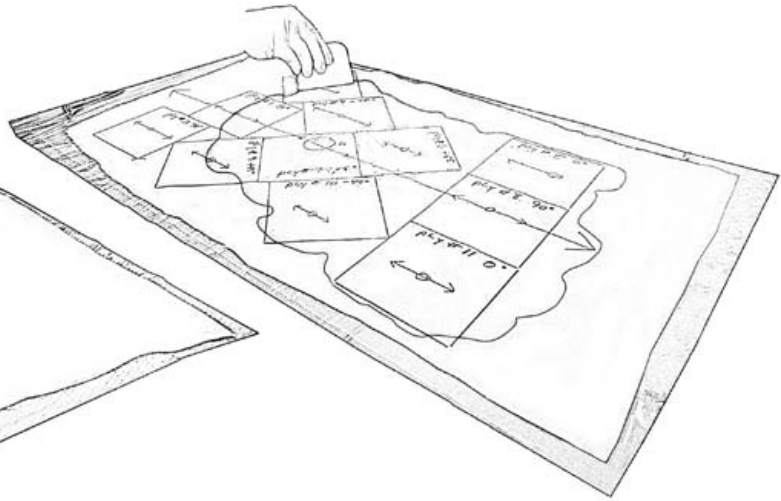


Figure 20. Sweep resin between nylon films

absorbing the resin. If you sweep the resin too fast you may end up with inconsistent resin content throughout the fabric. Start light at first, as you see the resin saturating the fabric, go back over and pull out the excess resin on the second sweep.

Fifth—Cut out your ply templates located on the top sheet of nylon film. Take care to use sharp scissors or sharp knives. Also use a straight edge with a hand guard. Sharp blades will help in keeping the saturated fabric between the nylon films until you are ready to apply the material to the tool. A dull knife causes problems that may take up valuable time. Blades are very inexpensive and you should start every ply cutting process with a new sharp blade. Each ply should be numbered, and stacked in sequence next to the lay-up tool.



Practice makes perfect. It takes only a few tries before most people get the hang of resin application.

Remove the bottom layer of nylon film exposing the impregnated fabric. Turn ply over with the ply number and the ply orientation side up. Locate the first ply and verify that the orientation is correct. Press material in place using the nylon film. Once the ply is in place remove the top,



Figure 21. Cutting plies

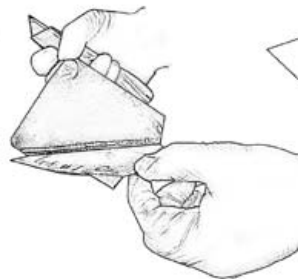


Figure 22. Remove bottom layer of parting film

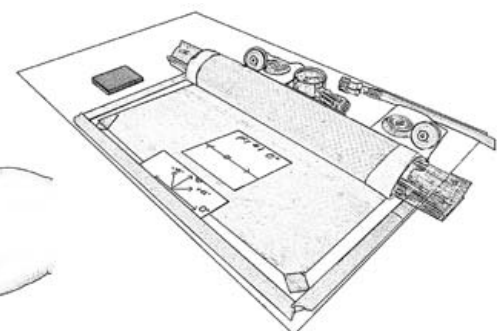


Figure 23. Locate plies on table and remove top layer of parting film

second layer of nylon film. Set nylon film aside so that you can count and confirm all nylon film has been removed prior to the bagging process.

Repeat the above process until all plies have been laid up in the proper sequence and orientation. Now you are ready to start the bagging process.

Example: Prepreg (Advanced Composite) Lay-Up

First—Prepare the material for lay-up by removing the required materials from the freezer.

Remember to keep your materials sealed in a moisture-proof 6-mil poly bag until material has reached ambient temperature. To verify that material is properly thawed and ready to be used, wipe away moisture or frost from the material bag, and place your bare hand on the material roll for 30 seconds. If condensation is present on the bag after removal of your hand, do not expose material. Additional thaw time is required.

Do not use your oven or heat lamps to thaw material quickly. This may cause serious damage to the material making it unusable. Maintain thaw temperature at ambient of 75°F or below.

Thawing large heavy rolls needs to be done with the material supported on each end; this will allow air to flow around the roll speeding up the thaw time. It will also keep your material from developing a flat spot on the roll, possibly causing resin and fiber separation, or distortion.

Smaller rolls and pre-kitted material will thaw much faster.

Thaw time examples:

ROLL SIZE	THAW TIME
65 YARDS	6 HOURS
5 YARDS	45 MINUTES
1' x 1' PRE-KIT	15 MINUTES

Pre-stage the work area—Do a dry run through the process prior to starting the lay-up. You want to double check that your tool is clean and mold release or parting film has been applied. Make sure you have all of the bagging materials available. This is the time to double check that all of your materials are available to proceed as planned.

Second—Mark all of your nylon templates with the type of material, ply number and orientation if applicable. Each template will be placed and orientated to meet your ply-table orientation as previously designed to meet your structural design.

Third—Expose the top side of the prepreg material by removing the top layer of parting film. Match the appropriate template with the corresponding material. Take care to position template in line with the material orientation. Then cut out each ply and set aside. Review your ply stack to verify that you have all of the required material cut at the correct orientation.

Fourth—Remove the bottom layer of parting film, or backing paper exposing the impregnated fabric. Turn ply over with the ply number and the ply orientation side up. Locate the first ply verifying that the orientation is correct. Press material in place using the nylon film. Once the ply is in place remove the top second layer of nylon film. Set all nylon film and backing paper aside so that you can count and confirm all of the non-bonding materials have been properly removed from all material prior to the bagging process.

Repeat the above process until all plies have been laid up in the proper sequence and orientation.

Temporary Vacuum Bagging

There are many opinions across the composite landscape regarding temporary vacuum bagging. Some will say you can lay-up ten plies before the need for a temporary vacuum bag. It depends on many factors such as:

- Are you curing this part in the oven or the autoclave, and at what pressure?
- Is the part flat without contours or radius?
- What type of material are we using? Does the lay-up consist of 100% unidirectional graphite tape, or a mix of different material types with a variety of weaves at multiple orientations?

If you are laying up less than six plies on a flat tool, you may not even need to temporary vacuum bag the plies. You can simply rely on hand pressure applying each ply with firm pressure and pressing out any trapped air prior to applying the next ply.

The bottom line is this: compacting every ply for a minimum of 1 minute at a minimum of 25" Hg adds much more value and quality without adding much more time or cost. That's cheap insurance.

Always temporary vacuum bag the following:

- The first ply laid on the tool
- The last ply laid on the part
- All adhesive plies
- All honeycomb and cured details
- All filler plies
- Any ply with contours or sharp radiuses

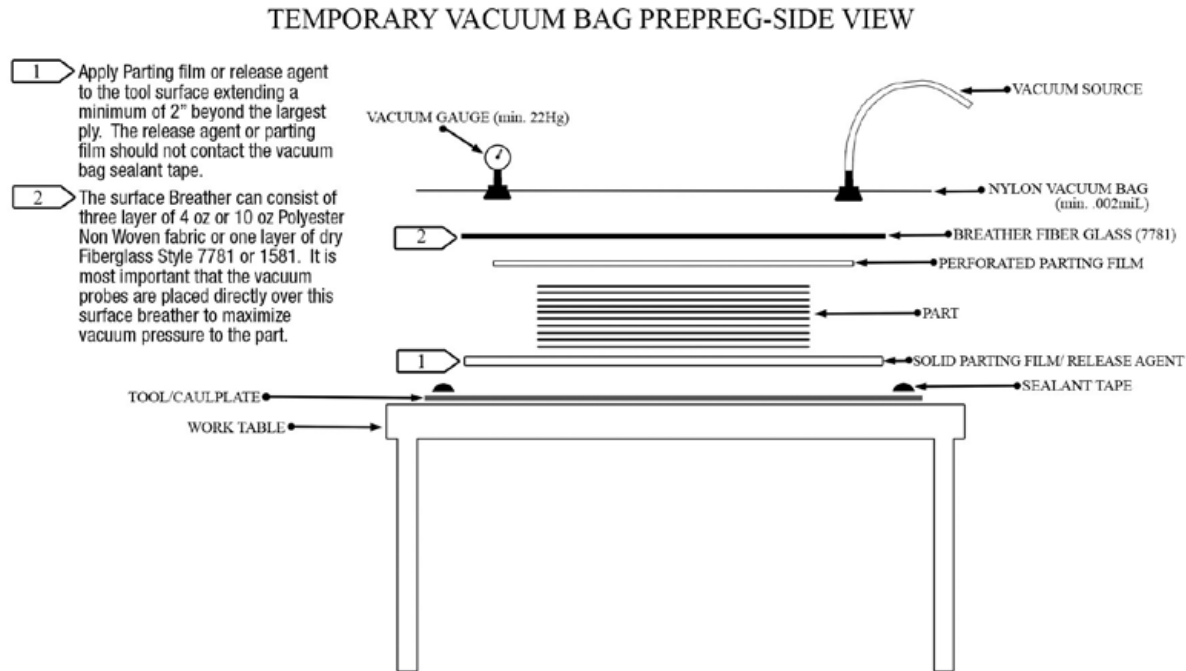


Figure 24. Temporary vacuum bag prepreg (side view)

Permanent Vacuum Bagging

1. The first step in applying the final bag is to verify that the perimeter of the tool where you will apply the vacuum bagging sealant tape is thoroughly cleaned. You do not want any foreign materials to come in contact with this seal. Do not remove the backing paper on the sealant tape until you are ready to apply the final nylon bagging film.
2. Apply edge breather continuously around all sides of lay-up. Edge breather should be .75 inches from the largest ply. Edge breather material can be a layer of 4-ounce or 10-ounce breather material or you can also use layers of dry fiberglass preferably style 7781.
3. Apply one layer of perforated parting film (FEP-P) over the entire lay-up extending half-way onto the edge breather. It is very important not to extend beyond the edge breather. Pull the parting film tight holding it in place with flash tape. The tighter you have the film, the smoother the final part will be. It is okay if the flash tape holding the parting film extends beyond the edge breather in a few areas.
4. Apply one ply of bleeder/breather material (nylon peel ply, or one layer of dry fiberglass style 120) over the (FEP-P). This bleeder/breather material must extend beyond the outer edge of the edge breather. For wet lay-ups use one ply of bleeder material for every five plies of wet fabric. For prepreg one ply is sufficient.
5. Place one layer of solid parting film (FEP-NP) over the bleeder plies extending halfway over the edge breather. Again hold material tight to minimize any wrinkling.