Beyond Composites 101

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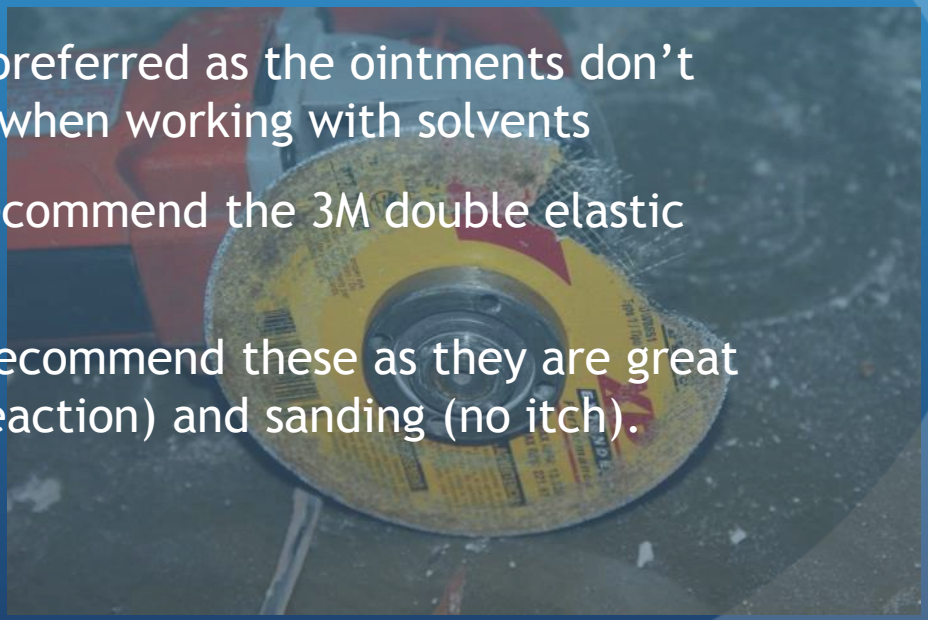
Background Information

Let’s consider the basics in tools & handling

Safety

- ✓ Eye Protection – use a least ANSI approved glasses. The missing piece in the photo nicked the side of my nose and I have since purchased a face shield.
- ✓ Hearing Protection – a least 23 dB of attenuation. The ‘band’ style is best so that you can wear glasses
- ✓ Skin Protection – gloves preferred as the ointments don’t protect enough, especially when working with solvents
- ✓ Breathing Protection – recommend the 3M double elastic style
- ✓ Tyvek sleeves – I highly recommend these as they are great when laminating (no skin reaction) and sanding (no itch).



Nomenclature

- Viscosity – measure of fluid's resistance to flow
- Pot Life – usually measured in time to gelation of 100 gms of resin
  - DBL or ½ the cure time with 10 deg change in temperature
- Glass Transition Temperature (T_g) – point when polymer begins to make a transition to a softer solid
- Heat Deflection Temperature (HDT) – similar to T_g but a little lower in temperature (~5 - 10°)
- Hardness (Shore-D) – ASTM measure of a measurement of surface "denting" with a slow pressure (not an impact test)
- Stoichiometry – the relative quantity of hardener to resin. Target ratios are typically 105% over 'stoke'
- TDS – Technical Data Sheet
- MSDS – Material Safety Data Sheet

Tools & Materials of the Trade

- Fabric Cutting Tools
  - Wheel cutters
    - These are excellent but need to use a good surface to cut on so that the blade lasts.
    - Use Masonite, plywood or spend the big money on the self healing urethane mat
    - I have used particle board but it leaves little wood chips in your fabric and you are annoyed picking them out of your
- Rags
  - Cloth rags are not used no matter how often they are washed or washed with
  - Preferred are the Scott Blue Shop or the Multi-Ply, Reinforced Nylon Fiber Utility Towel
- Gloves
  - Nitrile
    - These are great if one has a reaction to latex, however they are not resistant to ketone solvents
  - Latex
    - Resistant to strong solvents but may cause skin reaction
    - Skin reaction solution is to wear latex over the nitrile gloves when cleaning up with acetone or MEK
    - laminate

Tools & Materials Cont.

- Scissors
  - These should be good industrial grade which will save time and fatigue
- Razor blades
  - If the preference is still to use a single edge blade then cut using a straight edge and keep the blade at a shallow angle
- Straight edge
  - Preference is an aluminum straight edge. May want to add a non-slip surface on the back.
  - I also use a drywall square as it is convenient to make quick square cuts using the edge of the table or bench
- Hip square
  - Quick 45 degree cuts using the edge of the table or bench
- Table Top for Cutting Surface
  - A large table with a Masonite top works well. Do not use particle board or under lament for the cutting surface as it eventually results in little wood chips in the fabric

Tools & Materials Cont.

- Laminating Tools
  - Brushes – I recommend the Chip style natural bristle brushes
  - Squeegees – I prefer the Bondo® brand that are easily purchased at major auto part retailers
  - Paint rollers – get the paint rollers that have the solvent resistant core to them; any other kind comes apart with the resin
    - One can lay down a lot of material very fast with paint rollers. This is especially true when you have a large multi-ply lamination such as a wing
  - Fiberglass rollers
    - Work well in the areas where you can't get a squeegee to 'reach', especially when tabbing in a bulkhead
    - The aluminum or plastic work well; buy different sizes and diameters

Tools & Materials Cont.

- Mixing Tools
  - Tongue depressors / popsicle sticks / wooden coffee stirs
    - I buy tongue depressors by the box as I use them for a lot of things
    - Can cut them with a squared or angled end with wire cutters / diagonals
  - Yogurt cups
    - All sizes for mixing resins and putties
    - Ask the family or co-workers to save them (read free)
  - Epoxy pumps
    - I didn't use them at first and wasted a lot or resin. Dispense a little less than what you think you need as you can always come back for more. It'll pay for itself
    - Often check the ratio, certainly after they have sat for a while without use (especially the hardener spout)
  - Balance (old triple beam style)
    - They are affordable and one can mix very small quantities
    - Nice but slow. Always room for error
    - If a used one is found check to see if the balance pivots are in nice shape
  - Graduated mixing cups
    - Same issues with it being slow. Why does speed matter? If you are doing large laminates you have to mix a lot and your are always racing the clock, especially in warm weather

Tools & Materials Cont.

- Tapes
  - Teflon tape
    - This was a great discovery while at the Navy Lab
    - Provides quick non-stick surface at only 3 mils thick
  - Masking tape (especially 1/8 inch)
    - Personal discovery using 1/8 inch when cutting fabric on the bias. Place the 1/8 down the middle of the fabric before lifting from the table and it aids in keeping fabric from shifting
  - Flash break tape
    - This is similar to the Teflon tape only a little thicker and less expensive
- Part Trimming Tools
  - Dremel tool
  - Die grinder (pneumatic)
  - Electric woodworker's route (carbide bits)
  - Razor when laminate is still 'green'
  - Pneumatic sander / grinder

Tricks of the Trade

- Surface Contamination - Water Break Test
  - This is a simple test for surface contamination. Distilled water is applied with a clean eye dropper, if it beads then the surface is contaminated
- Surface preparation
  - Peel ply – quite common but not the best surface for secondary bonding.
    - Comes in several styles: Polyester or nylon, heat scoured or not a in different weaves
    - We found that heat scoured medium texture polyester works best for epoxies
  - Sanding
    - Don't have to be real course on the grit. Recent development of a composite patch showed that the bond for 180 grit was just as good as 80 grit. The finer grit does not disrupt the fibers as much
  - Media blasting
    - I really favor this though some of my colleagues are very cautious as there is the high potential for oil in the air lines, i.e., bond breaker
  - Degreasing (wax & grease remover, phosphoric acid)
    - Wax 7 grease remover (AKA prep-sol) I only recommend PPG DX-033
- Teflon Tape
  - This stuff is great! Used for a release tape on most surfaces. I've used it to help me make small and quick molds

Tricks of the Trade Cont.

- Laminating Surface
  - Formica – waxed or released laminate is great as a molding surface
  - Glass – if you can find a piece big enough for you needs
- Glass & Carbon Fabrics:
  - Fabric Cutting – rotary blades and/or scissors. Serrated scissors keep the material from pushing out of the jaws
  - Fabric Handling – with non-powered latex or nitrile gloves
  - Fabric Storage – dry cool place. (Tips on old kit purchase)
- Laminating Tools: squeegee / Bondo spreader, fiberglass rollers, small paint rollers, trimmed paint brush
- Resin Dispensing – epoxy pumps will save time, material waste and aggravation
- Modeling clay – for making fillets or plugging holes
- Bees wax – similar in use to the modeling clay. One can also use sheets of it to thicken a plug or mold for a secondary structure
- 1/8” Masking tape on bias cuts

Laminating Resins

- There are four basic families of resins in common use:
  - Esters: polyesters and vinyl esters
  - Acrylics (commercial)
  - Phenolics (commercial)
  - Epoxies

- Epoxies are in the widest use in aircraft construction
  - Ambient cure
  - High temperature cure
  - Snap cure

Technology

Things to know & things to consider

Higher Temp / Snap Cure Epoxies

- Applications that call for higher temp performance such as oil tank, spinner, cowl parts and baffling
- Excellent performance from ProSet M1017/2010
- Pro:
  - Long working times
  - Room temperature gellation
  - Requires post cure (at least 140°F for six to eight hours)
  - Free standing post cure up to 300°F for five minutes
  - Can be used on any fabric
- Con:
  - Have to build makeshift oven
    - Have to have air circulation
    - Have to have temperature controller
    - Very high temp cure need programmable controller

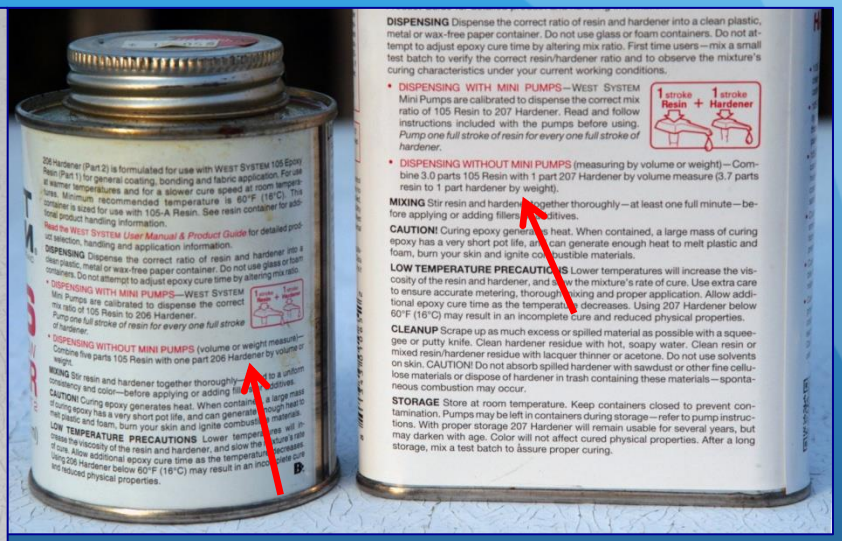
Mistakes, Who Me!?

23 Years Complex Pilot

24 Years Compositeer

ASSUME = lowest form of knowledge

Mistakes Cont.



206 Mix: 3:1 by Volume or Weight

207 Mix: 3:1 by Volume / 3.6:1 by Weight DOH!

Result => off ratio results in poor / never cures, amine blush, etc.

Why a Water Break Test? Fish Eye!

Water Break Test Cont.

Versatile Technology

Lets consider things we can do

Lamination Techniques

- Hand Layup
  - Still reliable and most common but requires good techniques and discipline for a quality laminate
  - Good technique is to get the laminate down with adequate amount of resin then work with the various tools to ‘pick up’ the extra resin
  - Rigorous use of squeegees and fiberglass rollers
- Wet bagging
  - Great for laminates made in a mold or on a flat surface
- VARTM (vacuum assisted resin transfer molding)
  - This technique is able to make beautiful parts with a little extra effort & materials
  - I will present easy techniques for this in my Saturday talks at 11:00.

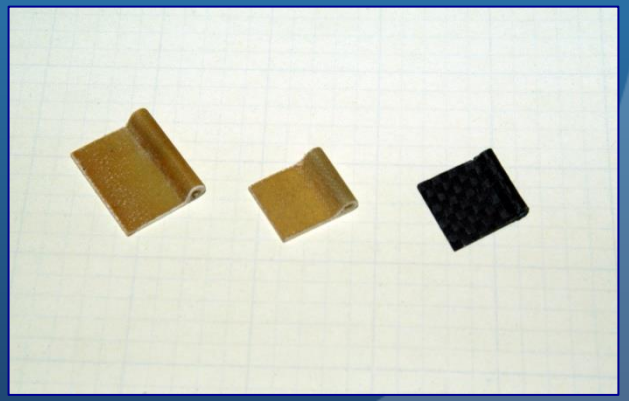
Hand Layup

Simple and versatile with a twist

Composite Piano Hinge

- Made with the use of Nylon-11 tubing, 7781 style glass, peel ply and stainless steel wire
  - Can make it with carbon fiber as well
- Hardware available from McMaster-Carr
- Hand lay-up with clamped angle or wet bag & vacuum
- Use a table or surface that has been sealed and released
  - Prefer Formica laminate top or glass sheet on table
- Once cured cut to the desired length
  - Lengths need to be shorter if installing on a curve such as a cowl or wing tips
- Bond in place with a good adhesive and ‘tab’ over each piece

Composite Piano Hinge Cont.



Piano Hinge Application

Fuselage Joining

Quick Molds

- Epoxy Face Plaster (EFP) Molds
  - Quick way to achieve production quality without the iterations required in a production tool (or mold)
  - Epoxy tooling resin is unique as it has to be hydrophobic. Two systems that are available are from ProSet Epoxies and PTM&W
  - Five simple steps:
    - Plug is made and surfaced is prepared to achieve a smooth class-A finish.
    - Mold release is applied to plug (wax, PVA or liquid release)
    - Tooling surface coat is applied
    - Plaster and burlap is applied for reinforcement
    - De-mold plug and prepare mold surface for part fabrication

Quick Molds Cont.

- Epoxy Face Composite Molds
  - Achieve production quality without the iterations required in a production tool (or mold). Lighter than EFP if making a large mold
  - Epoxy tooling resin are available from ProSet Epoxies and PTM&W (same as the EFP tooling systems)
  - Five simple steps:
    - Plug is made and surfaced is prepared to achieve a smooth class-A finish.
    - Mold release is applied to plug (wax, PVA or liquid release)
    - Tooling surface coat is applied
    - Epoxy and glass is applied for reinforcement
    - De-mold plug and prepare mold surface for part fabrication

Epoxy Face Plaster Mold Process

Plug has been sealed, painted, sanded, buffed & coated with mold release

Tooling Face Resin:
ProSet M1018 Surface Coat with LAM-224 Hardener

Epoxy Face Plaster Mold Process Cont.

ProSet Tooling Epoxy Applied with to desired thickness. This may require two coats especially on vertical surfaces.

First ply of burlap is worked into the tacky epoxy so that it sticks. Fingers, fiberglass roller or squeegee used for this. ‘Juicy’ plaster is applied to burlap layer and worked in with paint brush.

Epoxy Face Plaster Mold Process Cont.

Three more layers of burlap are applied with same loose mixture of plaster making sure there is no bridging in the corners.

After the last layer is worked down then the ‘feet’ are applied. Small diameter PVC pipe was used for this. Cardboard tube is ideal for this.

Epoxy Face Plaster Mold Process Cont.

Remove mold from glass caul plate for trim and remove plug

Trim the edges of the mold with a AlO_2 blade on 4-1/2” grinder

EFP Tool for O-200 Plenum

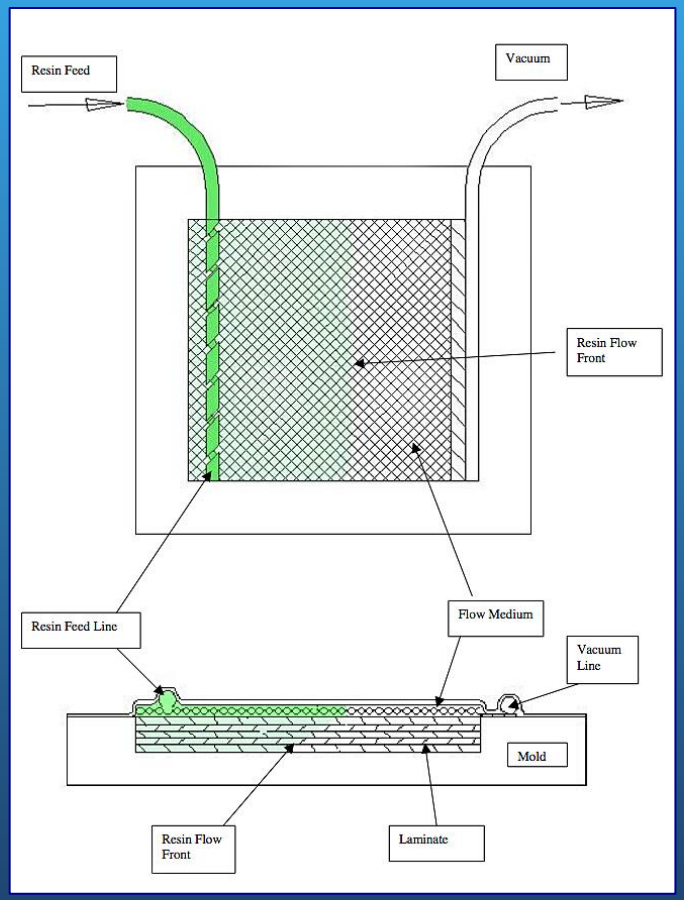
Eight Piece EFP Tool Prepped

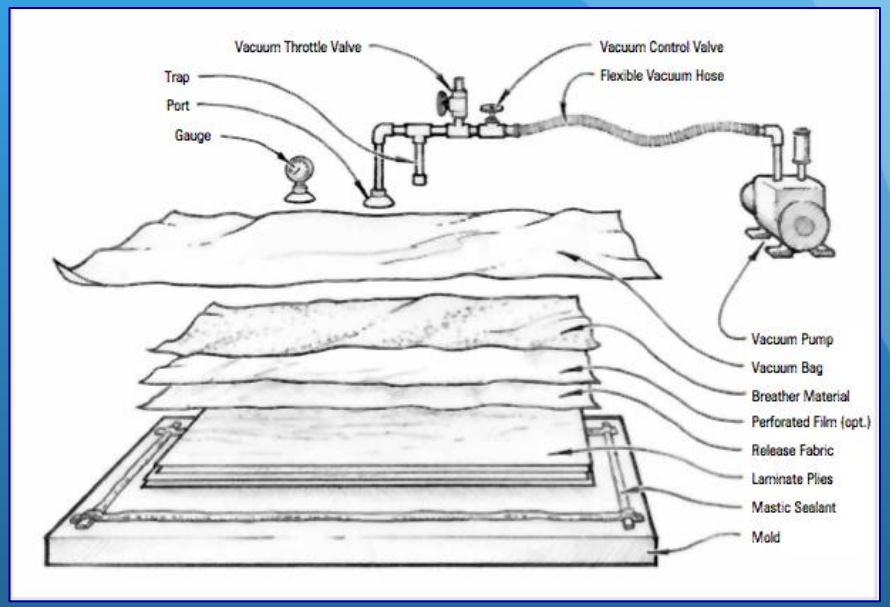
Molded Carbon Plenum

Wet Bagging & VARTM

One & two steps beyond hand laminating

VARTM & Wet Bag Diagrams





Courtesy Gougeon Brothers Inc.

Note the similarities. The VARTM method feeds the resin into the dry laminate. The breather ply is replaced with distribution media (aka shade cloth)

Sample Laminate Part

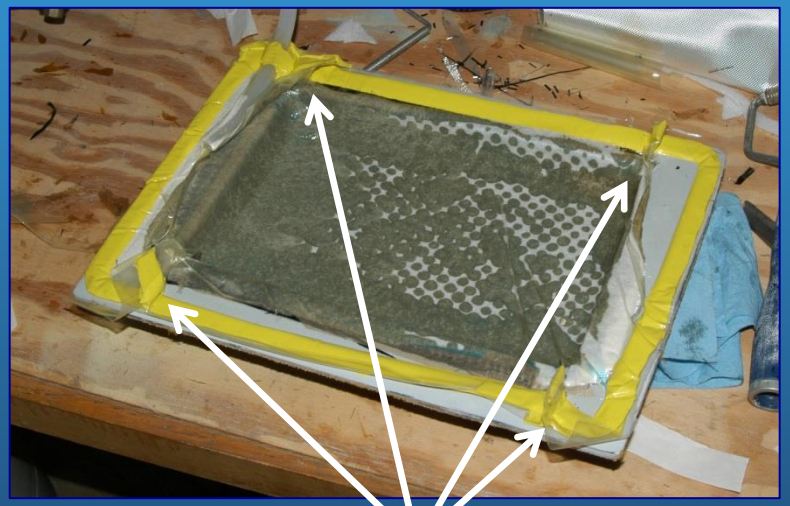
Epoxy Face Plaster Mold

Wet Loading Fabric

Peel Ply

P3 Perforated Film

Sample Part Cont.



Note the Darts in the bag. This helps the bag contour in the radii so that there's no bridging.

Air Weave

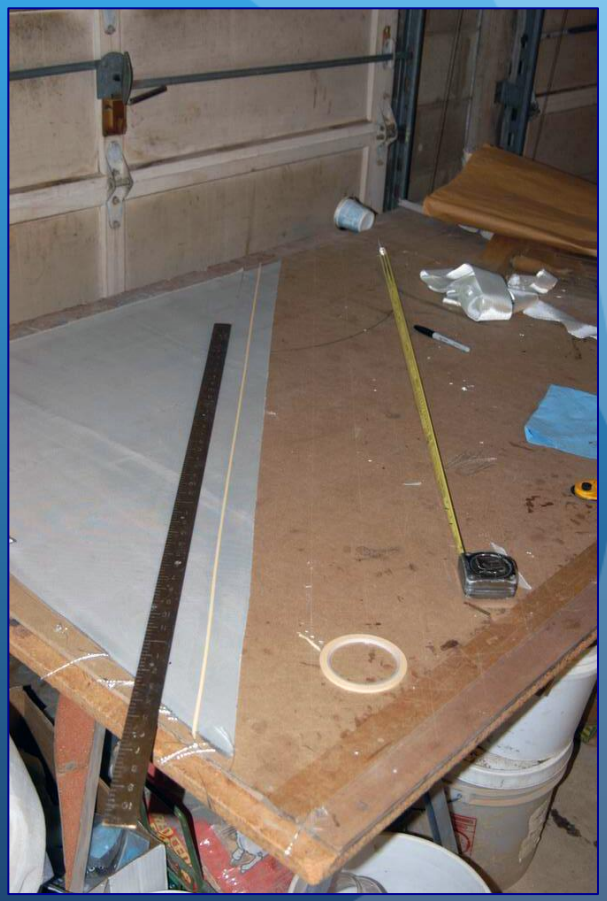
Vacuum Bag in Action

Etcetera

Helpful INFO

Bias Fabric Cuts

- Bias cuts (+/- 45°) act like a Chinese finger grip when handled
- This can be stopped by using 1/8” masking tape
- Rub finger over the back side of the tape a couple of times to knock down the adhesion
- Place in center of bias glass ‘tape’
- Lightly apply some resin to the laminating surface and place on aircraft
- Tape will lift off as the resin wets out the fabric



Quick & Simple Oven

- Made of insulating board purchased from home improvement store
- Tape together with Al foil tape
- Use heat gun as source for the heat and air circulation
- Use simple digital temperature controller
- Can build up to very large sizes if one can deliver enough heat

Quick & Simple Oven Cont.

Surface Treatment by Zyvax. Inc.

- ✓ CLEAN
  - Remove all contaminates from the mold surface
    - It is essential to start with a clean surface - dirt, oils and debris prevent bonding to the surface of the mold and may cause defects in the finished part surface
- ✓ SEAL
  - Eliminate mechanical bonding of the part and provide a durable base for the release agent
    - Mold sealing is the most important step – by sealing the mold both chemical and mechanical bonds can be formed at the mold-to-sealer interface
- ✓ RELEASE
  - Select the appropriate release agent and follow through with proper application
    - The function of the release agent is to provide the appropriate amount of horizontal slip while maintaining an effective vertical release

No No's

- Fabric Handling – not handle with bare hands
- Shop heating – I do not recommend kerosene heat as it puts contaminants in the air and so on the surface of your work
- Diluents in resin – some have used alcohols to thin out epoxy resin – DON'T! Keep your resins at temperatures in the 80's or 90's. Use a heat box if you have to (wooden box with light bulb & thermostat).
- Open Fabric storage – keep your fabric in a bag to be free of dust and moisture: preserves sizing
- Open Resin storage – epoxies last a long time when stored cool & dry
- Solvent wiping / cleaning – many like to clean with acetone or MEK; these are potential bond breakers. I recommend isopropyl alcohol as it does not have any recycled adds due to the medical requirements. Try to get 92%.
- Additives (fumed silica aka cabosil, micro-balloons, flox) – cabosil at less than 2% for thixing and balloons or flox as required. Cabosil has no strength. Additives are introduced after resin & hardener is thoroughly mixed
- Gloves: Ansell Edmont, ansell-edmont.com 800.800.0444; Best Manufacturing Company, showabestglove.com 800-241-0323; Broner Glove & Safety Company, shop.bronersafety.com 800-521-1318, Grainger Lab Safety Supply, grainger.com

Source List

- Reinforced Nylon Fiber Utility Towel: Grangers Part# 5LG 76 1000/PK or Item # 5LG97 150/PK
- Teflon Tape: CS Hyde Company, 1” wide Skived PTFE Part# 15-2A, 2” wide Skived PTFE Part# 15-2A
- Airtech Flash breaker Tape – Airtech (www.airtechonline.com) or Freeman Supply (www.**freemansupply**.com)
- Scissors: Kretzer Finny 74525 10.0” - Extra Heavy Duty, Industrial Scissors (on the web ~$40) or John A. Eberly, Inc. Textile and Sewing Scissors and Shears Professional Cutlery Industrial Tools and Supplies, Box 8047 Syracuse NY 13217, 800-532-3759
- Wheel Cutters: Olfa Rotary Cutter sold at many fabric stores
- Fiberglass Rollers: E S Manufacturing, St Petersburg, FL (www.esmfg.com)
- Tongue Depressors: non-sterile – any local medical supply
- Epoxy Tooling Gel: ProSet M1019/224 or PTM&W PT 1105A & B
- Resins: ProSet Epoxies, 888-377-6738 prosetepoxy.com or WEST System epoxies, 866-937-8797 westsystem.com
- Ultracal 30: Freeman Supply, freemansupply.com