Proper Composite Repair Techniques

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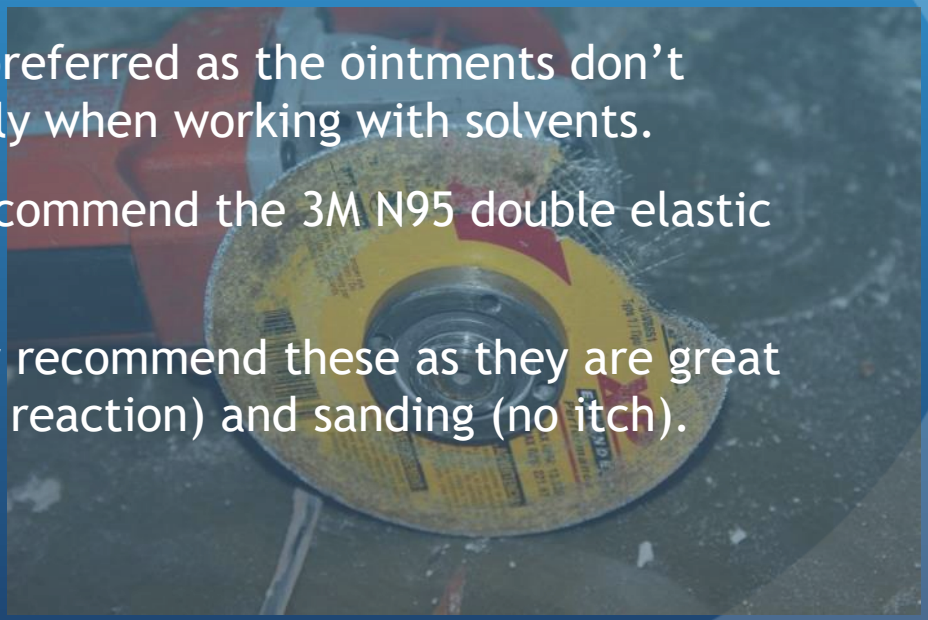
Background Information

Let’s consider the basics in tools & handling

Safety

- ✓ Eye Protection – use a least ANSI approved glasses. The missing cut off wheel 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 I prefer as it allows you to wear safety glasses comfortably.
- ✓ Skin Protection – gloves preferred as the ointments don’t protect enough, especially when working with solvents.
- ✓ Breathing Protection – recommend the 3M N95 double elastic style.
- ✓ Tyvek sleeves – We highly recommend these as they are great when laminating (no skin reaction) and sanding (no itch).



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
  - Kretzer Serrated Scissors
    - A good industrial grade will save time and hand fatigue
    - Serrated scissors keep the material from pushing out of the jaws
  - 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
- Rags (bond breaker)
  - Cloth rags are not used no matter how often they are washed or washed with TSP
  - Preferred are paper towels (Scott Blue Shop) or the Multi-Ply, Reinforced Nylon Fiber Utility Towel

Tools & Materials Cont.

- 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 nitrile under the latex gloves when cleaning up with acetone or MEK
- 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
- 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 or online.
  - 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.
  - Laminating 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
    - 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.
  - Graduated mixing cups
    - Come in multiple sizes including large (become expensive though)
    - If you are doing large laminates you have to mix a lot and your are always racing the clock, especially in warm weather.
  - Epoxy pumps
    - Dispense a little less than what you think you need as you can always come back for more. It'll pay for itself in less waste. Slow however.
    - Often check the ratio, certainly after they have sat for a while without use (especially the hardener spout).
  - Digital balance
    - Can be pricey but accurate and can mix large quantities.

Tools & Materials Cont.

- Tapes
  - Skived Teflon tape
    - 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

- Part / Repair Trimming Tools
  - Dremel tool
  - Die grinder (pneumatic)
  - Electric woodworker's router (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, Dacron, 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 or phosphoric acid)
    - Wax & grease remover (AKA prep-sol) like PPG DX-033 or Axalta 200 0r 220
- Teflon Tape (previously mentioned)
  - 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.
  - Fabric Handling – with non-powered latex or nitrile gloves
  - Fabric Storage – dry cool place. Tips on old kit purchase
- 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

- Resins in common use:
  - Polyesters
  - Vinyl Ester
  - Epoxies

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

The Three Recommended Resins

(Available from Aircraft Spruce and Wicks)

- Gougeon Brothers Inc. (GBI) ProSet Epoxy 125/135
  - Hardeners: LAM-226 (med), LAM-229 (slow), LAM-237 (extra slow)
- Martin G. Scheufler GMBH (MGS) L285
  - 285F (fast), 287S (slow)
- PTM&W Aeropoxy PR2032
  - PH3660 (fast), PH3665 (slow)
- With all three of these resins room temperature curing results in good properties; some curing at elevated temperatures, or post curing, will result in the highest achievable strength and Tg.

Repair Examples

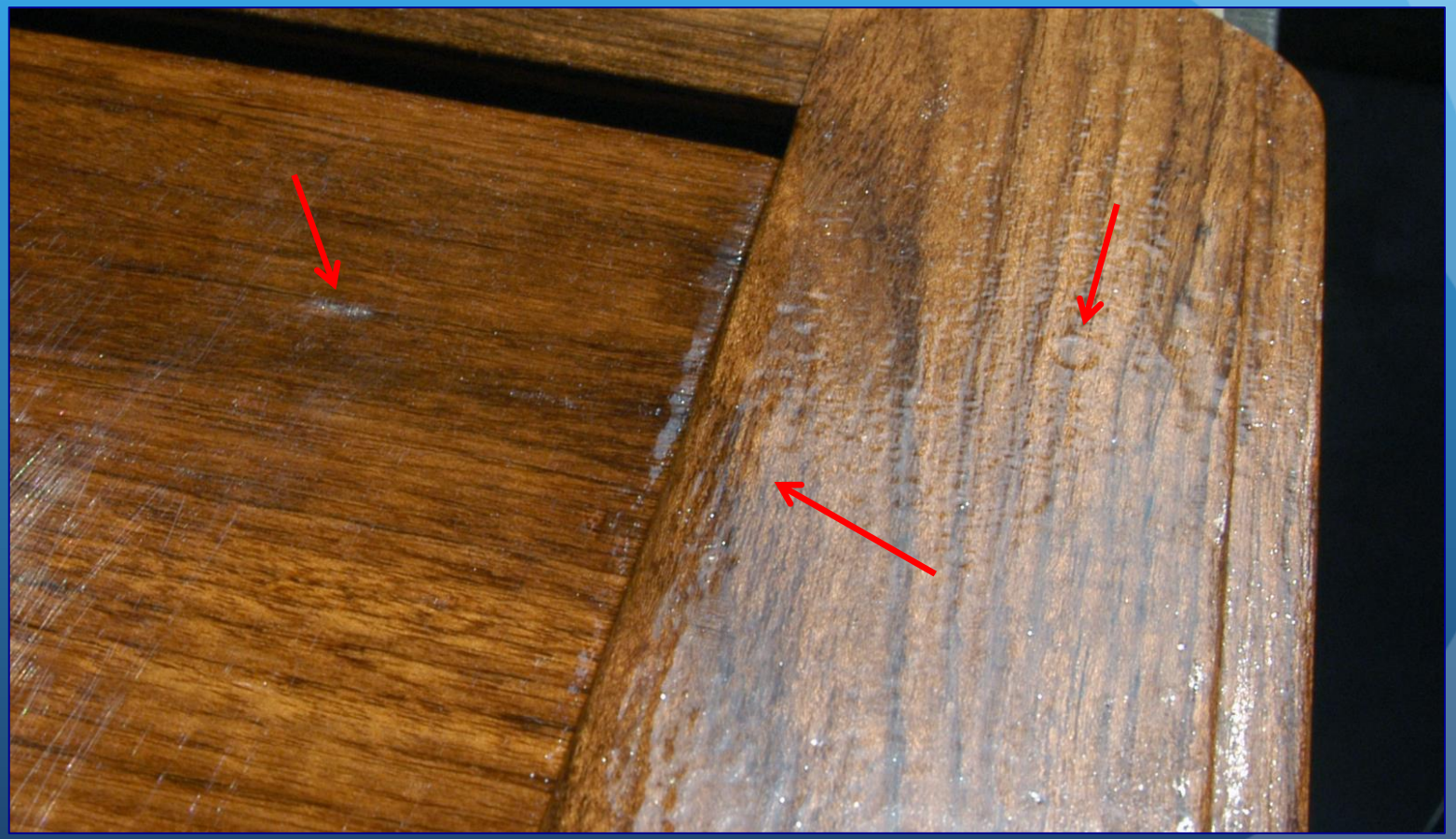
Things to know & things to consider

Higher Temp Epoxies for:

- Applications that call for higher temp performance such as oil tank, cowl parts and baffling
- Excellent performance from ProSet ,MGS or PTM&W by postcuring
- Can be achieve +200°F by post cures
- Makeshift oven can be made easily (detail later)

Water Break Test

Water Break Test Cont.



Versatile Technology

Lets consider things we can do

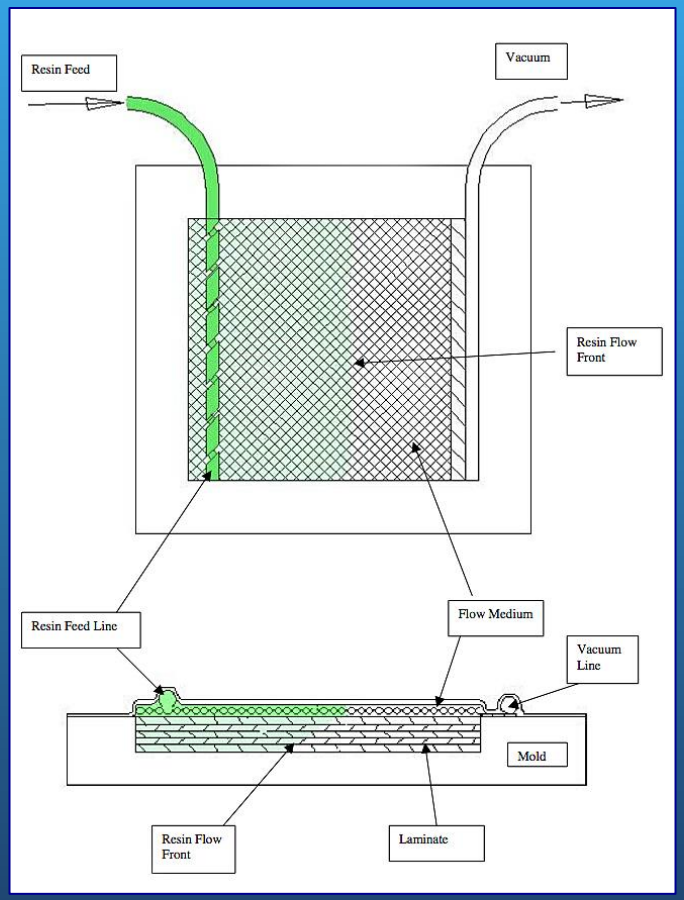
Lamination Techniques

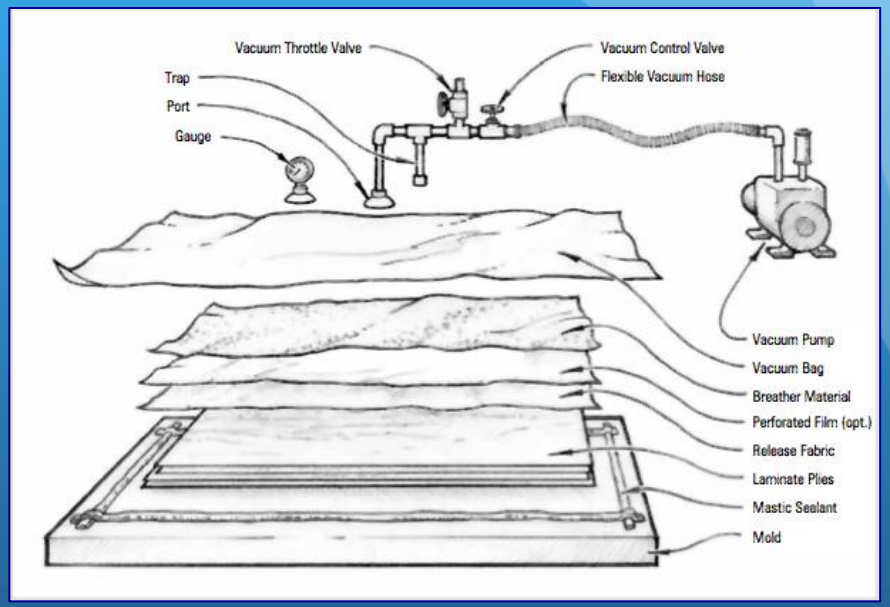
- Hand Layup
  - Still reliable and most common but requires good techniques and discipline for a quality laminate
  - Good technique is to get the laminate down with adequate amount of resin then work with the various tools to ‘pick up’ the extra resin
  - Rigorous use of squeegees and fiberglass rollers
- 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 techniques for this in the Composite Workshop.

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

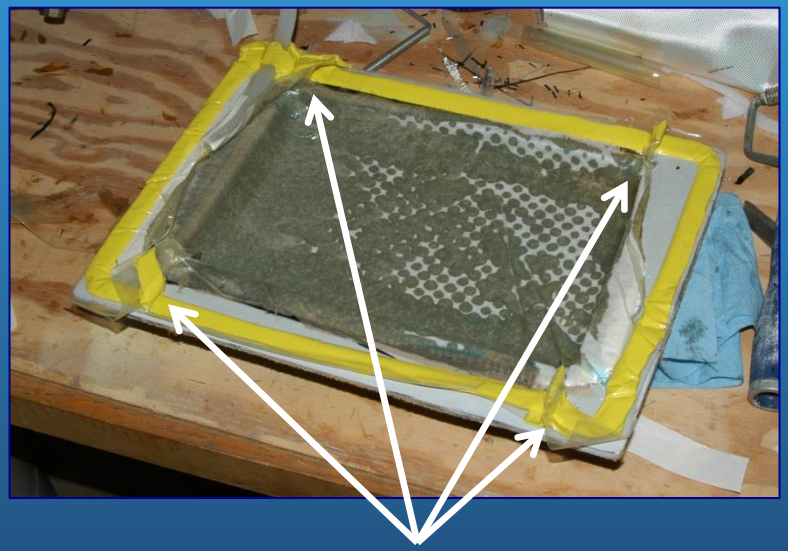
Epoxy Face Plaster Mold

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

Cowl Repair

Too much putty and paint.

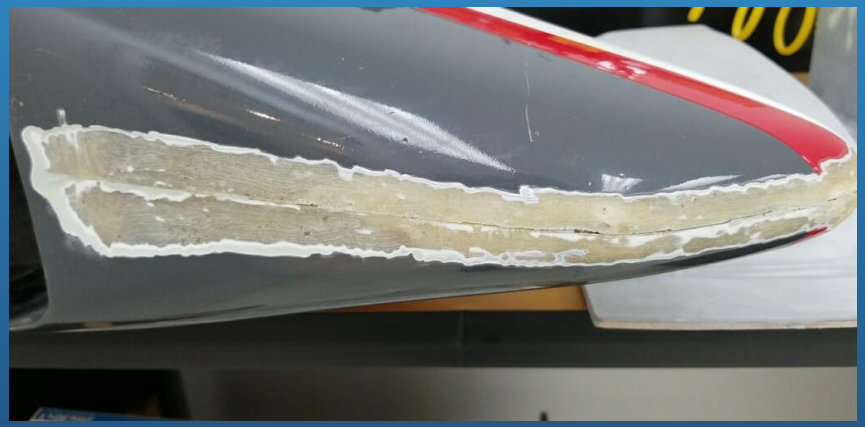
Cowl Repair Cont.

Required Stripping the Paint to the Bare Composite

Repainting Complete

Wheel Pant Repair

Single Scarf Repair along cracked seam. Then apply fiberglass tape.



Need to be aggressive in grinding out all of the damage and beyond to assure repair fidelity. Finish repair with Bondo.

Glassair TD Wing Repair

Impact just missed the fuel tank.
Repair will be a double scarf.

Glassair TD Wing Repair Cont.

Spot glaze putty was applied to disrupted area and sanded smooth.

Teflon tape applied as a mold release.

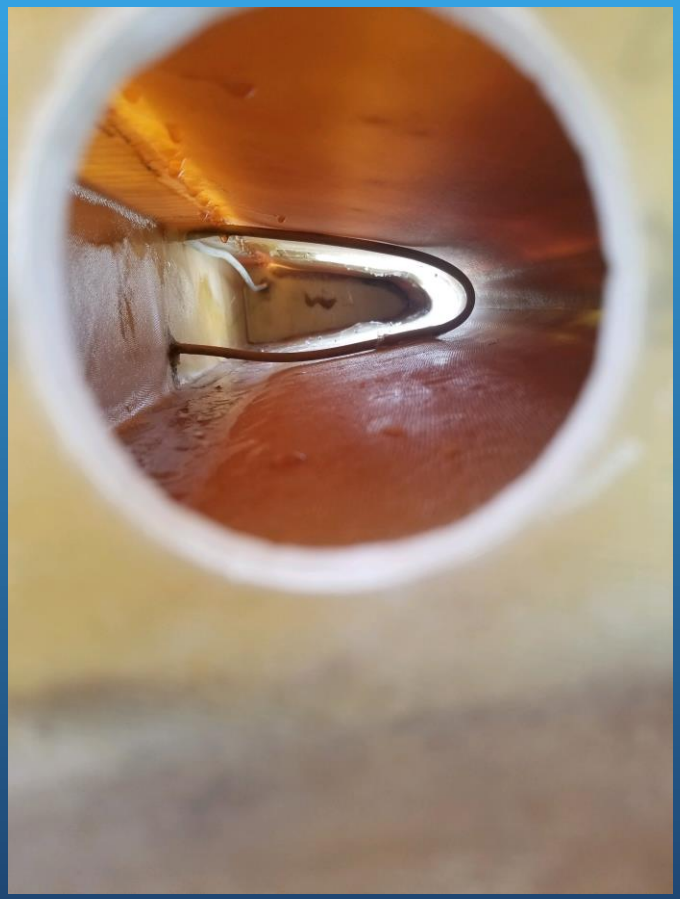
Fabricate a skin to insert to the inside of the wing to create a vaccum seal. The area adjacent to the damage was utilized as a mold to make the insert.

Glassair TD Wing Repair Cont.

Three layers of 9oz glass

Cut out damaged area until there is no delamination.

Glassair TD Wing Repair Cont.

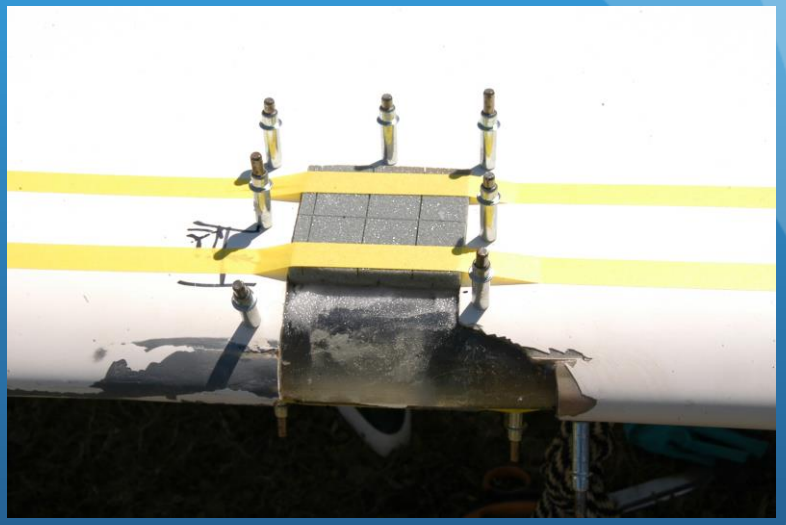


Cut a hole in the outside rib to gain access to the inside.

Cleco the laminate in place.

Glassair TD Wing Repair Cont.

Adhesively bond in place.



Adhesively bond foam in place.

Glassair TD Wing Repair Cont.

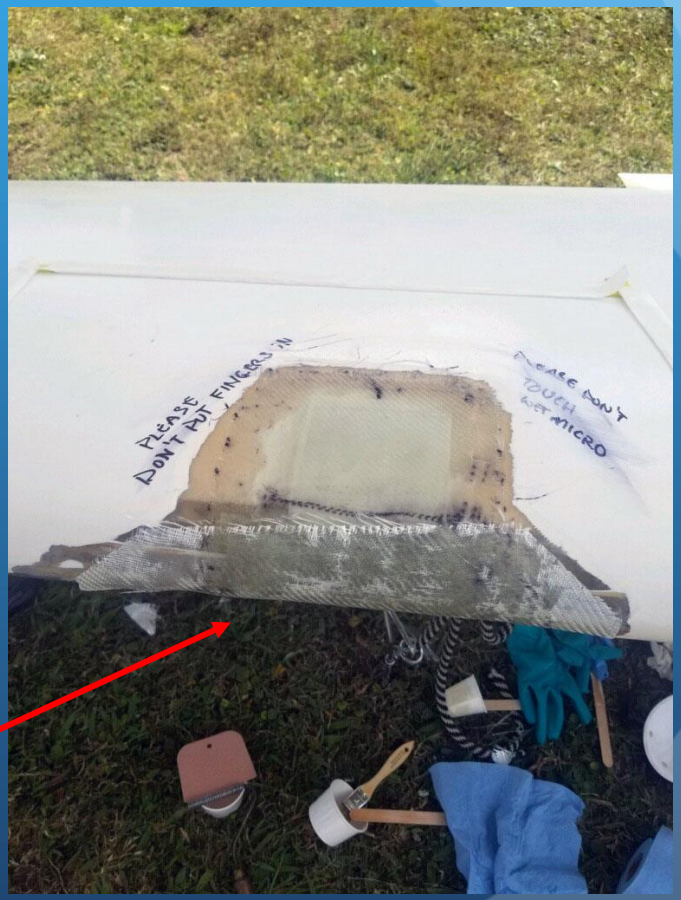
Adhesively bond foam in place on the bottom.

Taper grind margins out from foam.

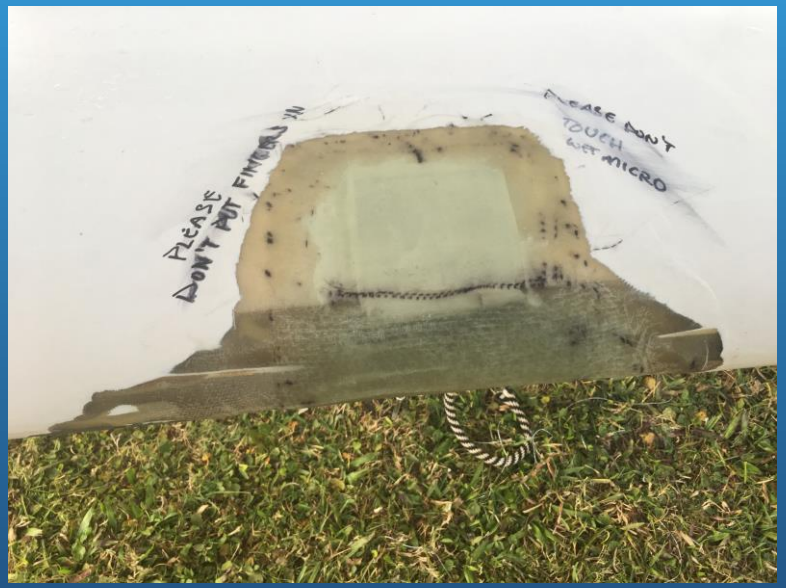
Glassair TD Wing Repair Cont.

Make micro balloon putty and fill in any porosity.

Apply extra laminate to the leading edge and fill in Cleco holes.



Glassair TD Wing Repair Cont.



Apply 9 oz fabric overall.

Vacuum bag the entire laminate and let cure.

Glassair TD Wing Repair Cont.

Dry micro to fair the repaired area.

Towed back to the flight line.

Etcetera

Helpful INFO

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.

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. I've installed a coal stove in my shop.
- 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 or heated resin bath).
- 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 sealed, 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 additives due to the medical requirements. Try to get $\geq$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

- Teflon Tape: CS Hyde Company, 1” wide Skived PTFE Part# 15-2A, 2” wide Skived PTFE Part# 15-2A (Amazon is a source we’ve used in the past)
- Airtech Flashbreaker Tape – Airtech (www.airtechonline.com) or Fibergalss Coatings Inc., fgci.com
- Scissors: Kretzer Finny 74525 10.0” - Extra Heavy Duty, Sewn Products, www.sewnproducts.com, 971 Airport Road, Jefferson, GA, 30549, 800-327-2677
- Wheel Cutters: Olfa Rotary Cutter sold at many fabric stores (preference is Olfa vs. Fiskars as the blade is stiffer)
- Fiberglass Rollers: E S Manufacturing, St Petersburg, FL (aircraftspruce.com or fgci.com)
- Tongue Depressors: non-sterile – any local medical supply or online
- Epoxy Tooling Gel: PTM&W PT 1105A & B (Aircraft Spruce)
- Resins: ProSet Epoxies, 888-377-6738 prosetepoxy.com or WEST System epoxies, 866-937-8797 westsystem.com (Composite Envisions or Aircraft Spruce)