Fiberglass-Epoxy Wet Layup Tooling Procedure for Room-Temperature Set, High-Temperature Service

Scope:

There are many ways to build wet layup high-temperature laminated epoxy tools. This procedure is one that has worked successfully for making high-quality tools suitable for 350 F. oven or autoclave service. The room-temperature setting aspect of the chosen materials allows heat sensitive patterns to be used. Post-curing is done off of the pattern. Different materials and process options will be offered where applicable.

Facility Requirements:

The tool fabrication area should be free of silicone cutting fluids, greases and airborne release agents. Contaminates from sanding, machining, grinding and spraying should be kept to a minimum. It is recommended that the facility be kept at 72-75 F, with a maximum relative humidity of 60%.

Tooling Material Requirements:

Please refer to individual product data sheets for information on mix ratios, handling and processing parameters.

- **Epoxy Surface Coat:** PT1995 A/B (B1 hardener as an option)
- **Epoxy Laminating System:** PT2846 A/B2 (unfilled) or PT2848 A/B2 (filled). Use the B hardener of either system for patching or tying on back-up structure.
- **Fiberglass Fabrics:** Style 7500 – 10 oz./yd., 0.015-inches thick, Style 7544 – 20 oz./yd., 0.030-inches thick, ***Option:*** Style 7587 – 40 oz./yd., 0.045-inches thick. All cloth should be cut into 24" X 24" squares, with half cut in the 0°, 90° direction and half on the bias (45°). ***Option:*** 4"-wide fiberglass tape.

Equipment and Processing Materials Requirements:

Vacuum Pump & Hoses

Nylon Film Vacuum Bag

Vacuum Bag Sealing Compound

Company Approved Cleaning Solvent

10-ounce Bleeder/Breather Material

Peel Ply, Corona Treated

Flash breaker and Masking Tape

PA0801 Non-Silicone Paste Wax

Lint-free Cloths

Thermocouple

Perforated Release Film ("P" perforations – 0.045" dia. Holes on ¼" centers

or "P3" perforations – 0.015" dia. Holes on ¼" centers)

Scotchbrite-type Pads

Adhesive-backed Cork Dam Material

2”-wide Plastic Packaging Tape or equivalent

PTM&W-style 2”–wide Stiff-Bristle Brushes

4”-wide Plastic Squeegees

Non-absorbent Mixing Tools and Containers

Clock

Air Circulating Oven or Autoclave

Prepare Pattern:

1. Clean pattern surface, if required, with Scotchbrite-type pads and approved solvent to remove all previous release agents. Solvent wipe with lint-free rags.
2. Determine the vacuum integrity of the pattern by applying one ply of 10-oz. breather to the pattern surface and vacuum it down using nylon bagging film and sealant tape. Pull at least 24-inches of Hg, turn off the pump and observe the vacuum drop. The maximum allowable vacuum drop shall not exceed 5-inches in five-minutes. If in excess, trace down the vacuum leaks and repair them. Retest in the same manner, until the pattern is vacuum tight.
3. ***Option:*** Apply cork dam edge to the pattern surface where you want the laminate to end. Cover the cork with 2-inch wide plastic packaging tape. Use the cork dam to butt-end your laminate against. This will eliminate the need of trimming the tool when completed.
4. Apply vacuum-bag sealant compound to the periphery of the pattern. Leave the paper on so that resin will not contaminate the sealant during laminating. ***Option:*** Use Flash breaker tape to cover area where sealant compound will be applied. Wait until the bagging process to remove the tape and apply the sealant compound.
5. If a non-porous pattern is used, apply a minimum of three coats of PA0801 wax release to the pattern surface with a lint-free cloth, buffing between coats and the final coat. If a porous pattern (wood or plaster) is used, seal it with a minimum of three coats of lacquer-based sanding sealer and wax as previously stated. Apply a coat of PVC (preferred) or PVA liquid barrier film and allow to dry. If PVC, you can carefully apply another coat of wax over the film.

Apply Surface Coat(s):

High temperature surface coats should always be kept thin to avoid cracking and crazing during thermal cycling during production.

1. Thoroughly mix PT1995 A/B at the proper ratio, transfer to another container and mix again (double cupping).
2. Pour the mixed material onto the center of the pattern and spread evenly over the entire pattern surface with a squeegee. Next, use a stiff bristle brush and, going in one direction, brush out the surface coat picking up excess resin as you go. Try to keep film thickness to 0.015-0.020 inches thick. Lightly brush again, 90° to the previous brushing. Watch for buildup in female corners.
3. Allow this coat to cure at room temperature (around 60 minutes depending upon batch size and shop temperature) until it has cured to a tacky condition, where you can leave a fingerprint on the surface but not transfer to your finger. **Warning:** If allowed to cure to a hard glazed surface, you must either remove the coat and start over or sand the back surface of the coat until the glaze has been removed.

4. ***Option 1:*** Proceed directly to the laminating steps. ***Option 2:*** Apply a second surface just as in step 3 (use a brush instead of a squeegee), allow to tack, then proceed to laminating steps. ***Option 3:*** Mix PT1995 A with PT2846 B2 (or PT2848 B2) hardener (100:6 pbw). Mix an equal amount of PT2846 A/B2 (or PT2848 A/B2) at the proper ratio. Start keeping time at this point. Take these two mixtures and blend them together at a 50:50 ratio. Brush this mixture onto the back of the first surface coat while it is still tacky. Immediately start laminating.

Laminating Procedure:

The most critical part of the laminated tool is the first few plies, because any air trapped there will result in blisters or delaminations during the final cure or during production cycling. Spend half of your laminating time on the first quarter of the tool thickness.

1. Weigh the amount of pre-cut cloth to be used and try to use that same amount of resin/hardener mixture in the laminate. This will help keep the glass/resin ratio to about 50%.
2. Mix PT2846 A/B2 or PT2848 A/B2 to the proper ratio. Start keeping time from this point unless you used option 3 (surface coat step 4). Brush the entire back surface of the tacky surface coat with laminating resin until the entire surface is covered.
3. Immediately apply the first ply of Style 7500 cloth (0°, 90° direction) into the wet resin. Overlap the joints by ½" maximum. Use a stiff-bristle brush to work the wet resin up through the dry cloth, working out as much air as possible. Laminate a second ply of Style 7500 cloth (45°) in a similar manner. Laminate a third ply using thicker cloth, either Style 7544 or 1597 in a 0°, 90° direction, butting the joints. ***Option:*** Use 4"-wide glass tape around periphery of tool, against the optional cork edge dam to 'picture frame' the tool. Use regular cloth inside the picture frame.
4. While laminating, monitor the clock. You should plan to have the laminate under vacuum within a maximum of 4 hours (depending upon shop temperature) from the start of mixing the first batch. Allow time for bagging and chasing down vacuum bag leaks. If time does not allow for three plies, only laminate two. The laminating resin must be liquid and able to move under vacuum pressure. **Note:** As an alternate or in addition to using a clock, make a small test laminate in a separate area. For every ply made on the working tool, laminate a small ply on the test area. Monitor the resin used for the first ply. When it starts to thicken, stop work and start the bagging procedure.
5. Apply peel-ply, bleeder, perforated release ply, breather and nylon vacuum bag according to normal vacuum-bagging procedures. Pull a vacuum and check for leaks. Leave under vacuum over night.
6. Remove the peel ply, being careful not to disturb the laminated plies. ***Option:*** At this point you can embed a thermocouple behind the first three plies, outside of the working surface of the tool. This is for monitoring the post-cure cycle.
7. Continue laminating (start the clock) with Style 7544 or 1597 cloth. Rotate each ply orientation and butt the edges together. Apply resin to the back of the previous laminate and work the dry cloth into the wet resin. Use a squeegee to spread the resin and a stiff brush or roller to work the resin up through the cloth. ***Option:*** Wet-out the cloth on a table away from the work and apply the pre-impregnated cloth to the tool. This method works faster, since one person can be applying resin to the cloth on a flat surface, but it tends to trap more air in the laminate, which has to be removed by hand working or by vacuum-bagging.
8. Continue laminating until the desired thickness is achieved or you reach the end of the working life of the resin. If necessary, debulk under vacuum, then continue laminating until desired thickness is achieved.
9. Repeat step 5 while the resin is still liquid. Allow to cure overnight under vacuum. ***Preferred Option:*** If the pattern can take 120°F, cure overnight at that temperature, under vacuum.

Apply Backup Structure:

1. Remove bagging materials. While nesting on the pattern, apply egg-crate backup structure, preferably using high-temperature epoxy laminated flat stock (either purchased or made with the same materials as the tool). Locate the structure within ¼" of the back of the laminate. Tie structure to the tool using three plies Style 7500 cloth and PT2846 A/B or PT2848 A/B laminating resin. The tie-ins should be attached a minimum of six inches on the structure wall and laminate back. The tie-in should not be continuous but should leave gaps for airflow. Optional: Hole-saw round holes in the structure to allow airflow.
2. Cure the entire tool and backup structure on the pattern for a minimum of 48 hours at 75° F. Preferred Option: Cure on the pattern at 120° F. for a minimum of 12 hours.

Post-Cure:

Using the proper post-cure cycle can control shrinkage and warpage. Being in a hurry at this point can cause a tool to become scrap. Slower heat-up rates and longer dwell times minimize problems.

1. Place the tool into a cool oven. Make sure the tool is adequately supported on its backup structure and is not racked in anyway.
2. Connect the optional thermocouple to a monitor. All temperatures suggested below should be from the thermocouple readings, not from oven gages. All heat-up rates should be 3° F./minute or less.
3. Heat to 150° F. Dwell at 150°F. for 4-hours to stabilize the tool.
4. Raise the temperature in 50° F. increments with 2-hour increments and dwell for 2-hours at each stage, until reaching the final temperature.
5. The final temperature should be 25-50° F. above the expected operating service temperature of the tool. Dwell for 4-hours.
6. Turn off the heat, crack open the oven door and allow the tool to return to room temperature before removing.

Prepare Tool for Service:

1. Inspect the tool for any blisters or cracks in the surface coat. Make any repairs using PT1995 A/B. Make sure to remove any mold release before repairs are made.
2. Make a vacuum leak check of the tool using the same procedure as outlined in Prepare Pattern step 2. If the tool fails the vacuum check, repair by using the method described in "Using PT2210 A/B to Restore Vacuum Integrity of Tools".
3. Clean the working surface with an approved solvent. Do not sand the tool surface unless absolutely necessary.
4. Apply a good quality tool sealer, like Chemlease MPP117, according to the manufacturer's directions.
5. Place the tool into service.

There are many other ways to build high-temperature laminated epoxy tools. This is just one proven method. Other hardeners are available which provide 8-hours or more working time. These usually have to be made on patterns that can withstand heat cures.

If there are any questions about the procedures outlined here, or if you have an application that does not fit with this method, please call us at 800 421-1518 and we will be glad to confer with you on an individual basis.

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