

Appendix A) Supplement: Selected Epoxy Techniques

This supplement to Appendix A contains information about epoxy that can be used for special techniques not normally applied in the construction of Grain Surfboards. Except for general information that is found in the Builder's Manual, these techniques are unsupported for the construction of kits, and should be undertaken at your own risk as they complicate the construction process. They are normally used only by professional board builders on custom boards we build at the Grain Surfboards shop.

IN THIS CHAPTER

Tech 1: Epoxy Summary	A-1
<i>Table of Set-times - Epoxy w/ Slow Hardener</i>	<i>A-3</i>
Tech 2: Mixing Epoxy	A-4
Tech 3: Epoxy Sealing	A-5
Tech 4: Post-Curing Epoxy	A-9

It's recommended that this appendix be read in full prior to attempting these techniques.

TECH 1: EPOXY SUMMARY

Warnings on all labels should be read and understood, and material safety data sheets reviewed before using these compounds. When improperly used, just about everything is toxic - even water - so use appropriate protective equipment when handling and using these products. The table below summarizes some information that you'll need to get started..

Name /Description	Use in Grain Surfboards	Cleanup	MSDS ^a
Low-Viscosity Epoxy Resin (MAS Epoxies)			
Mixed with slow hardener, provides a zero-VOC, non-blushing, phenol-free epoxy resin. Thinned with denatured alcohol, penetrates wood to seal the surface against moisture intrusion, gassing	Mounting hardware, fins, fiberglass shell, sealing board interior.	Citrus oil-based solvents, lacquer thinner.	www.masepoxies.com/users/0142C6E0-CF1D-CEE2-59ED58C41CE094DA/library/files/resin.pdf ----- www.masepoxies.com/users/0142C6E0-CF1D-CEE2-59ED58C41CE094DA/library/files/slow.pdf ----- www.msdsvault.org//GENERALPDF/4309-Cabot-Cab_O_Sil_Untreated_Fumed_Silica.pdf

a. MSDS = Material Safety Data Sheet, a structured document containing detailed descriptions of compounds, proper use, and warnings.


Step	Glue Properties
A.1.1	<p>Lo-Viscosity Epoxy + Hardener: Mix at 2:1 ration (resin:hardener). <i>Always.</i> In the shop, we use different hardeners to get different curing rates- there is no way to accelerate cure by using more hardener. Curing will accelerate DRAMATICALLY if mixed epoxy stays in the pot too long. See <i>FIGURE A-1</i>.</p> <p>MIX WELL. At least two minutes, more for quantities of 5 ounces or more. Scrape the sides and corners of the mixing pot and scrape off your mixing stick. Poor mixing is the largest single cause of problems with epoxy coats.</p> <p>You can tint with artist’s acrylic, or thin (so that it soaks into wood better) using de-natured alcohol - a little goes a long way. You can use water-based stains underneath epoxy, but they must be fully dried.</p> <p>Epoxy as an adhesive should not be squeezed out of the joint like a normal wood glue. It relies to a large degree on the epoxy that is left in the joint. When using this epoxy to fill gaps, it should be used with micro-balloons, cabosil, or wood dust. If wood dust is used, be sure that it’s very fine dust. You can use a varnish strainer to get only the finest dust (a sander with a collection bag will produce a very fine dust). Mix epoxy and hardener thoroughly before adding any thickening agents.</p> <p>Re-coat can be done without sanding as long as the resin is still “green” and tacky. Sanding is required if a cotton-ball does not leave fibers behind on contact.</p>
Min Temp.	For clearcoating, 55 - 60 degrees Fahrenheit, for bonding, 45 degrees Fahrenheit
Set Time:	See <i>FIGURE A-1. Table of Set-times - Epoxy w/ Slow Hardener</i> . Temperature is critical. Pot life doubles for every 18 degrees below 77 degrees. Understand that breathing or having skin contact with epoxy or epoxy dust that is not fully cured can cause long-term health impacts.
	<p>Read the MSDS. Epoxy contaminates easily - so use clean mixing sticks and cups, and do not prep surfaces with solvents, acetone, tack cloths or the like. De-natured alcohol is acceptable for surface prep.</p> <p>Disposable gloves should always be used and eye protection is important if any splashing were to occur. A respiratory mask (like 3-M Easy Air) should be used. The epoxy may cause irritation of the skin, especially fair skin, especially when ambient temperatures are warm.</p> <p>Avoid all direct skin contact with resin, hardeners and mixed epoxy by wearing gloves and other protection. Clean uncured epoxy off skin with waterless soap immediately after contact. NEVER use solvents to remove epoxy from skin. Always wash thoroughly with soap & water right after contact.</p> <p>Protect your eyes by wearing protective eye wear. If contact should occur, flush eyes immediately with running water for 15 minutes. If discomfort continues, seek medical attention.</p> <p>Avoid breathing vapors. Use epoxy only in areas with good ventilation. In small areas, be careful have a supply of fresh air and to exhaust any fumes. Wear a respirator with an organic vapor cartridge. Wear a dust mask when you sand the epoxy. If it has cured for less than a week, use a respirator with the organic vapor in combination with a dust pre-filter.</p> <p>Avoid ingestion. Wash thoroughly after each use and especially before eating or drinking. That means take a shower when you’re done sanding, before eating or smoking.</p> <p>Dispose of resin, hardener and empty containers safely. Do not dispose of resin or hardener in a liquid state. Before disposing of resin and hardener containers, puncture the corners of can and drain residue into clean containers for re-use. Small quantities of resin and hardener can be mixed and cured completely to a non-hazardous solid. Place pots of curing resin and hardeners outside on the ground to avoid the danger of excessive heat and vapors. Dispose of after the reaction is complete and the mass has cooled. Then follow local state and federal regulations for proper disposal.</p>

FIGURE A-1. Table of Set-times - Epoxy w/ Slow Hardener

Temp. (deg.F)	PotLife / Thin Film Set / FullCure
140	1.5m / 28m / 11:15h
131	2.25m / 42m / 16:52h
122	3.0m / 56m / 22.5h
113	5.75m / 1:15h / 30h
104	8.6m / 1:52h / 45h
95	11.5m / 2:30h / 2.5d
86	17.25m / 3:45h / 3.75d
77	23.0m / 5.0h / 5.0d
68	34.5m / 7.5h / 7.5d
59	46.0m / 10.0h / 10.0d
50	69.0m / 15.0h / 15.0d *
41	92.0m / 20.0h / 20.0d *

*Not recommended

WARNING: Epoxy cures under exothermic conditions, which means that the more of it you have in one place, the hotter it will get, and the hotter it gets, the faster it cures. If you leave it all in your cup, it's going to set much faster than if you pour it and start spreading or brushing it. It can get so hot in the cup, that it smokes and starts fires. This can be dangerous, and fume generating. Set partially full cups outside on pavement or gravel if you don't need all that you mixed.

TECH 2: MIXING EPOXY

Mixing epoxy would seem a simple process, but there are a few important techniques that you need to apply consistently in order to get a good batch.

Important guidelines for mixing epoxy.

1. Use latex gloves even for mixing. The outside of the mixing cup gets drips on it very easily.
2. Always use a two-to-one ratio (resin-to-hardener). You'll ruin the mix if you add more of one or the other. The pumps that come with the epoxy are metered so one pump from each provides exactly the correct mix.
3. It helps to alternate between the resin and the hardener when pumping multiple pumps into a single mix so that you don't lose count. In other words, one pump from the resin once, then the hardener once, back to the resin for one pump, then the hardener for one pump. All you have to remember is which you started with.
4. When you begin mixing, use a stirrer that does not have any cavities or irregularities for the mix to get caught in. Railstrips are no good because of the cove - it captures un-mixed epoxy and may release it into the mix creating un-catalyzed inclusions.
5. Mix for at least two minutes. Three is better.
6. Use your mixing stick to scrape the sides of the mixing cup periodically - all the way around. Try to scrape every part of the inside of the cup... even the bottom, and especially in the corners.
7. Try to move the mixing stick slowly enough that you reduce amount of bubbles that you fold into the mix. Some are unavoidable, so don't worry about it too much, but fewer is better!
8. If you're thinning the epoxy for an interior coat, always add the thinner after the epoxy has been mixed for two minutes. We use denatured alcohol from the hardware store - NOT rubbing alcohol.
9. If you're adding cabosil or wood flour to make a putty, add that after the two minute mixing as well.
10. Cabosil (if you have it) is a good additive for the purpose of reducing some of the inherent surface tension to make smoother gloss coats. Use only a level teaspoon for eight ounces. Always use a respirator around Cabosil, and do not let it puff up into the air.

TECH 3: EPOXY SEALING

This technique is employed for board interiors to reduce chances that leaks or forgotten vent plugs will damage the board, and for exteriors when we want to reduce the chances of outgassing. Outgassing is when changing temperatures push expanding air out of the surface and interior of the board and through the lam coat and/or hot coat. The result is small bubbles that can show up virtually everywhere.

Grain surfboards are sound and should not leak, but for those concerned with forgotten plugs, sealing the inside of the board can avoid damage. Depending on the size of the board, this could add as much as a pound of weight (on a longboard) but it's good insurance. Sealing the inside of the board also complicates some operations, because you will need to use glues that are compatible with the epoxy sealer for attaching the chine logs, starter strips, top planks and blocking.

Epoxy-sealed boards are more difficult to close up than are unsealed boards because the epoxy is harder to control and to work with than Titebond III. We will take some time to prep the board to keep it as clean as we can - especially at the rails which are 90% to 95% shaped - but also on the bottom where big drips of epoxy can create a lot of extra work and the unnecessary generation of epoxy dust.


In both these cases, the bare wood is sealed with a thinned coat of epoxy before moving on. Instructions that pertain to sealing before lam coat are noted.

This Tech involves the use of denatured alcohol as a thinner that facilitates the penetration of the epoxy into the wood grain. Note that curing times may be considerably longer the more alcohol is used. **DO NOT** use rubbing or isopropyl alcohol - denatured only.


Goal: To apply epoxy in a thin coat that seals bare wood by soaking in and creating an impermeable membrane.

Application: A laminate coat is about to be applied (Task 17, page 98) or panel(s) have been glued up (Step 5.2, page 21) or the board is about to be closed up (Step 10.4, page 74) and the interior is to be water-proofed.


Step	Action	Result
A.3.1	Read the usage notes in Tech 1, Step A.1.1 before working with epoxy.	You understand how to safely use epoxy.
A.3.2	We will be diluting the epoxy mix by 10% - 25% which increases the amount available... so don't mix up too much epoxy. The more you mix, the hotter it gets in the mixing bucket and the faster it goes off. After thoroughly mixing an amount of epoxy appropriate to the job you are doing, add small amounts of denatured alcohol a bit at a time to thin the mix. Don't use rubbing alcohol - it contains water. Keep stirring it in until you have thinned the mix noticeably.	A liquidy mix of epoxy soaks into the wood and which you can apply in a thin film.

Step	Action	Result
A.3.3	<p>Apply the mix with a brush as thin as you can do it - the alcohol needs to be able to gas off during cure.</p> <p>Lam Coat Prep: you should be applying the epoxy thin enough that you don't require tape around the rails as you would with other epoxy applications.</p>	The epoxy is thinly applied and appears to soak in quickly.
A.3.4	<p>As you complete the area which you are sealing, you can go back and reapply thin immediately if the surface looks like it is soaking it all up.</p> <p>Lam Coat Prep: This is especially true if you are sealing in advance of a lam coat. Appreciable weight should not be added with this thin applied coat because the epoxy that's being soaked up now will prevent subsequent coats from penetrating as far, using less epoxy.</p>	The surface never gets "plastic" looking as the epoxy should soak in enough that it is still below the surface of the wood being prepped. If it pools and floats, there is probably too much epoxy applied.
A.3.5	<p>These coats will not have an appreciable aesthetic impact on the board. Just get it on thin - but evenly.</p> <p>Lam Coat Prep: If you protect the stand, you can even flip the board and do the other side as soon as the surface is tacky.</p>	The process is over very quickly, with reverse sides of the board (if applicable) completed as soon as the board can be handled.
A.3.6	<p>If you need to epoxy on top of the sealed surface (as with the lam coat) wait until the surface is cured, then use a Scotch-Brite pad or 120-grit sandpaper to scratch the surface. Prep as you normally would, cleaning with denatured alcohol before applying the lam coat.</p>	The coat is ready to be bonded mechanically to the next coat of epoxy.
A.3.7	<p>Interior Sealing: If you decide to seal the interior of the board, it is easiest to treat the panel(s) before the frame is attached. It saves time to have your top panel ready for this step so that you can do them both at once.</p>	You have an epoxy mix that can be applied much more thin than standard epoxy.
A.3.8	<p>Interior Sealing: Apply a thinned epoxy mix to the panel with a brush as thin as you can do it - the alcohol needs to be able to gas off during cure. You have cut your panel oversize, so you don't have to go all the way to the edges - but you do need to be sure that you will have epoxy under the starter strip and chine log.</p>	The panel is coated on the inside.
A.3.9	<p>Interior Sealing: Let the panel set up thoroughly. It may take a couple of days because the film is so thin, but in a very warm location, curing will be accelerated. Rough up the interior surface with a ScotchBrite pad or some 80-grit sandpaper after it is cured. Wipe the panel down with alcohol, then proceed with Step 5.2</p>	The interior of the panel is scratched to allow other adhesives to stick.
	<p>Remember that you need to use epoxy for the attachment of chine logs, starter strips, blocking (including swallow-tail blocking and possibly external tail or nose blocking) and top planks (between the lands and the planks) now that the interior of the board is sealed. Titebond III will not adhere to the epoxy surfaces you have created. Also, epoxy MUST be roughed up with sandpaper or a Scotch-Brite pad for subsequent applications of epoxy to adhere.</p>	

Before installing the deck panel, more sealing must be done to the board interior:

Step	Action	Result
A.3.10	Check the inside of the top planks (which should be trimmed to fit the lands of the board.) Ensure that the epoxy coat extends to the edge, or at the very least, to point that will correspond to the inside of the lands. If not, recoat those areas with a thinned epoxy.	The top panel is coated enough to protect it.
A.3.11	If the epoxy on the top planks is cured, rough up the surface with a ScotchBrite or some 80-grit sandpaper. Just scratch it thoroughly... don't sand into wood. Set it aside - we won't need it quite yet.	There are sufficient scratches on the inside of the panel to promote adhesion of other glues.
A.3.12	With 2" masking tape, cover the rails of the board - start below the rail (on the bottom) and put overlapping courses of tape until you have reached the tape that is marking the transition line.	The entire rail is protected from drips.
A.3.13	We will be covering only the frames, the keel, the insides of the rails, and any exposed blocking we have added <i>plus</i> we will be diluting it by 10% - 25% which increases the amount available... so don't mix up too much epoxy. The more you mix, the hotter it gets in the mixing bucket and the faster it goes off.  After thoroughly mixing up some epoxy, add small amounts of denatured alcohol a bit at a time to thin the mix. Don't use rubbing alcohol - it contains water. Keep stirring it in until you have thinned the mix noticeably. You should never use more than 25% alcohol - you will probably need around 10%.	A liquidy mix of epoxy that will soak into the wood and which you can apply in a thin film is prepared.
A.3.14	Use a bristle chip brush to apply the epoxy. Start with the rails - it helps to set the board up on edge if you can do it without dripping all over your shaping stand. DON'T get any epoxy on the lands if you can help it. You spent a lot of time making them true and it will suck to have to chip hunks of epoxy off them later.	The inside of the rails are well sealed.
A.3.15	After the rails are sealed, set the board level and coat the frames - be sure to brush inside all the lightening holes in the frames and keel. There is a lot of end-grain exposed there, and end-grain loves moisture. Even marine plywood like that used in Grain Surfboards will break down in the right conditions of moisture. The frame edges and blocking can be brushed over as well. Anywhere that we will be using 3M 5200 is fair game - the epoxy will actually improve the adhesion of the 5200. You can brush epoxy right over the 3M 5200 fillets, though it is not necessary.	Frames are sealed.
A.3.16	There will be wood blocking also exposed inside the board. Brush that with the epoxy as well - tops, too. Work some in under the vent blocking.	Blocking is sealed
A.3.17	Look around carefully - brush over any spots that could need a second coat - some will soak in quickly.	Everything is covered.
A.3.18	Inspect the lands to be sure that there are no epoxy drips. Scrape them down flush if there are. Allow this coat to set up before installing the top planks.	There are no lumps of epoxy to harden on the lands and create obstructions.

Installation of the deck panel requires the use of epoxy where ever Titebond would have been used:

Step	Action	Result
A.3.19 	<p>Epoxy is harder to control than Titebond, and it's also harder to clean up, so we should take time to protect both the board and the rocker table from drips.</p> <p>You need some type of sheeting that will catch epoxy drips and that masking tape will adhere to. The sheeting only needs to cover the outer parts of the rocker table - just below where the rails land. You may find it easiest to tape the sheeting to the bottom of the rail provided that you fix it directly to the tape that you put on in Step A.3.12 letting it cover the rocker table outside of the rails.</p>	<p>There is no way for epoxy to run down under the board or onto the rocker table.</p>
A.3.20	<p>Mix up a batch of slow-setting epoxy. If you have an assistant, then s/he can mix the second half of what you will need as you begin applying the first half.</p>	<p>The epoxy stays cooler and doesn't kick off too quickly.</p>
A.3.21	<p>Thicken the epoxy with cabosil or super-fine wood flour. You want just enough thickening to discourage the epoxy from running off the lands - which are tilted almost everywhere, but thin enough that there is liquid that can soak into the wood fibers a bit.</p>	<p>Epoxy is mixed to a thin putty.</p>
A.3.22	<p>Butter the epoxy onto the lands. Ideally, none would drip off, but some dripping is normal if you have mixed it to a loose enough consistency. You want to put enough on so that some of it can run off (while you are getting all the clamping done) while still leaving plenty to make a good bond.</p>	<p>Epoxy is applied to the lands everywhere on the board. There may be small runnels of epoxy on the rails, but it should all be trapped by masking tape and sheeting applied in Step A.3.19.</p>

Epoxy cures to a plastic compound. “Plastic” literally means “capable of being deformed continuously and permanently in any direction without rupture.”

Though it may feel hard to the touch, epoxy remains in a flexible state for a long time - depending on temperature. On a molecular level, there can still be a lot going on, and when an epoxy board is subjected to heat or ultraviolet, things happen.

An epoxy board heated beyond the ability of the epoxy to resist these molecular responses will show a characteristic known as “print-through”. Print-through is the tendency of a beautifully finished epoxy surface to start feeling textured as the weave of the glass cloth beneath it begins to form the hot- and gloss-coats into ridges that correspond to the location of the fibers in the weave. This can happen particularly quickly when the board is not fully cured (depending on temp, that could be up to a couple of weeks after the epoxy is applied.) There are also other factors that can contribute to print-through, such as poor hardener-to-resin ratios.

One way to deal with this is to use more epoxy in the hot- and gloss-coats. Another is to “post-cure” the board to push the epoxy to its maximum performance characteristics. Post-cure simply means to heat the board under controlled conditions after the hot coat is complete.

One other outcome (besides optimizing the epoxy) is that much of the shrinkage and movement happens right away, and the subsequent sanding in preparation for the next steps can knock down the texture that results from the print-through.

There is a way to post-cure on the cheap. After the hot-coat is complete, past the green stage and before sanding, make sure the vent hole is definitely clear and venting. Then, take the board out to a car parked in the sun and put it inside. Ideally, you want the board to be exposed to about 140 degrees Fahrenheit for about four hours. That’s it. When you remove the board, there is a good chance that you will be able to feel some print-through. That’s good. Now take the board on to the next steps.

TECH 4: POST-CURING **EPOXY**

A short description of the “poor man’s” post-cure.

