TOOLING PREPREG

Autoclave Cured Tools Using

LC-E445T/LC-E345T Variable Temp Epoxy Tooling Prepreg

1. ***MASTER PATTERN***

I *Selection of Materials*

The selection of suitable materials for any tool master or plug is of prime importance when aiming for dimensional accuracy and optimal surface finish. In order to maximize the benefits of low coefficient of thermal expansion and excellent surface finish achievable using LC-E455T/LC-E345T variable temperature epoxy tooling prepreg, the following alternative combinations of materials are recommended.

1. A high-quality epoxy tooling board coated with PTM&W PT1995 High Temp Epoxy Surface Coat. (PTM&W products available from TMI)

2. Epoxy/wet lay-up splashes.

Note: There are a number of alternative materials currently in use with LC-E455T/LC-E345T however, any alternative material must be proven by physical testing prior to use.

II *Vacuum Integrity*

In all cases the master must be proved prior to lamination of mold tool, by carrying out a "mock cure". This will enable any potential problems such as lack of vacuum integrity or poor stability under pressure to be checked before any actual laminate construction (see section 6 Autoclave cure).

III *Release Coating*

Completely remove contaminants from tool master or plug surface using a solvent mold cleaner such as Chemlease® Mold Cleaner EZ. Allow ample time for the surface to dry at ambient temperatures.
Apply a mold prep and primer such as Chemlease® MPP 2180 for gelcoat or surface coat tool masters/plugs. Chemlease® MPP 2737 can be used for non-gelcoat or surface coat tool masters/plugs.
Apply a mold sealer such as Chemlease® Sealer 2739.
Finally use a mold release agent such as Chemlease® R&B EZ to complete the release coating process.
(All Chemlease® products are available from TMI)

Note: It is important to follow the mold release manufacturer’s process application recommendations. If you have any questions or need any technical support, please contact your TMI sales staff.

2. ***PREPARATION OF MATERIALS***

Is essential for out-life to be optimized by keeping it in a frozen state (0°F) for as long as possible. It could be appropriate to construct a series of templates to enable single ply kits of materials to be prepared prior to lamination. The following points should be noted:

(a) The material must be allowed to reach room temperature before opening the sealed packaging, this is to avoid formation of condensation on the material surface as it warms up.

(b) Materials should be cut on a clean stable surface that is not likely to produce any potential contaminants in final lay-up. Typical table top surfaces like - glass sheet, polypropylene, nylon, rubber, self-healing urethane or mocathane products. (Contact TMI sales staff for available options)

(c) Individual kits of a single ply each should be prepared and stored in a freezer separately. This will enable operators to ensure a minimal amount of material is out of the freezer at any time - refer to Appendix I for ply type and orientation.

(d) Material can also be pre-cut into a series of conveniently cut squares, typically 12-inch x 12-inch (304.8mm x 304.8mm) or 16-inch x 16-inch (406.4mm x 406.4mm) square tile sizes.

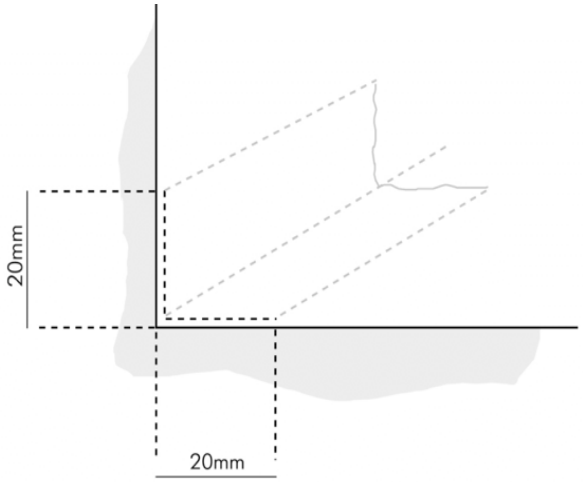
2. ***LAMINATION TO TOOL***

Appendix I shows a copy of a typical customers work sheet with easy reference for ply type and fiber orientation.

The first and final plies will be lighter surfacing plies with the core made from a heavier material to bulk up the center of laminate.

Remove the first appropriate kit of materials from freezer and allow to thaw, this is essential to avoid formation of condensation on surface.

(a) Trim strips – Lay up a series of 45º trim strips in to all external corners and tight radii, ensure pattern runs in a consistent direction for aesthetics. Strips should be approx. 1.5-inches (40mm) wide positioned evenly on center of corner.

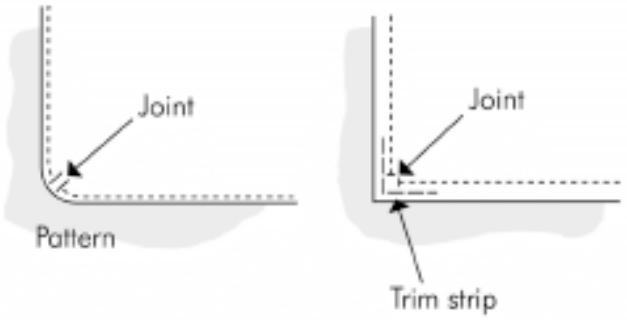


Lay up the first ply, carefully cutting and fitting keeping in mind the following points.

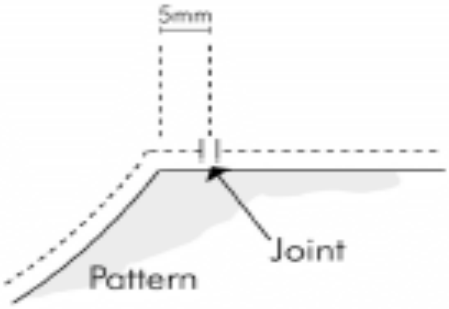
(a) All pieces should be butt joined, no overlaps are permissible at this stage

(c) The weave pattern should be consistent if the fiber orientation is correct.

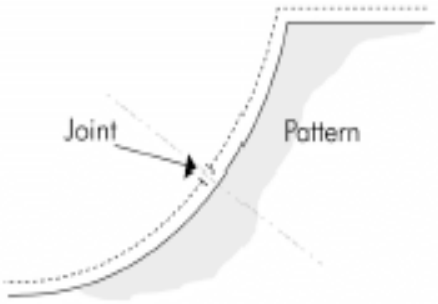
(d) Cut material to fit into all external radii and corners taking care not to disturb the trim strips.



(e) On all internal right-angled corners allow material to form around angle, but by no more than 0.2-inch (5mm)



(f) On large external radii the material should be tailored to fit in mid-point of the radius.

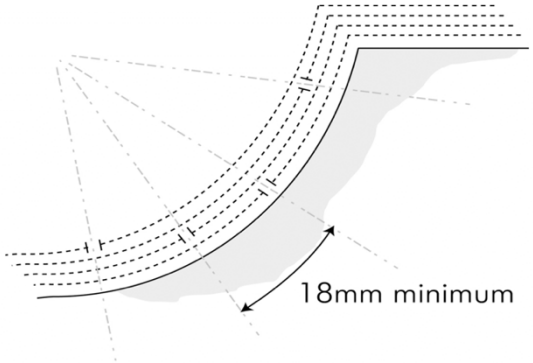


(g) Avoid pushing material into corners with a sharp implement as this is likely to cause unseen damage to fibers and can lead to a structurally weakened laminate at this point.

This procedure is repeated throughout the laminate, with the following additional points for the heavier plies (refer to Appendix I).

Heavier plies-

(b) All joints should be staggered between plies with a minimum of 0.75-inches (18mm) spacing for adjacent plies. Overlaps should be avoided if possible.



(b) Under no circumstances should any gaps be left as this is likely to cause voids in the completed tool.

(c) The weave pattern should be consistent if the fiber direction is correct.

(d) Avoid pushing material in to corners with a sharp implement.

4. *DEBULKING (Reference to Appendix I)*

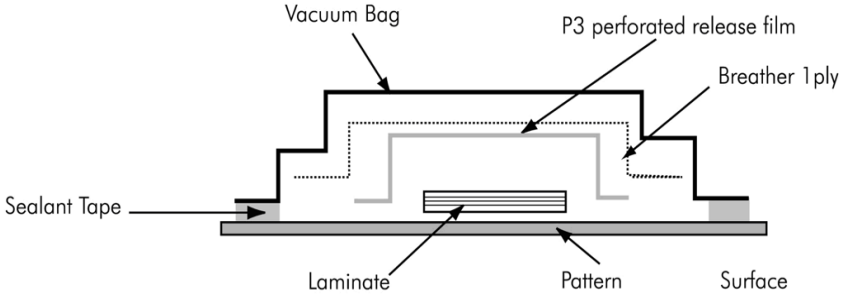
It is essential to debulk the prepreg at least at the stages stated i.e

After ply 1,
Approximately every subsequent 3 plies,
After the final ply has been completed.

This will ensure even consolidation and remove air from the laminate prior to final curing.

More complex shapes can sometimes be easier to laminate if more frequent debulks are used, but in these cases the time factor must be taken into consideration.

If a laminate is to take more than one day to lay-up then it must be de-bulked overnight to ensure that it stays in place.



(a) Cover entire laminate surface with a perforated release film type P3, extending beyond the lay-up by approximately 1-inch (25mm).

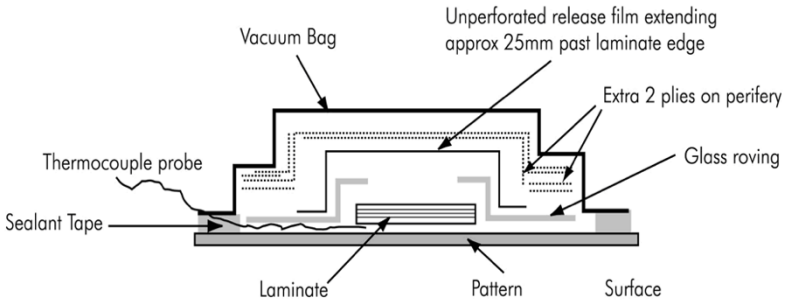
(b) Apply single ply of breather/bleeder cloth 10oz/yd^2 (340g/m^2) in total to the surface. Customize fit to avoid bridging. The breather/bleeder cloth can be omitted from the tightest corners if not practical.

(c) Cover the laminate/assembly with a vacuum bag ensuring that enough slack has been provided to pull into all corners without any bridging.

(d) Apply full vacuum and leave for 20 minutes.

(e) Care must be taken when materials are removed from the surface afterwards, be careful not to lift up the previously laminated plies.

5. ***PREPARATION FOR AUTOCLAVE***



(a) Place a thermocouple underneath the first ply of material on an area that is not a critical mold surface.

(b) Lay in strips of dry carbon fiber tow for tools produced from carbon tooling prepreg or dry fiberglass tow for tools produced from fiberglass tooling prepreg (Glass Roving) every 12 inch (300mm) around the edge of the laminate continuing to the area on the periphery about to be covered with breather and described in (d).

(c) Cover entire laminate with a non-perforated release film, extend edges by around 1-inch (25mm).

(d) A single ply of heavyweight breather/bleeder cloth 10oz/yd^2 (340g/m^2) is recommended. Customize fit and ensure all areas connect. Apply an additional 2 plies around the periphery between the edge of the laminate and the inside of the vacuum seal. It is not advisable to miss breather from any of the surface.

(e) Cover with a vacuum bag film and ensure there is enough slack provided to pull into all corners without bridging. The vacuum pack will appear very bulky, care must be taken to ensure all materials remain in position as the vacuum bag pulls down. It may be necessary to use a pressure sensitive adhesive tape to assist with holding some vacuum bagging materials in place.

(f) Apply full vacuum pressure and hold for 25 minutes prior to autoclave processing. Check for vacuum integrity, internal corner consolidation, and position of tucks in the bag.

6. ***AUTOCLAVE CURE***

Due to the highly reactive nature of the resin system it is essential that curing is carried out under the strictest control possible, to ensure entire laminate is fully cured and to avoid a possible exotherm.

1. Apply full vacuum pressure (29”Hg) at room temperature, 70ºF (21ºC).
2. At 100ºF (37ºC), apply 100 psi (7 bar) gauge pressure.
3. Increase air temperature at a rate of 3+/-1 ºF/min (1.5+/-.5 ºC/min). Ramp to the required curing temperature and cure for at least the stated minimum time.
4. Cool down to 100ºF (37ºC) at maximum rate of 5ºF/min (3ºC/min).
5. Release Pressure/Vacuum
6. Remove vacuum bagging materials from mold.

CURING CYCLES

Temperature	LC-E445T	LC-E345T
150ºF (65ºC)	10 hrs	10 hrs
175ºF (79ºC)	3 hrs	3 hrs
250ºF (121ºC)	1-1/2 hrs	1-1/2 hrs

Initial Curing Cycles (in hours)

Important: Time and temperatures shown are minimums assuming a low mass master tool or plug. Increase time at temperature for high mass, thicker master tools or plugs, or to allow areas of difficult geometry to reach full curing temperature. If the master used is then walled, e.g., epoxy/wet lay-up splash, an alternative cure should be used to include a dwell at low temperature then continue with the standard cure cycle. Initial cure cycles must be followed by a higher temperature post cure for ultimate Tg.

7. ***REMOVAL FROM MASTER***

Should the tool require a backing structure* (i.e. to prevent a large tool from distorting under its own weight), it should be fitted at this point prior to the release from the master.

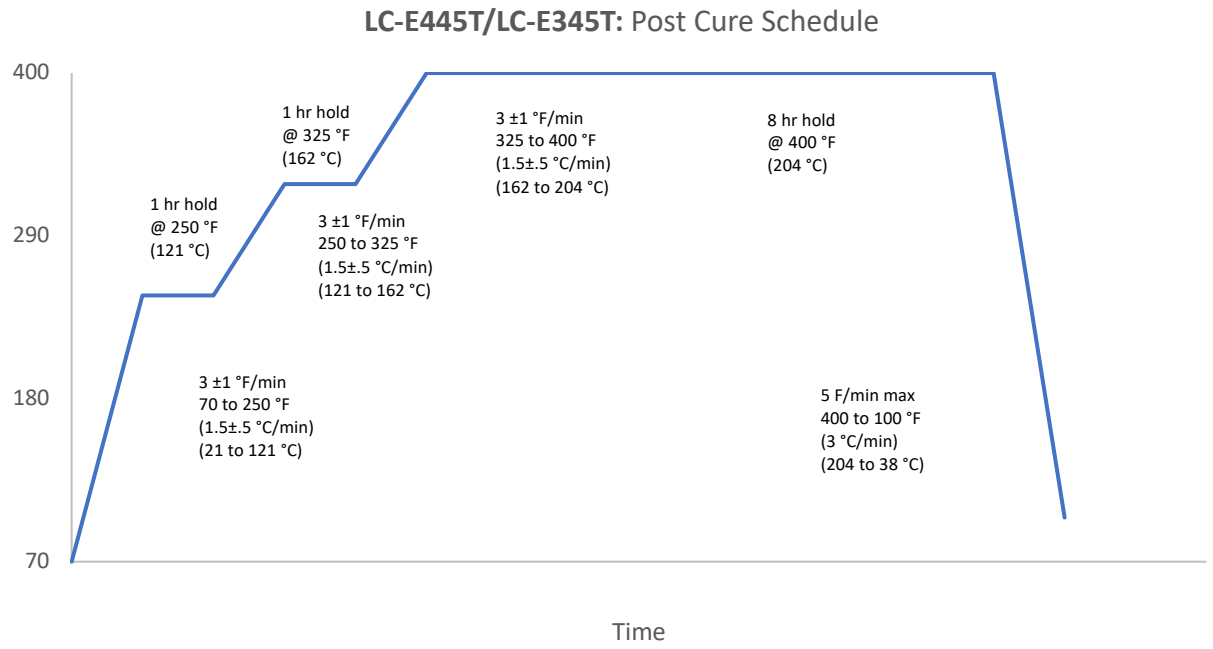
Care should be taken not to induce stresses on removing the tool from the master, since it will be mechanically weak at this stage. The mold should be gently eased off the master and lifted evenly all round.

* Contact TMI sales staff for details.

8. ***POST CURE***

The tool should be set up with suitable support around the base with its weight spread as evenly as possible. It is essential to carry out post-curing as close as possible to the above schedules, to retain maximum end use properties. Carry out any one the following two stepped curing schedules

Post Cure Schedule for LC-E445T & LC-E345T Tooling Prepreg		
Ramp	250ºF (121ºC) at a rate of 3+/-1ºF/min (1.5+/-.5ºC/min)	Hold for 1 hour
Ramp	325ºF (162ºC) at a rate of 3+/-1ºF/min (1.5+/-.5ºC/min)	Hold for 1 hour
Ramp	400ºF (204ºC) at a rate of 3+/-1ºF/min (1.5+/-.5ºC/min)	Hold for 8 hours
Cool down to 100ºF (37ºC) at maximum rate of 5ºF/min (3ºC/min) before removing tool from oven/autoclave.		



9. ***RELEASE PREPARATION/PRIMING***

It is essential to consider the correct regime for coating and releasing the mold at this point.

a) Wash surface thoroughly with clean water and allow to dry.

b) Clean surface with mold cleaner such as Chemlease® Mold Cleaner EZ, apply to the mold surface with a clean, 100% cotton cloth. While the mold surface is still wet, vigorously wipe the mold dry with a second clean, dry, 100% cotton cloth. Frequently exchange saturated cloths with new, clean cloths. Repeat process several times (a minimum of two cleanings is recommended) until all residues (dirt, dust, grease, moisture, etc.) are removed.

c) A mold prep and primer such as Chemlease® MPP 2180 can be used for gelcoat or surface coated composite tools. Chemlease® MPP 2737 can be used for non-gelcoat or surface coated composite tools as well.

d) Apply a mold sealer such as Chemlease® Sealer EZ or Chemlease® Sealer 2739. Note: Use of this product without a release agent may result in severe damage to the mold.

e) Finally use a mold release agent such as Chemlease® R&B EZ to complete the release coating process. (All Chemlease® products are available from TMI)

Note: It is important to follow the mold release manufacturer's process application recommendations. If you have any questions or need any technical support, please contact your TMI sales staff.

10. ***IN SERVICE MAINTENANCE***

Different release agents, pre-pregs can have a wide variation in effects on the surface of the mold.

Points in general to note are:

a) Avoid any aggressive abrasion on the surface, i.e. when removing components from mold.

b) Avoid cutting into mold surface during lamination.

c) Do not use excessive force when releasing from mold.

d) Follow release agent data sheets as recommended.

11. ***RE-PRIMING MOLD SURFACE***

Surface deposits can be removed by fine abrasion by hand with either fine nylon scouring pads or cutting paste. Generally, the use of mechanical means is not recommended.

For touch-up coats, it is best to do preventative maintenance, therefore reapply after 15 releases, or as trials determine. Wipe on and wipe off 1 coat and allow a minimum of 15 minutes prior to recommencing lay-up. The tool surface may require to be completely cleaned from build-up after a designated number of lay-up cure cycles. If so, revert back to section 9 and follow the release preparation/priming steps.

Appendix I. Job Sheet

Lay-up sequence and checklist for autoclave cured LC-E445T or LC-E345T.
1-8-1 lay-up construction with a thickness of approx. 0.25-inches (6.35mm)

Part Number:	Job Number:	Issue Date:

Ply Number	Ply Orientation	Operation	Operator(s)	Inspected	Date
-	+/- 45º	Trim Strip Surface Ply			
1	0º	Surface Ply			
-	-	Debulk			
2	0º	Bulk Ply			
3	+45º	Bulk Ply			
4	-45º	Bulk Ply			
-	-	Debulk			
5	90º				
-	-	Laminate Mid Plane			
6	90º	Bulk Ply			
7	-45º	Bulk Ply			
-	-	Debulk			
8	+45º	Bulk Ply			
9	0º	Bulk Ply			
10	0º	Surface Ply			
-	-	Final Debulk			
-	-	Preparation for Autoclave			
-	-	Autoclave Cure			
-	-	Post Cure			
-	-	Preparation and Release Prime			

Carbon Tooling Prepreg:

1.) LC-E445T/C106, 205g/m^2, 2x2 Twill, 3k Carbon Fabric (Surface Ply)

2.) LC-E445T/C115, 670g/m^2, 2x2 Twill, 12k Carbon Fabric (Bulk Ply)

Fiberglass Tooling Prepreg:

1.) LC-E345T/120, 107g/m^2, 4HS, E-glass Fabric (Surface Ply)

2.) LC-E345T/1210, 850g/m^2, 2x2 Twill, E-glass Fabric (Bulk Ply)