MULTIPREG HX SERIES AUTOCLAVE TOOLS PROCESSING INFORMATION

Autoclave Cured Tools using Multipreg HX Series Low Temperature Curing Epoxy Prepreg

1. THE MASTER PATTERN

i Selection of Materials

The selection of suitable materials for the master is of prime importance when striving for dimensional accuracy and optimum surface finish. In order to maximise the benefits of low coefficient of thermal expansion and excellent surface finish achievable using MULTIPREG HX SERIES low temperature prepreg, the following alternative combinations of materials are recommended.

(a) A high quality epoxy tooling block coated with EC85 Hard Epoxy Surface Coat (also available from Amber Composites) or seal with Chemlease® MPP 712 EZ.

or (b) Epoxy/wet lay-up splashes.

There are a number of alternative materials currently in use with MULTIPREG HX SERIES 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 mould 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 6 Autoclave cure).

iii Release Coating

- Thoroughly degrease the surface using an organic solvent such as Chemlease® Mould Cleaner EZ allowing all traces to evaporate by drying at 60°C (140°F) for ½ hr.
- Apply 1 - 2 coats of Chemlease® MPP 712 EZ using wipe on buff off technique leave for 30 minutes between coats. After the final coat, allow a minimum of 1 hour to cure at room temperature.
- Apply the appropriate Chemlease® mould release e.g. 5 coats of Chemlease®2185
- Heat tool to 60°C (140°F) for one hour to enable release solvents to be driven off.
- (All products are available from Amber Composites)

2. PREPARATION OF MATERIALS

Due to the low temperature curing nature of the prepreg it is essential for outlife to be optimised by keeping it in a frozen state at -18°C (0°F) for as long as possible. At this stage the customer will probably find it 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 surfaces are - glass sheet, polypropylene, nylon or rubber.

(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 dimensions of 0.5, 0.33 and 0.25m^2.

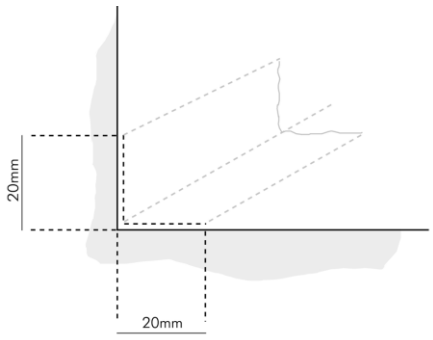
3. LAMINATION TO TOOL

Appendix I shows a copy of a typical customers work sheet with easy reference for ply type and fibre orientation. Appendix II shows other typical laminate constructions.

The first and final plies will be lighter surfacing plies with the core made from a heavier material to bulk up the centre 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 approximately 40mm (1½ inch) wide positioned evenly on centre of corner.

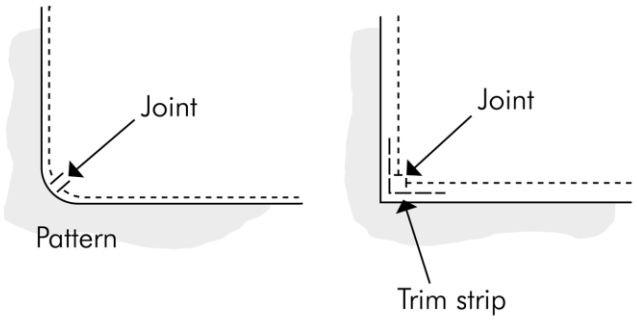


Lay up the first ply, carefully cutting and fitting bearing in mind the following points.

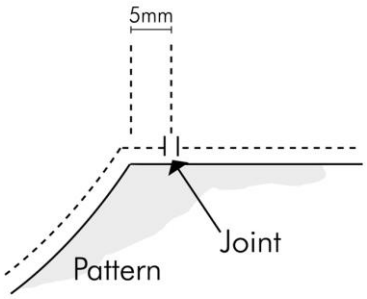
(b) All pieces should be butt joined, no overlaps are permissible at this stage

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

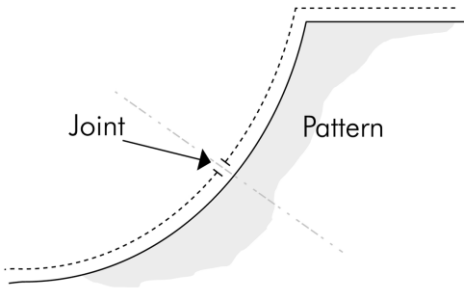
(d) Cut material to fit into all external radii and corners taking care not to disturb the trim strips.



(e) On all internal right-angled corners allow material to form around angle, but by no more than 5mm (¼ inch).



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

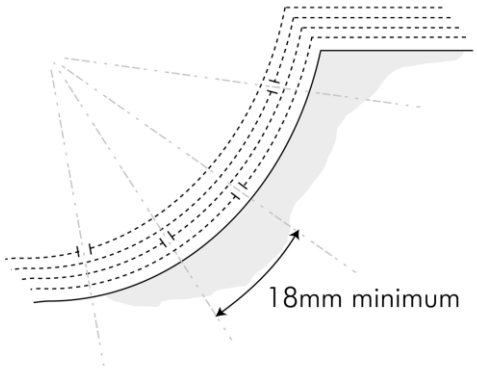


(g) Avoid pushing material into corners with a sharp implement as this is likely to cause unseen damage to fibres and can lead to a structurally weakened laminate at this point.

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

Heavier plies -

(a) All joints should be staggered between plies with a minimum of 18mm (¾ inch spacing for adjacent plies. Overlaps should be avoided if possible.



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

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

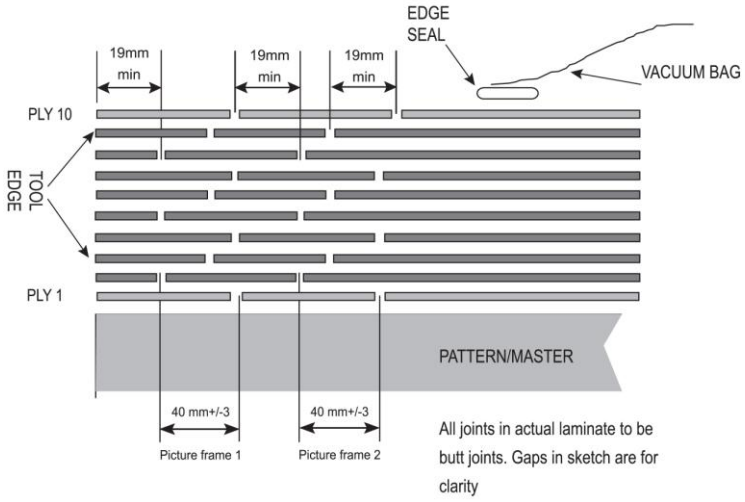
(d) Avoid pushing material in to corners with a sharp implement.

INTEGRITY SEAL

Some tools will be subjected to a large number of autoclave cycles in service and there is a possibility that the tool surface may become damaged due to operators cutting on its surface or from impact damage. A leak path could possibly form through the damage site and along a fibre bundle exiting at the trimmed edge of the tool. To avoid this, the tool laminate should be laid up in squares.

As an additional barrier to this form of leakage, it is desirable to ensure that all fibre bundles are cut at least twice in the area between the strip where the vacuum bag sealant tape will be applied and the tool edge. This will build up a “picture frame” of cut plies around the vacuum bag seal area.

INTEGRITY SEAL



4. DEBULKING (Reference to Appendix I)

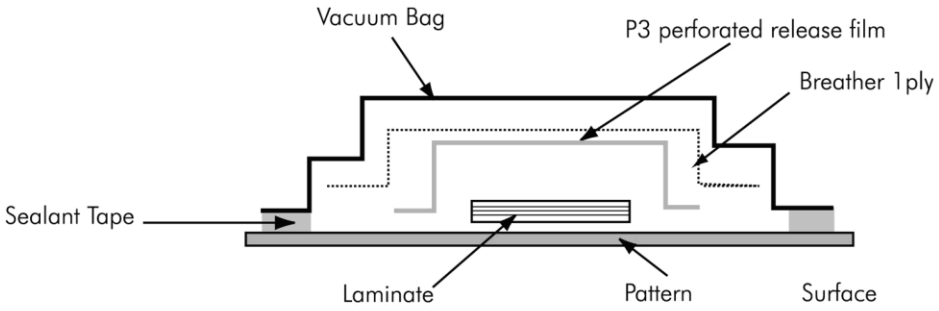
It is essential to debulk the prepreg at least at the stages stated i.e

- 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 25mm (1 inch).

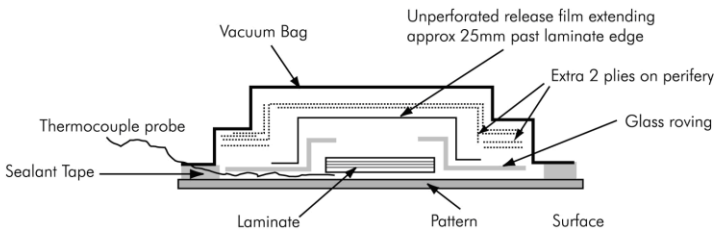
(b) Apply a breather coat of around 350gsm (10.3 oz/yd^2) in total to the surface. Tailor to fit to avoid bridging. At this stage the breather can be omitted from the tightest corners if not practical.

(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) Fit a thermo couple underneath the first ply of material on an area that is not a critical mould surface.

(b) Lay in strips of glass rovings every 600mm (24 inch) 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 25mm (1 inch).

(d) Apply a breather coat of around 700gsm total weight, typically 2 plies of 350gsm (10.3 oz/yd^2) Tailor to fit and ensure all areas are interlinked. Fit an extra 2 plies around the periphery between the edge of the laminate and the inside of the vacuum seal.

At this stage it is not advisable to miss breather from any of the surface.

(e) Cover with a vacuum bag ensuring that enough slack has been provided to pull into all corners without bridging. At this stage the vacuum pack will appear very bulky, care must be taken to ensure all materials remain in position as the vacuum bag pulls down.

(f) Apply full vacuum pressure and leave for 25 minutes prior to autoclave processing.
Check for vacuum integrity 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 avoid deviation and hence possible exotherm during cure.

Apply 1.45 bar (21 psi) with vacuum
Vent to atmosphere
Raise pressure to between 4.15 bar (60 psi) and 6.20 bar (90 psi)

Increase air temperature at 30^{o}C (54°F) per hour to 55°C (131°F) or any other required curing temperature and cure for the stated minimum time.

CURING CYCLES

	Initial Cure Time (hrs)			
Temperature	**HX70**	**HX50**	**HX42**	**HX90N**
30°C (86 °F)	35			
35°C (95°F)	23			
40°C (104°F)	15	18		34
45°C (113°F)	10	12.5		23
50°C (122°F)	6.5	8.5	18	15
55°C (131°F)	4.25	6	11	10
60°C (140°F)	3		8	7
65°C (149°F)			5	
75°C (167°F)			2.5	
85°C (185°F)			1.25	

If the master used is thin walled, eg epoxy/wet lay-up splash, an alternative cure should be used to include a dwell at low temperature. To satisfy this requirement introduce a dwell at 40^{o}C (104°F) or for 2 hours, then continue with the standard cure cycle.

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 stage prior to 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 mould should be gently eased off the master and lifted evenly all round.

8. POST CURE

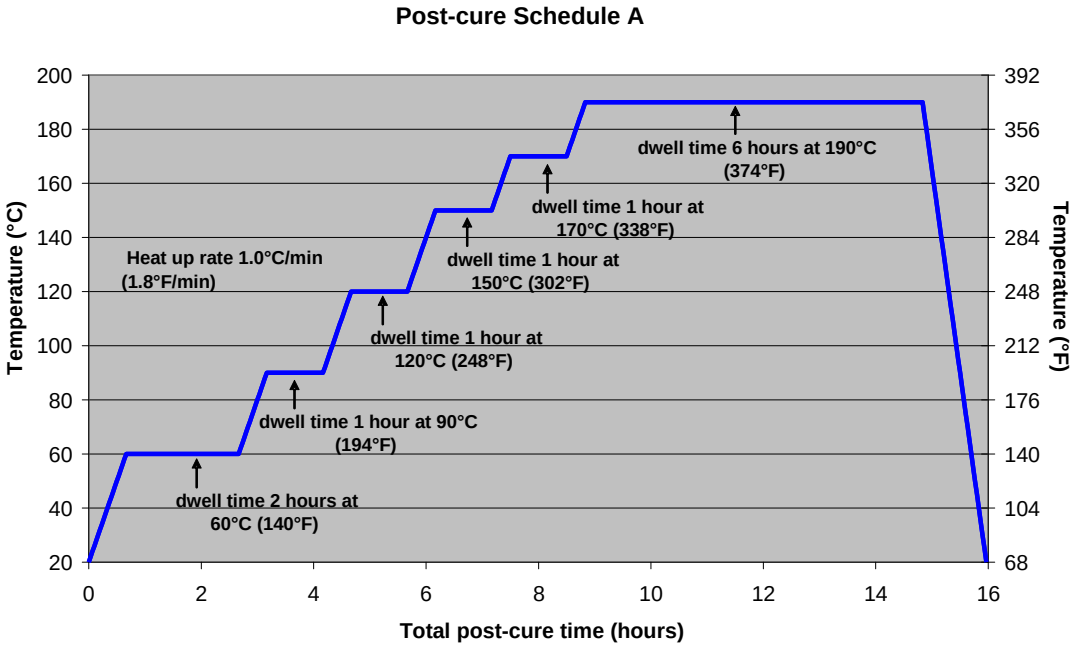
The tool should be set up with suitable support around the base with its weight spread as evenly as possible.

Carry out any one the following two curing schedules

Post-cure schedule A:

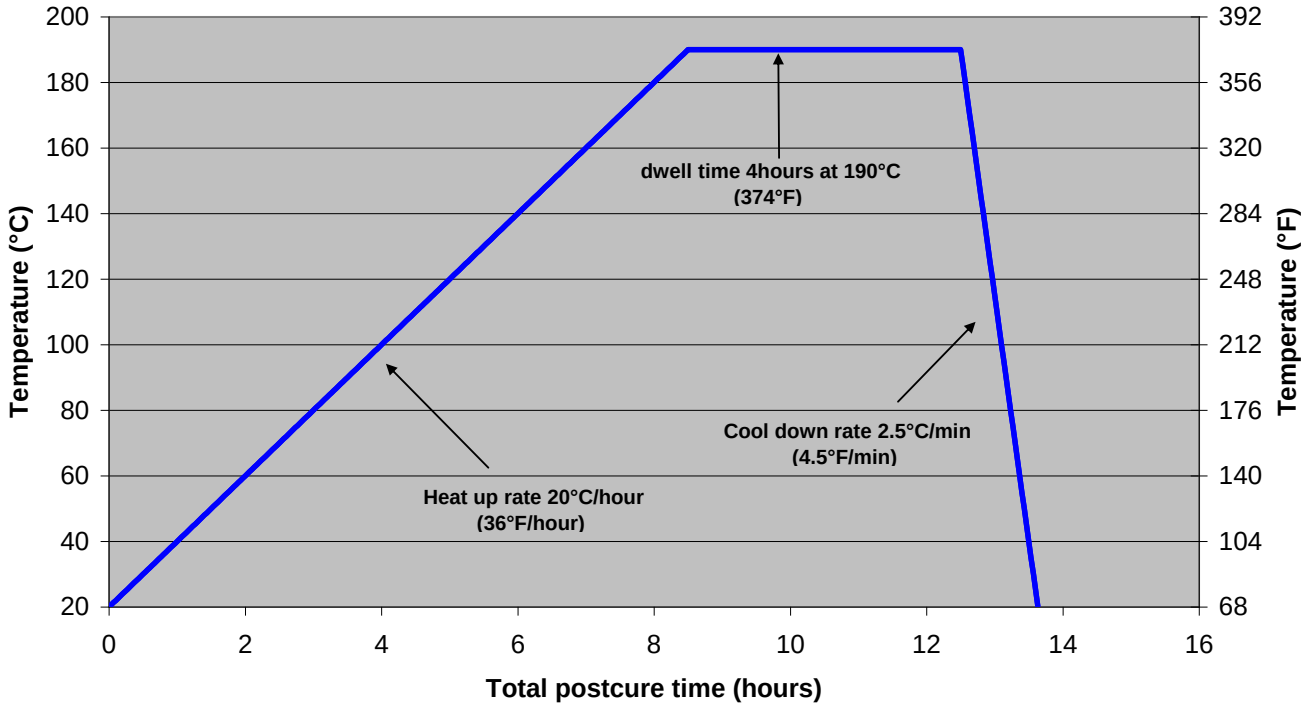
Ramp	1ºC (1.8°F) / min to 60ºC (140°F)	Dwell for 2 hours
Ramp	1ºC (1.8°F) / min to 90ºC (194°F)	Dwell for 1 hour
Ramp	1ºC (1.8°F) / min to 120ºC (248°F)	Dwell for 1 hour
Ramp	1ºC (1.8°F) / min to 150ºC (302°F)	Dwell for 1 hour
Ramp	1ºC (1.8°F) / min to 170ºC (338°F)	Dwell for 1 hour
Ramp	1ºC (1.8°F) / min to 190ºC (374°F)	Dwell for 6 hours

Cool to 50ºC (122°F) at 2.5ºC/min (4.50ºF/min)



An alternative post-cure schedule may also be used as follows:

Postcure Schedule B



It is essential to carry out post-curing as close as possible to the above schedules to retain maximum end use properties.

In cases where the end use temperature is likely to be lower than 180^{O}C (356°F), the post cure can be suitably modified providing the final stage is at least 20^{O}C (68°F) higher than maximum end use temperature, and held at this temperature for the appropriate final dwell time 6 hours).

Eg 150^{O}C (302 °F) end use = 170^{O}C (338°F) maximum post cure temperature plus dwell for 5 hours.

9) RELEASE PREPARATION/PRIMING

It is essential to consider the correct regime for coating and releasing the mould at this stage:

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

b. Clean surface with Chemlease® Mould Cleaner EZ, apply with a clean 100% cotton cloth. While the mould surface is still wet, vigorously wipe the mould dry with a second clean cloth, until mould is “squeaky clean” by thumb rub test. Frequently exchange saturated cloths for new and repeat several times until all residue is removed. Alternatively test on an “off part” area with a non-silicone adhesive tape.

Mould Prep and Primer

c. For a high quality finish, apply 1 or 2 coats of Chemlease® MPP 712 EZ sealer by wipe on / wipe off, allowing 30 mins between each coat and at least 1 hour at an ambient temperature to finally cure. Use of this product without a release agent may result in severe damage to the mould.

d. Apply 1 to 2 coats of Chemlease® 15 sealer EZ by wipe on / wipe off coats. Saturate a clean cloth and wipe on a smooth film of no more that 0.6m² at a time. When the film begins to evaporate at the edges, wipe the surface with a second clean cloth using a circular motion. Repeat until entire mould surface has been covered. Allow 1 hour at an ambient temperature to cure prior to applying mould release.

e. Apply 6 x wipe on / polish off coats of Chemlease® 255 release agent (if a high gloss finish is required) OR Chemlease® PMR EZ (if a minimum transfer is required), allowing 15 mins between coats and 30mins for a full cure at ambient temperature.

f. For touch up coats of your selected release agent, apply 2 coats as before.

10) IN SERVICE MAINTENANCE

Points in general to note are:

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

b) Avoid cutting into mould surface during lamination.

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

d) Follow release agent data sheets as recommended.

e) Different release agents and different prepregs can have a wide variation in effects on the surface of the mould.

11) RE-PRIMING MOULD 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 polish off 1 coat and allow a minimum of 15 mins prior to recommencing lay-up.

a) The surface should be cleaned with Chemlease® Mould Cleaner EZ, change cloths frequently and use liberal quantities of cleaner.

b) Take mould to 60°C (140°F) for 30 mins to ensure all moisture/solvent is removed.

c) Revert back to 9 d) for all release preparation/priming.

APPENDIX I

TYPICAL CUSTOMER JOB SHEET FOR A CARBON FIBRE REINFORCED LAMINATE OF TOTAL THICKNESS 5.30mm (0.2")

Part number:

Job number :

Issue date :

Procedure	Ply Number	Fibre Orientation	Pattern Direct^{n}	Operator(s)	Inspected	Date
Trim Strips PPI	-	+/- 45º	-			
Laminate PP1*	1	0^{o}	↗			
Debulk						
Laminate PP2	2	0^{o}	↗			
Laminate PP2	3	+45^{o}	↑			
Laminate PP2	4	-45^{o}	→			
Debulk						
Laminate PP2	5	90^{o}	↖			
	LAMINATE MID PLANE					
Laminate PP2	6	90º	↖			
Laminate PP2	7	-45^{o}	→			
Debulk						
Laminate PP2	8	+45^{o}	↑			
Laminate PP2	9	0^{o}	↗			
Laminate PP1	10	0^{o}	↗			
Final debulk						
Preparation for autoclave						
Autoclave cure						
Post cure						
Preparation and release prime						

* Abbreviations: PP1 = Carbon 200gsm 2/2 Twill / HX SERIES
PP2 = Carbon 650gsm 2/2 Twill / HX SERIES

APPENDIX II

TYPICAL LAMINATE CONSTRUCTIONS - FOR AUTOCLAVE CURED TOOLS

1. CARBON FIBRE LAMINATES

(a) 1 ply 200gsm 2/2 Twill)
8 plies 650gsm 2/2 Twill) Approx Thickness = 5.3mm **(0.2")**
1 ply 200gsm 2/2 Twill)

Typical Application:- Medium sized mouldings requiring high stability and low C.T.E. (Appendix I describes this laminate)

2. GLASS FIBRE LAMINATES

(a) 1 ply 300gsm 8-H Satin (yarn)) Approx Thickness = 5mm **(0.2")**
8 plies 860gsm 8-H Satin (yarn)) (Reverse fibre direction from centre
1 ply 300gsm 8-H Satin (yarn)) to achieve fully balanced laminate)

Typical Application:- High stability mouldings where C.T.E. is not a major concern.

(b) 1 ply 300gsm 8-H Satin (yarn)) Approx Thickness = 5mm **(0.2")**
8 plies 870gsm 2/2 Twill (roving)) (Reverse fibre direction from centre
1 ply 300gsm 8-H Satin (yarn)) to achieve fully balanced laminate)

Typical Application:- More economical version of 2(a)

Other laminate specifications may also be utilized. Please contact Amber Composites Technical Department for further information.