

TECHNICAL DATASHEET

Variable Cure Tooling Pre-impregnated Materials

CML's variable curing tooling pre-preg (*VCTP*) is a proven high performance material based upon a proprietary multi functional, modified epoxy resin formulation which when post cured offers high temperature performance in excess of 200°C.

The low initial cure temperature allows high quality composite tooling to be produced directly from a suitable pattern material such as CML 678 tooling board. After which the composite tool can then be post cured as a free standing item to its final service temperature in a subsequent post-cure cycle.

The flexibility, tack and handling characteristics of this pre-preg have been set so that optimum drapability is achieved allowing complex moulds to be easily produced

Additional Benefits:

- Out life 4-5 days at room temperature (20°C)
- Improved tool accuracy with low residual stress
- Pre-preg storage life greater than 6 months at -18°C
- Good retention of mechanical properties up to 210°C
- Long term service life (in excess of 320 autoclave cycles at 135°C without deterioration to the mould surface has been achieved).
- Low pre-preg volatile content <1%
- Uniform resin distribution through the reinforcement
- Processing by autoclave cure with a high quality surface finish achievable

Applications: Manufacture of composite tools, laminating fixtures, gauges, holding and drill fixtures with high contour accuracy.

Processing Methods: Autoclaving, Vacuum bag & Press moulding.

Instructions for Use:

Pre-preg should be removed from the freezer and allowed to reach room temperature prior to opening the sealed bag. The presence of moisture within the curing laminate may degrade the quality and aesthetic appearance of the structure produced. Consequently it is prudent to ensure that pre-preg of all types is thawed to the core of the roll before opening the sealed bag to avoid moisture contamination as a result of condensation. The typical thawing time for a 25Lm roll of pre-preg is 6 hours, therefore it maybe advantageous to order pre cut pieces or roll lengths dependant upon each particular application.

Manufacturing procedure for autoclave cured tool laminates:

These procedures have been designed to enable users to produce consistent, high quality composite tooling laminates. Minor deviations can have unexpected and undesirable effects on the final product. We recommend you consult CML's technical department before making any changes.

Pattern Preparation:

- The pattern should be soundly constructed so as to withstand the autoclave cycle. Solid patterns are preferred, however, hollow patterns may be used provided they are suitably sealed. A hollow pattern should never be envelope bagged.
- It is recommended that a suitable epoxy tooling board such as CML's 678 is used. If the pattern is constructed from urethane boards or an alternative pattern material then it must be sealed to prevent any possible reaction with the pre-preg.

- A suitable sealer such as CML's 2192 or 2197 should be used (please consult the technical datasheet)
- Thoroughly degrease the pattern ensuring it is complete dry and free from any contamination.
- Then release the pattern with a suitable release agent such as Marbocote® 220 or 227 following the manufacturer's procedure available from CML's technical department.

Lay up procedure:

- Materials should be cut prior to removal of the polythene interleave and layed-up in accordance with the laminate schedule in appendix 1. Cleanliness is important during the lay-up procedure. Avoid introducing any contaminants into the lay-up i.e. interleave or release film as these will adversely affect the tool laminate and may lead to premature tool failure. To avoid bridging, no single piece of pre-preg should ever be layed-up and around more than one corner.

Note: The tool must be layed-up and cured within the out life of the first ply of material.

- Ensure there is sufficient material available to complete the job allow 10-15% for scrap.
- Lay a series of 45° trim strips into all external corners and tight radii; ensure pattern runs in a consistent direction for aesthetics. Strips should be 40mm wide positioned evenly on centre of corner.
- Apply the 1st ply of material at 0°. (Please refer to appendix 1.) The pre-preg should be cut to fit into all external radii and corners taking care not to disturb the trim strips. Ensure that no bridging occurs and overlap joints are 4-6mm wide (1st ply only)
- After the 1st ply it is important to carry out a de-bulk cycle as detailed below use a P1 or P3 release film with a suitable breather.
- With the 2nd and subsequent plies butt jointing is preferred to overlapping. Care must be taken so that the butt joints of each ply are staggered and do not occur above one another. If overlapping is unavoidable ensure that the overlap is a maximum of 3mm wide and the overlaps are staggered.
- Finish the lay-up as per the appropriate schedule, de-bulking as called for. (Please refer to appendix 1)

De-bulk cycle:

- Cover the lay up with a suitable perforated release film such as vac-lease 20R P3, ensure no bridging.
- Lay a suitable breather over the release film. It is preferable not to use a polyester breather as the filaments left in the laminate may cause premature tool failure.
- Apply vacuum bag and pull a minimum 840-940mbar of vacuum and hold for a minimum of 30 minutes.
- Remove vacuum bag and breather materials and set to one side for future use.

Note: Overnight de-bulks are only permissible from the 2nd de-bulk onwards.

Once the lay up is completed, the final consumable pack can be fitted as follows:-

- Position one or more thermocouples between the first two plies of the tool lay up well beyond the planned tool end (approximately 75mm) and ideally situated near the thickest part of the pattern.
- Apply tows of glass fibre every 0.3 metre of laminate edge to reach beyond the release film and meet the breather cloth.

- Apply a layer of P8 perforated release film. If this is not available then pin prick non-perforated every 50-60mm approximately. This should overlap the edge of the lay up by at least 25mm. **Cut and tailor as necessary and completely avoid bridging.**
- Apply a non woven breather of suitable conformity. Use a single layer of 340gsm over the majority of the lay up and two layers locally around the vacuum ports or complex features. Cut and splice accordingly to avoid bridging.
- Insert at least 2 vacuum ports on breather pads do not place directly onto the laminate. Position them against the pattern or in tucks in the vacuum bag itself, ensuring they are connected to the breather pack. For laminates over 2m² surface area add 1 additional vacuum point for every additional 1m² of mould surface.
- Apply the vacuum bag to the lay-up using a high quality nylon bagging film such as vac-tite B ensuring plenty of slack is provided in all bagging material to avoid bridging.

This is a critical part of the whole procedure, as bridging vacuum bags and consumables are a common cause of poorly consolidated female corners on moulds, leading to potentially serious un repairable leakage problems.

- Check all vacuum lines, connections and one way connectors for leaks. The complete system must be leak free prior to testing, and capable of achieving a vacuum of 940mbar
- Test the vacuum to ensure a leak rate not greater than 65mbar per 10 minutes and preferably 0. If the tool is to be autoclaved repeat this test under autoclave pressure.

Recommended Cure procedure:

- With full vacuum applied (minimum of 880-940 mbar)
- Increase Autoclave temperature to 30°C at a heat up rate of 3°C/min
- Once the initial temperature is achieved, indicated by the leading thermocouple apply 4-8 bar autoclave pressure (6 bar is preferred). It may be necessary to pressurize in stages to avoid overheating.
- Once full pressure is achieved continue to heat at 3°C/min to the final cure temperature (60°C is preferred for optimum resin flow characteristics). Once the final cure temperature is achieved do not allow the autoclave temperature to exceed 15°C above this temperature as it is important to promote an even temperature through the laminate.
- When the lagging thermocouple on the lay up reads the same as the final cure temperature allow a dwell for a specified time as shown in the chart below.
- Allow to cool to 30°C before removing from the autoclave.

Cure Schedules:

Temperature °C	Dwell Time (hrs)
50	16
55	12
60	8
65	6
70	4
75	3

Release Procedure:

- Remove bagging materials.
- Attach support structures if desired
- Carefully release the tool around the periphery and ease off the pattern. Always use soft plastic wedges, never use metal chisels or scrapers.

Note: In its partially cured state, the tool laminate will be brittle. Do not attempt any trimming or finishing operations or use any solvents on the laminate surface until after postcure.

Postcure procedure:

Postcure of the tool laminate is critical to the long-term performance of the tool, do not try to rush or omit any operations.

- Place the tool in an oven with thermocouples attached. Support the tools so as to avoid deformation under its own weight. A backing structure may be required for this.

Post cure A (Recommended)

- Heat The tool to 80°C with a ramp rate of 1°C per minute and hold for 2 hours then
- Heat The tool to 120°C with a ramp rate of 1°C per minute and hold for 1 hours then
- Heat The tool to 150°C with a ramp rate of 1°C per minute and hold for 1 hours then
- Heat The tool to 180°C with a ramp rate of 1°C per minute and hold for 1 hours then
- Heat The tool to 200°C with a ramp rate of 1°C per minute and hold for 8 hours.

Post Cure B (Alternative single ramp)

- Heat the tool to 200°C with a ramp rate of 20°C per hour and hold for 15 minutes then
- Cool down to 190°C at 3°C per minute and hold for 8 hours.

In both instances allow the laminate to cool slowly to 50°C at 3°C per minute before removing the tool from the oven. Both cycles will develop the maximum glass transition temperature (T_g). Other post cures can be used for tools operating at lower service temperature however we recommend you discuss your requirements with CML technical department before implementing an alternative cycle.

Backing structures:

All composite tools require some form of support structure. This may take the form of an extended flange or a complex structure designed to prevent deflection under normal service conditions. One of the following three products may be considered.

- Tubular or box section structures
- Honeycomb Panels
- Integral Stiffeners

CML provides a range of suitable honeycomb panels that can be processed to form the support structure for the composite tool (please speak with your local technical engineer or our technical department).

Preparing the tool for production:

- It is essential to remove all contamination from the surface of the tool prior to applying release agent. A mould cleaner such as Marbocote[®] MC Cleaner is recommended as standard solvents will not remove wax.
- Apply a release agent such as Marbocote[®] 220 or 227 as per the manufacturer's technical datasheet to the mould surface.

Typical Mechanical Properties – Tooling Laminates:

Laminates were prepared using VCTP-C200-T-1250 at 0°/90° configuration after the recommended full post cure.

Flexural Strength (MPa)	22°C	935
	150°C	726
	200°C	565
Flexural Modulus (GPa)	22°C	47
	150°C	43
	200°C	33
Interlaminar Shear Strength (MPa)	22°C	33
	150°C	33
	200°C	26
Tg (°C)		207

Cured Laminate Physical Properties

VCTP – Cured Laminate Physical Properties		Units	Values
Laminate void content	Autoclave cure	%ov/v	<1
	Vacuum bag cure	%ov/v	<1
Shrinkage during manufacture	Carbon Tool	%	0.05*
	Glass Tool	%	0.12*
C.T.E. (Autoclave laminates) RT • 180°C	Carbon Tool	E x 10 ⁻⁶ /°C	2.0-4.0*
	Glass Tool	E x 10 ⁻⁶ /°C	10-12*
Glass Transition Temperature Tg (General)	Fully Postcured at 200°C	°C	205-210
	Initial cure 50°C	°C	67
	Initial cure 60°C	°C	78
	Initial cure 70°C	°C	88

* Shrinkage & CTE is dependant upon construction and processing. Information quoted is based upon CML standard 10ply lay up using C200 and C600 for carbon and G300 and G600 for glass laminate.

Availability:

Standard fabric reinforcements available with VCTP resin system are detailed below. All are supplied either as cut pieces or as 25Lm rolls.

Designation	Description	Dry Fabric Wgt(g/m ²)	Nominal Moulded Thickness (mm)	Fibre Type
C200-T2	2/2 Twill carbon fabric	200	0.20	High strength carbon fibre
C600-T2	2/2 Twill carbon fabric	600	0.60	High strength carbon fibre
C600-BI	+/- 45° carbon Non crimped fibre	600	0.55	High strength carbon fibre
G202-T2	2/2 Twill glass fabric	202	0.18	E Glass continuous filament
G280-T2	2/2 Twill glass fabric	280	0.24	E Glass continuous filament
G300-H	8 End satin glass fabric	300	0.25	E Glass continuous filament
G600-T2	2/2 Twill glass fabric	600	0.45	E Glass continuous filament

Alternative reinforcements are available upon request.

Storage & Outlife:

Moisture in pre-preg can have an adverse effect on the void content of the laminate. It is extremely important to fully defrost the material prior to use. CML's VCTP tooling pre-preg should be stored at -18°C in sealed polythene bags. On removal from cold storage always allow the material to reach room temperature before breaking the seal on the bags. This will take at least 6 hours for a full roll.

Storage at -18°C is greater than 6 months.

Appendix 1:

Customer:		Part:		Job No:		
Material:		Roll No:	Pack No:	Remaining Outlife:	Time	Date
Pattern Material:		Pattern Sealer:				
Release Agent:		No: of coats:				
Ply Number	Procedure	Direction of Weave	Fibre Orientation	Operator	Inspected	Date
0	Trim Strips P1	-	+/- 45°			
1	Laminate P1	•	0°			
De-bulk						
2	Laminate P2	•	0°			
3	Laminate P2	•	+45°			
De-bulk						
4	Laminate P2	•	-45°			
5	Laminate P2	•	90°			
De-bulk						
6	Laminate P2	•	90°			
7	Laminate P2	•	-45°			
De-bulk						
8	Laminate P2	•	+45°			
9	Laminate P2	•	0°			
De-bulk						
10	Laminate P1	•	0°			
Preparation for the autoclave						
Autoclave cure						
Date Started:	Ramp Rate:	°C/hr	Cure Temp	°C	Dwell Time	hrs
Pressure Bar	Vacuum	mBar				
Post cure						
Preparation and release prime						

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