CYFORM® 22
Tooling Prepreg

Description

Cyform® 22 Tooling Prepreg is a proven high performance and cost effective low temperature curing composite tooling system available with both carbon and glass reinforcement.

Cyform® 22 Tooling Prepreg allows high quality tooling laminates to be produced directly from a low temperature master model permitting a wide choice of master model materials. Using a low temperature vacuum bag / oven or autoclave process for the initial cure, the tool laminate can then be de-moulded and post cured "free-standing". Autoclave cured tools require no surface coat and are therefore always preferred over surface coat tools.

Cyform® 22 Tooling Prepregs are supplied in roll form. Standard roll sizes are 25 meters; widths vary depending on product from 1000 to 1067mm. Materials are shipped frozen.

Features and Benefits

* **Versatile Low Temperature Curing**: from 7 days at 20°C to 5 hours at 55°C.

* **Out Life**: 3-4 days at room temperature (20°C).

* **Work life**: 2-3 days at room temperature (20°C).

* **Storage Life**: > 6 months at -18°C.

* **Twill Fabrics**: All **Cyform® 22** prepregs are manufactured using balanced twill weave fabrics. This greatly simplifies the lay-up procedure and eliminates the need for mid plane ply inversion such as is necessary with satin weaves.

* **Uniform Resin Distribution**: All **Cyform® 22** prepregs are manufactured using a proprietary tower impregnation process, which ensures thorough impregnation of the fabrics with <1% volatile content. This means improved handleability and a more consistent and defect free surface finish.

* **Thermal Stability**: The **Cyform® 22** resin system was formulated to provide long term thermal oxidative stability during normal 175°C service.

* **Low Shrinkage**: Shrinkage of both carbon and glass systems is very low and predictable. Combined with the flexibility of cure schedules possible with **Cyform® 22**, a process can be tailored to produce net molded accuracy from a variety of master model materials.

* **Thermal Expansion Compatibility**: **Cyform® 22** Tooling Laminates closely match the thermal expansion of the composite parts. This reduces dimensional inaccuracies and residual stress levels inherent in the use of other tooling materials such as wet lay up, mass cast or metallic at a fraction of the cost of alloy tooling.

* **Long Tool Life**: In excess of 250 autoclave cycles at 175°C without deterioration of the system have been achieved.

* **Good Vacuum Bag Processed Laminates**: When used with a surface coat tool laminates of extremely low void content can be produced when autoclave facilities are not available. In some cases, tool laminates may be produced without a surface coat or autoclave process, consult **Cytec Engineered Materials Ltd.** for applications.

* **Good Health and Safety Characteristics**: **Cyform® 22** prepregs contain no MDA or VCHDs. The resin system has been extensively tested via toxicological screening and has been found to be safe to use. Unlike many low-temperature curing prepregs, **Cyform® 22** is not a significant cause of skin related complaints.

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Specification

Carbon Prepreg Properties

	CP 200	CP 650
Weave Style	2x2 Twill	2x2 Twill
Fabric Weight, gsm	199	650
Warp, ends/cm	4.92	3.92
Fill, ends/cm	4.92	3.94
Prepreg Weight, gsm	361	1053
Resin Weight, %	45	38
Volatile Content, %	<1	<1
Shelf Life @ -18°C, months	>6	>6
Out life @ RT, days	3-4	3-4
Work Life @ RT, days	2-3	2-3
Gel time @ 20°C, hours	108	108
Gel time @ 40°C, min	24	24
Cured Ply Thickness, Autoclave, mm	0.22	0.62

Carbon Tooling Laminate Properties

(CP200 Quasi-Isotropic lay-up)

Tg, °C		204
Shrinkage, %		0.031
CTE, $^{o}C^{-1}$		2.5×10^{-6}
Void Content - Autoclave, %		< 0.5
- Vacuum bag, %		< 2.0
Flexural Modulus,Gpa (Msi)		
after post-cure	- @ 20°C	46 (6.7)
	- @ 90°C	45 (6.5)
	- @ 175°C	38 (5.5)
after thermal cycling[1]	- @ 20°C	41 (6.0)
	- @ 175°C	35 (5.0)

Additional mechanical test data available on request.

[1] Testing performed after 250 thermal cycles as below:
i) Heat to 175°C at 2.0°C / minute. ii) Dwell at 175°C for 1 hour. iii) Cool to 20°C at 3.0°C / minute.

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Specification

Glass Prepreg Properties

	GPT 160	GPT 400	GPT 870
Weave Style	2x2 Twill	2x2 Twill	2x2 Twill
Fabric Weight, gsm	161	390	870
Fill, ends/cm	12.0	6.0	3.94
Prepreg Weight, gsm	267	619	1131
Resin Weight, %	43	37	30
Volatile Content, %	< 1	< 1	< 1
Shelf Life @ -18°C, months	> 6	> 6	> 6
Out Life @ RT, days	3-4	3-4	3-4
Work Life @ RT, days	2-3	2-3	2-3
Gel Time @ 20°C, hours	108	108	108
Gel Time @ 40°C, min	8	8	8
Cured Ply Thickness Autoclave,mm	0.13	0.35	0.60

Glass Tooling Laminate Properties

(GPT400 Quasi-Isotropic lay-up)

Tg, °C		204
Shrinkage, %		0.15
CTE, °C^{-}		14.5×10^{-6}
Void Content - Autoclave, %		< 0.5
- Vacuum bag, %		< 2.0
Flexural Modulus, Gpa (Msi)		
after post-cure	- @ 20°C	26.0 (3.7)
	- @ 90°C	23.0 (3.4)
	- @ 175°C	16.0 (2.4)
after thermal cycling[1]	- @ 20°C	26.0 (3.7)
	- @ 175°C	17.0 (2.5)

Additional mechanical test data available on request.

[1] Testing performed after 250 thermal cycles as below:
i) Heat to 175°C at 2.0°C / minute. ii) Dwell at 175°C for 1 hour. iii) Cool to20°C at 3.0°C/ minute.

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Manufacturing Procedures for Autoclave Cured Tool Laminates

General Instructions

These procedures have been designed to produce consistent, high quality tooling laminates. Minor deviations can have unexpected and undesirable effects on the final product. Please consult **Cytec Engineered Materials Ltd.,** before making any changes.

Master Model Preparation

Note: It is recommended that master models be cycled at temperature and pressure above that of the desired cure, before lay-up commences, as any leakage, softening, or outgassing during cure can degrade the performance of the finished tool.

- Either epoxy modeling boards or epoxy composite masters are preferred.
- If master models constructed from urethane or phenolic modeling boards must be used, they must be sealed to prevent reaction with the prepreg. A suitable sealer such as **CYFORM ® CHP102** should be used, **refer to Cytec Fiberite data sheet "CYFORM ® PU Master Model Moulding Technique" for details**.
- Thoroughly dry plaster masters if used (24-72 hours at 65^{o}C).
- Model should be soundly constructed so as to withstand the autoclave cycle. Solid models are preferred; however, hollow models may be used provided they are suitably sealed. A hollow model should never be envelope bagged.
- Seal surface of master with an epoxy surfacing resin such as **CYFORM ® CHP102** or other suitable sealer. Polyester and other acid catalyzed surface coatings are not recommended for use with **CYFORM ®** tooling prepregs. Some types of Polyurethane sealers can cause an adverse reaction with the resin system, producing an unacceptable finish. Epoxy resin sealers are recommended.
- Thoroughly degrease the master model surface. Ensure all solvent is removed; this may require elevated temperature, then release with a solvent based release sealer, i.e. Frekote® FMS or B15, and 3 coats of a suitable carnauba paste wax, following the manufacturer's instructions.
- Apply 6.0mm perimeter dam, using bag sealant tape, to define periphery of the tool edge.

Thawing Procedure

- Allow the prepreg rolls to warm to room temperature before opening the protective bag. Do not remove from freezer and leave out overnight. Generally it is sufficient to wait until condensation is no longer visible on the outside of the bag.

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Lay-up Procedure

Materials should be laid up in accordance with the laminate schedules below. Cleanliness is very important during the lay-up procedure. Avoid introducing any contaminants into the lay-up, i.e. paper, polythene 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 prepreg should ever be laid up around more than one corner.

Note: The tool must be laid up and cured within the out life of the first ply of prepreg.

- Ensure sufficient material is available to complete the job. Allow 10 - 15% for scrap.
- Apply first ply of prepreg oriented at 0^{o}. The initial choice of which direction will be "0" is up to the individual but once chosen, subsequent angles must be measured relative to this datum. Ensure that prepreg is spliced in corners and any female tight radii. Pay special attention to ensure that no bridging occurs and overlap joints are 3.0 to 6.0mm wide (1^{st} ply only).
- Apply second ply of prepreg oriented at 0^{o}. On this and subsequent plies butt jointing is preferable 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 3.0mm wide and the overlaps are staggered.
- Carry out debulk cycle as described below. If necessary this debulk may be carried out after the first ply on highly contoured tools to assist conformance to the master model surface; in this case use a P3 perforated release film. For optimum tool surface debulk after the second ply.
- Finish the lay-up per the appropriate schedule, debulking as called for.

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Debulk Cycle

- Cover the lay-up with a suitable (P) **punched hole** release film, e.g. PTFE or Halohydrocarbon, ensure no bridging.
- Lay light weight felt breather or 400 gsm 2x2 twill, 7781 or equivalent, dry glass fabric over the release film to act as a breather, ensure no bridging by cutting to fit complex areas. Do not use a non-woven polyester breather, as filaments left in the laminate may cause premature tool failure.
- Apply vacuum bag and pull a minimum of 25 inches Hg vacuum and hold for 15 - 30 minutes depending on shop temperature; Warm 15 minutes; Cool 30 minutes
- Remove vacuum bag and breather materials and set to one side for future use.

Note: Overnight debulks are only permissible from debulk No. 2 onwards.

Final Bagging Procedure

- Place two or more thermocouples into prepreg (between ply 1 and 2), ideally situated near the thickest part of the master model and in a trim area.
- If secondary bonding to the tool laminate is required, apply 1 ply of nylon peel ply to the lay-up, ensuring no bridging.
- Cover lay-up with solid release film and seal film around perimeter to master model with tape, pin prick the solid release film every 100-150mm across the surface of the tool. This is to form vacuum connections to the breather pack.
- Apply breather pack. Use a 280gsm non-woven polyester plus 50-75mm wide glass fabric tape, laid over the breather in a 500x500mm grid to provide a good air path over the entire tool; ensure materials do not bridge.
- Locate a minimum of two vacuum ports, on breather pads, for a laminate up to 2 square meters and another port for every additional 1 square meter (always use an even number of vacuum ports). Do not locate vacuum ports directly on top of the laminate; position them against the model or in 'tucks' in the vacuum bag ensuring they are connected to the breather pack.
- Vacuum bag the lay-up using a good quality nylon bagging film, ensuring no bridging in the bag.
- Check vacuum integrity. Pull a full vacuum (28" Hg) and disconnect vacuum source. If bag loses more than 2 inches of Hg in 15 minutes check and seal leaks.

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Recommended Cure Procedure

- Apply a minimum of 26 inches of Hg vacuum.
- Apply 60 -120 psi autoclave pressure (90+ psi preferred). Vacuum may be vented at 25 psi if desired.
- Heat lay-up at a rate of 1-2°C / minute. To promote even heat up, do not allow autoclave temperature to exceed 5°C above the cure temperature.
- When the lagging thermocouple on lay-up reads 45°C +3 -0 °C, hold for 10 hours minimum.
- Cool under pressure to 30°C at 3°C/ minute maximum.

Alternative Cure Schedules

TEMPERATURE	DWELL TIME
30°C	48 hours
35°C	25 hours
40°C	14 hours
45°C[1]	10 hours
50°C[1]	6 hours
55°C	5 hours

[1] Preferred cure cycle.

Release Procedure

- Remove bagging materials. Remove peel ply at this time only as necessary to allow backing structure attachment.
- Attach support structure if desired (see below).
- Carefully release the tool laminate around its entire periphery and ease off the master model. 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 until after post-cure.

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Post-cure Procedure

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

- Place the tool in an oven with thermocouples attached. Support the tool so as to avoid deformation under its own weight. The backing structure may be used for this.
- Heat tool at 1-2°C/ minute to 45°C

- Post-cure A (Preferred)

- Heat tool at 10°C/ hour to 200°C and hold for 5 hours.
- Cool tool to room temperature at 3°C/ minute.

or - Post-cure B

- Heat tool at 0.5 - 2°C/ minute to 60°C and hold for 2 hours.
- Heat tool at 0.5 - 2°C/ minute to 100°C and hold for 2 hours.
- Heat tool at 0.5 - 2°C/ minute to 140°C and hold for 2 hour.
- Heat tool at 0.5 - 2°C/ minute to 180°C and hold for 3 hours.
- Heat tool at 0.5 - 2°C/ minute to 200°C and hold for 5 hours.
- Cool tool to room temperature at 3°C/ minute.

For information regarding post-cures suitable for lower temperature service please contact **Cytec Engineered Materials Ltd.**

Backing Structures

All composite tools require some kind of support structure. This may take the form of an extended flange or a complex structure designed to prevent deflection under normal service conditions. These usually fall into one of three categories:

Eggcrate structures: This kind of structure is prefabricated from either solid or honeycomb cored composite panels and can be applied before de-moulding or after post-cure. Attachment is by wet lay up 'cleats', Silicone RTV adhesive or mechanical fasteners; the structure should be spaced 3mm away from the back face of the tool laminate.

Tubular Structures: This kind of structure is also prefabricated using composite tube sections and can be applied before de-moulding or after post-cure. Attachment is by wet lay up 'cleats' or mechanical fasteners. Additional pads are usually added to the back of the tool laminate to spread loads at the local attachment points.

Refer to **Cytec Engineered Materials Ltd.** data sheet "Tool Support Structures" for additional information on these types of structure.

Integral Stiffeners: This method can provide a very quick and cost effective support structure when used in conjunction with an inexpensive metal support trolley. In addition accuracy benefits can be obtained by effectively 'locking' the tool into shape on the model thereby reducing spring in / out during post-cure.

Refer to **Cytec Engineered Materials Ltd.** data sheet "Integral Tool Stiffening" for additional information on this type of structure.

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Putting the Tool into Service

Before application of any release agent, the tool surface must be cleaned to remove all traces of the wax release used during manufacture. A cleaner such as Frekote® PMC or a mild cutting/polishing compound is recommended (T-Cut etc.); wiping with a solvent will **not** remove wax.

Do not forget to apply a release agent before use. It is recommended on new tools, and after refurbishment of older tools, that 2 or 3 applications of a tool surface sealer such as Frekote® B15 be applied per manufacturer's instructions before the normal production release agent is applied. For best results cure the final coat of Frekote® B15 at the end use temperature of the tool.

Apply production release agent per manufacturer's instructions.

The tool is now ready for 175°C service.

Health and Safety

Refer to Material Safety Data Sheets and product labels.

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Suggested Tool Constructions

Carbon

CYFORM ® 22 - 7.0mm Laminate Schedule

Ply No.	Dir. (°)	Material Type
12	0	CP200/22
		DEBULK
11	0	CP650/22
10	45	CP650/22
9	45	CP650/22
		DEBULK
8	0	CP650/22
7	0	CP650/22
		Axis of Symmetry
6	0	CP650/22
5	0	CP650/22
		DEBULK
4	45	CP650/22
3	45	CP650/22
		DEBULK
2	0	CP650/22
1	0	CP200/22
		MODEL

CYFORM ® 22 - 5.0mm Laminate Schedule

Ply No.	Dir. (°)	Material Type
10	0	CP200/22
		DEBULK
9	0	CP650/22
8	45	CP650/22
7	45	CP650/22
6	0	CP650/22
		DEBULK
5	0	CP650/22
4	45	CP650/22
3	45	CP650/22
		DEBULK
2	0	CP650/22
1	0	CP200/22
		MODEL

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Suggested Tool Construction

Glass

CYFORM® 22 - 6.0mm Laminate Schedule

Ply No.	Dir. (°)		Material Type	
13	0		GPT160/22	
		DEBULK		
12	0		GPT400/22	
11	45		GPT400/22	
10	0		GPT870/22	
9	45		GPT870/22	
		DEBULK		
8	0		GPT870/22	
7	0		GPT870/22	**Axis of Symmetry**
6	0		GPT870/22	
		DEBULK		
5	45		GPT870/22	
4	0		GPT870/22	
3	45		GPT400/22	
		DEBULK		
2	0		GPT400/22	
1	0		GPT160/22	
		MODEL		

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