



# Fortified Tooling Prepreg 140

Technical Bulletin

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## Product Description

3M™ Fortified Tooling Prepreg 140 features a nano-silica loaded epoxy resin that can be cured under vacuum or autoclave pressure at 140°F (60°C) and freestanding post cured at 420°F (216°C) to attain a final onset Tg of 410°F (210°C). 3M™ Fortified Tooling Prepreg 140 is available on glass or carbon based reinforcements and is single side coated to allow for low void consolidation in or out of the autoclave. The utilization of high loading levels of nano-silica enables features that would be unobtainable from other systems.

## Product Features

Improved resistance to fracture, increased tool hardness, improved Z axis CTE, vastly decreased exothermic potential, improved spring back, improved interlaminar shear strength and increased thermal conductivity.

## Master Mold

If possible, choose a master mold that is vacuum integral and also capable of withstanding the required cure pressure. It is recommended to run a trial cure prior to lamination of the mold tool to ensure proper vacuum integrity and stability under the necessary cure pressures. 3M™ Fortified Tooling Prepregs can be molded against most materials.

Bake the master mold at a temperature equal to or preferably slightly higher than that at which the prepreg is to be initially cured to remove all traces of solvent, which may have been absorbed by the mold surface. Also, this will help remove moisture and help ensure that a pit-free mold surface is obtained. Removal of all contaminants and a thorough drying is critical to proper master preparation.

Choosing the correct sealer and release treatment is crucial to ensure a satisfactory result. 3M recommends conducting a trial on small piece of the master mold material if unknown materials are involved.

Thoroughly degrease the surface using an organic solvent such as Chemlease® Mold Cleaner EZ. Follow the manufacturer's recommendation for application. The mold is now ready for application of a mold sealer.

Apply 1 to 2 coats of Chemlease<sup>®</sup> MPP2180 Mold Prep and Primer making sure to buff between coats. Follow the manufacturer's recommendation for application. The master mold should then be heated to 140°F (60°C) for 1 hour to ensure the release solvents are driven off.

Apply a total of 3-5 coats of Chemlease<sup>®</sup> 41-90 EZ Semi-Permanent Release Agent. Follow the manufacturer's recommendation for application. Allow 15 minutes between coats to cure and 30 minutes for the final coat to cure at room temperature.

### **Storage and Handling**

3M<sup>™</sup> Fortified Tooling Prepreg 140 has a storage life of 6 month when stored at 0°F (-18°C) and an optimal handling life of 5 days when stored at 70°F (21°C). It is recommended to keep the prepreg in a frozen state for as long as possible due to the low temperature curing nature of the prepreg. To minimize moisture contamination it is imperative that all prepregs be fully defrosted before being removed from a poly bag and that all material returning to the frozen state be well evacuated and or desiccated before freezing. 3M<sup>™</sup> Fortified Tooling Prepregs may be prepared into a series appropriate sized squares which may then be stored and frozen in airtight flat packages.

### **Prepreg Layup for Flat Surfaces Carbon Prepreg**

3M<sup>™</sup> Fortified Tooling Prepreg 140 can be layed up in many different configurations. Where high strength and stiffness is critical, a 1:8:1 configuration is recommended. Alternatively, a 1:6:1 configuration can be used in certain applications due to the increased stiffness of 3M<sup>™</sup> Fortified Tooling Prepreg 140. It is recommended that some initial small-scale experimentation be conducted to determine if this alternative lay-up may be used in the particular application of interest

The prepreg should be plied in the following orientation for a 1:8:1 tool.

Ply #1 - 3M<sup>™</sup> Fortified Tooling Prepreg 140 / 3K 2x2 Twill [0°] - Dry side against the tool.

Plies #2-9 - 3M<sup>™</sup> Fortified Tooling Prepreg 140 / 12K 2x2 Twill [0°, +45°, -45°, 90°, 90°, -45°, +45°, 0°].

Ply #10 - 3M<sup>™</sup> Fortified Tooling Prepreg 140 / 3K 2x2 Twill [0°] - Dry side away from the tool.

The prepreg should be plied in the following orientation for a 1:6:1 tool.

Ply #1 - 3M<sup>™</sup> Fortified Tooling Prepreg 140 / 3K 2x2 Twill [0°] - Dry side against the tool.

Plies #2-7 - 3M<sup>™</sup> Fortified Tooling Prepreg 140 / 12K 2x2 Twill [0°, +45°, -45°, -45°, +45°, 0°].

Ply #8 - 3M<sup>™</sup> Fortified Tooling Prepreg 140 / 3K 2x2 Twill [0°] - Dry side away from the tool.

For flat panels no debulk is required and the bagging procedure/cure cycle can be initiated.

## **Prepreg Layup for Curved Surfaces Carbon Prepreg**

The prepreg should be plied in the following orientation for a 1:8:1 tool.

Ply #1 - 3M™ Fortified Tooling Prepreg 140 / 3K 2x2 Twill [0°] - Dry side against the tool.

Plies #2-7 - 3M™ Fortified Tooling Prepreg 140 / 12K 2x2 Twill [0°, +45°, -45°, 90°, 90°, -45°, +45°, 0°].

Ply #8 - 3M™ Fortified Tooling Prepreg 140 / 3K 2x2 Twill [0°] - Dry side away from the tool.

The prepreg should be plied in the following orientation for a 1:6:1 tool.

Ply #1 - 3M™ Fortified Tooling Prepreg 140 / 3K 2x2 Twill [0°] - Dry side against the tool.

Plies #2-9 - 3M™ Fortified Tooling Prepreg 140 / 12K 2x2 Twill [0°, +45°, -45°, -45°, +45°, 0°].

Ply #10 - 3M™ Fortified Tooling Prepreg 140 / 3K 2x2 Twill [0°] - Dry side away from the tool.

For curved surfaces a room temperature (RT) debulk is required. The number of debulks will be a function of the maximum degree of curvature. For simple curvatures (radius of curvatures over 6 inches) a RT debulk can be performed after plies 1 and 5. For more complex curvatures (radius of curvatures under 6 inches) a RT debulk can be performed after plies 1, 3 and 5. The RT debulk should reach at minimum 25 inches Hg for at least 15 minutes. The objective of the debulk is to conform the prepreg to the curvature of the structure without fully blocking air passages for final cure consolidation.

## **Final Bagging Procedure**

3M™ Fortified Tooling Prepreg 140 layups can be vacuum bag cured with standard release liners at a minimum of 28 inches Hg or corresponding press pressures. Each layup will be different depending on the finished structure's parameters. The key parameter of the processes is to maximize the exposure of dry prepreg fibers at the edge of the structure for each ply such that they are exposed to a direct vacuum path. This can be easily obtained from a combination of edge breather strings and nylon fabric window or nylon fabric surface plies that are restricted from fully infusing into the breather ply.

## **Autoclave Cure**

Exotherms associated with the 3M™ Fortified Tooling Prepreg 140 system are greatly reduced. Table 1 below show no exotherm occurred during the cure of thick 16 ply carbon fiber laminates containing 3M™ Fortified Tooling Prepreg 140 Resin over a temperature range of 63 to 125°C.

This feature of the 3M system is particularly important for toolmakers in situations where the exotherm associated with traditional tooling prepreps is used to drive curing of these tools. It is recommended for toolmakers who apply this approach conduct small scale trials with suitable temperature monitoring equipment to understand how the reduced exotherm influences processibility.

Temperature (°C)	Time (Hrs)	Laminate Temperature at mid-plane (°C)	Exotherm
63	10	62	No
75	2	73	No
95	2	84	No
125	2	123	No

**Table 1.** Exotherm of a 16 ply laminate; all zero direction. Environment: heated platen press

3M™ Fortified Tooling Prepreg 140 should be cured with a ramp rate of 100°F/hr (38°C/hr) to a dwell point of 140°F (60°C) for 3-8 hours. The part may then be removed from the bag for a free standing post cure ramping at 50°F/hr (10°C/hr) to 420°F (216°C) for a 2 hour dwell to achieve the maximum Tg of 410°F (210°C). If an onset Tg of 410°F (210°C) is not necessary, 3M™ Fortified Tooling Prepreg 140 can undergo a freestanding post cure that is 75°F (24°C) over the maximum temperature of the finished structure.

While applying full vacuum, simultaneously increase the autoclave pressure to 21 psi. Vent the bag to atmosphere. Raise the pressure to 95 psi.

### Alternative Autoclave Cure Cycles

	Dwell Temperature				
	113°F (45°C)	131°F (55°C)	145°F (63°C)	167°F (75°C)	185°F (85°C)
Minimum cure time (hrs)	24	12	3.5	2	1

**Table 2.** Autoclave Cure Cycles

### Out-of-Autoclave/Low Pressure cure

3M™ Fortified Tooling Prepreg 140 should be cured with a ramp rate of 100°F/hr (38°C/hr) to 140°F (60°C) for 8-10 hours. It is important to follow the recommended cure profile to ensure proper vacuum integrity and surface finish, while minimizing the risk of surface pitting and internal voids.

### Standard post cure cycle

3M™ Fortified Tooling Prepreg 140 should be post cured with a ramp rate of 50°F/hr (28°C/hr) to 420°F (216°C) for a 2 hour dwell and a maximum cool rate of 5.5°F/min (3°C/min).

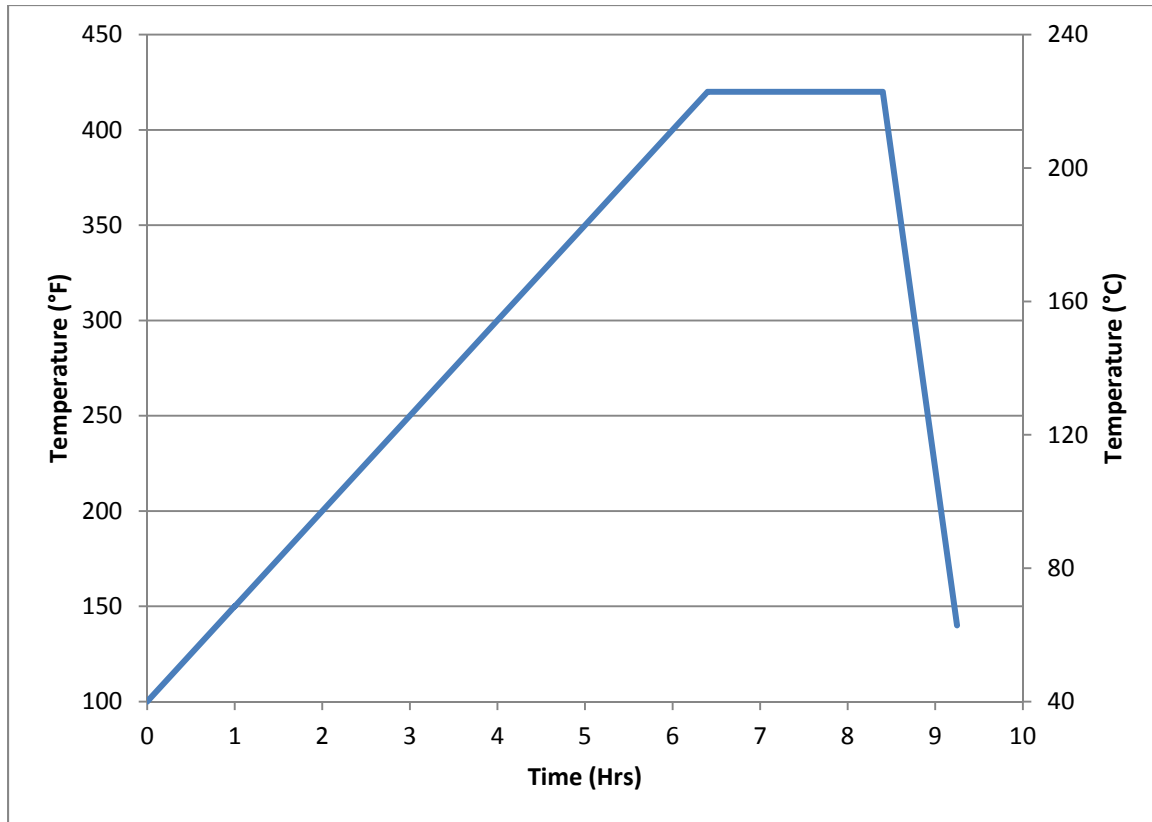


Figure 1. Standard post cure cycle

**Alternative Post Cure Cycles:**

Use the following table to determine other maximum post cure temperatures:

Maximum End-Use Temperature	Recommended Maximum Post Cure Temperature and Dwell Times
180°F (82°C)	205°F (96°C) for 3-8 hrs
240°F (116°C)	265°F (130°C) for 3-8 hrs
300°F (149°C)	325°F (163°C) for 3-8 hrs
340°F (171°C)	365°F (185°C) for 3-8 hrs
380°F (193°C)	405°F (207°C) for 3-8 hrs

Table 3. Alternative post cure cycles

**Support Structures:**

Support structures may be manufactured from solid laminate, honeycomb sandwich panels or composite tubes. If the support structure is to be attached to the tool, the support structure should be manufactured from the same type of fiber reinforcement as the tool and be cured using the same cure conditions used to cure the tool.

**Release Priming of New Composite Tool:**

Thoroughly degrease the surface using an organic solvent such as Chemlease<sup>®</sup> Mold Cleaner EZ. Follow the manufacturer's recommendation for application. The mold is now ready for application of a mold sealer.

Apply 1 to 2 coats of Chemlease<sup>®</sup> MPP2180 Mold Prep and Primer making sure to buff between coats. Follow the manufacturer's recommendation for application. The master mold should then be heated to 140°F (60°C) for 1 hour to ensure the release solvents are driven off.

Apply a total of 3-5 coats of Chemlease<sup>®</sup> 41-90 EZ Semi-Permanent Release Agent. Follow the manufacturer's recommendation for application. Allow 15 minutes between coats to cure and 30 minutes for the final coat to cure at room temperature.

**Processing Checklist for a 1:8:1 lay-up**

<b>Step</b>	<b>Ply Orientation</b>	<b>Date/ Time</b>	<b>Operator Initials</b>
Dry the master mold			
Check master mold for vacuum integrity			
Apply and bake cycle release agent			
Apply ply 1 - 3M™ Fortified Tooling Prepreg 140 3K 2 x 2 Twill – dry side against tool	0°		
Vacuum debulk (for all curvatures) At RT - minimum 25” Hg for 15 minutes			
Apply ply 2 - 3M™ Fortified Tooling Prepreg 140 12K 2 x 2 Twill	0°		
Apply ply 3 - 3M™ Fortified Tooling Prepreg 140 12K 2 x 2 Twill	+45°		
Vacuum debulk (for curvatures < 6’’) At RT - minimum 25” Hg for 15 minutes			
Apply ply 4 - 3M™ Fortified Tooling Prepreg 140 12K 2 x 2 Twill	-45°		
Apply ply 5 - 3M™ Fortified Tooling Prepreg 140 12K 2 x 2 Twill	90°		
Vacuum debulk (for all curvatures) At RT - minimum 25” Hg for 15 minutes			
Apply ply 6 - 3M™ Fortified Tooling Prepreg 140 12K 2 x 2 Twill	90°		
Apply ply 7 - 3M™ Fortified Tooling Prepreg 140 12K 2 x 2 Twill	-45°		
Apply ply 8 - 3M™ Fortified Tooling Prepreg 140 12K 2 x 2 Twill	+45°		
Apply ply 9 - 3M™ Fortified Tooling Prepreg 140 12K 2 x 2 Twill	0°		
Apply ply 10 - 3M™ Fortified Tooling Prepreg 140 3K 2 x 2 Twill – dry side away from tool master	0°		
Vacuum debulk (for all curvatures) At RT - minimum 28” Hg for 15 minutes			
Check for vacuum leaks			
Ramp to 140°F (60°C) with a ramp rate of 100°F/hr (38°C/hr). Dwell for 3-8 hours for an Autoclave cure and 8 hours for Out-of-Autoclave cure at 140°F (60°C)			
Remove from bag			
Post cure with a ramp rate of 50°F/hr (10°C/hr) to 420°F (216°C) for a 2 hour dwell			

**Table 4.** Processing checklist for a 1:8:1 lay-up

**Processing Checklist for a 1:6:1 lay-up**

<b>Step</b>	<b>Ply Orientation</b>	<b>Date/Time</b>	<b>Operator Initials</b>
Dry the master mold			
Check master mold for vacuum integrity			
Apply and bake cycle release agent			
Apply ply 1 - 3M™ Fortified Tooling Prepreg 140 <b>3K</b> 2 x 2 Twill – dry side against tool	0°		
Vacuum debulk (for all curvatures) At RT - minimum 25” Hg for 15 minutes			
Apply ply 2 - 3M™ Fortified Tooling Prepreg 140 <b>12K</b> 2 x 2 Twill	0°		
Vacuum debulk (for curvatures < 6’’) At RT - minimum 25” Hg for 15 minutes			
Apply ply 3 - 3M™ Fortified Tooling Prepreg 140 <b>12K</b> 2 x 2 Twill	+45°		
Apply ply 4 - 3M™ Fortified Tooling Prepreg 140 <b>12K</b> 2 x 2 Twill	-45°		
Vacuum debulk (for all curvatures) At RT - minimum 25” Hg for 15 minutes			
Apply ply 5 - 3M™ Fortified Tooling Prepreg 140 <b>12K</b> 2 x 2 Twill	-45°		
Apply ply 6 - 3M™ Fortified Tooling Prepreg 140 <b>12K</b> 2 x 2 Twill	+45°		
Apply ply 7 - 3M™ Fortified Tooling Prepreg 140 <b>12K</b> 2 x 2 Twill	0°		
Apply ply 8 - 3M™ Fortified Tooling Prepreg 140 <b>3K</b> 2 x 2 Twill – dry side away from tool master	0°		
Vacuum debulk (for all curvatures) At RT - minimum 28” Hg for 15 minutes			
Check for vacuum leaks			
Ramp to 140°F (60°C) with a ramp rate of 100°F/hr (38°C/hr). Dwell for 3-8 hours for an Autoclave cure and 8 hours for Out-of-Autoclave cure at 140°F (60°C)			
Remove from bag			
Post cure with a ramp rate of 50°F/hr (10°C/hr) to 420°F (216°C) for a 2 hour dwell			

**Table 5.** Processing checklist for a 1:6:1 lay-up



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