CYFORM® 777 EPOXY TOOLING PREPREG

TECHNICAL DATA SHEET

DESCRIPTION

CYFORM 777 is a proven, high-performance and cost-effective, low-temperature-curing epoxy tooling system available with either carbon or glass reinforcement.

CYFORM 777 allows high-quality tooling laminates to be produced directly from a low-temperature master model. After vacuum bag/oven or autoclave processing for the initial cure, the tool laminate can be de-molded and post-cured “free-standing”.

CYFORM 777 is supplied in roll form with a standard roll length of 25 yards (25 meters). Standard material width is 50 inches (1000 – 1270mm). Materials are shipped frozen and in insulated boxes.

FEATURES & BENEFITS

- Provides versatile low temperature curing options from 48 hours at 122°F (50°C) to 3 hours at 194°F (90°C)
- Manufactured to ensure uniform resin distribution in fabrics with <1% volatile content
- Formulated for long term thermal oxidative stability during normal 350°F (177°C) service
- Exhibits low and predictable shrinkage with both carbon and glass fiber reinforcement
- Closely matches the thermal expansion coefficient of composite parts reducing dimensional inaccuracies and residual stress levels
- When used with a surface gel-coat, produces tools of extremely low void content via vacuum-bag-only processing if autoclave facilities are not available
- Determined safe to use via extensive toxicological screening (contains no MDA or VCHDs)

SUGGESTED APPLICATIONS

- Tools used for manufacture of composite components where a balance of working time and low temperature cure capability is required

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CHARACTERISTICS & PROPERTIES

Table 1 | Carbon Prepreg Characteristics

Property	CP 200[1]	CP 220[2]	CP 650
Weave Style	2x2 Twill	2x2 Twill	2x2 Twill
Fabric Weight, gsm	200	220	650
Warp, ends/in (ends/cm)	12.5 (4.92)	14.0 (5.5)	10.0 (3.94)
Fill, ends/in (ends/cm)	12.5 (4.92)	14.0 (5.5)	10.0 (3.94)
Prepreg Weight, gsm	364	400	1048
Resin Weight, %	45	45	38
Volatile Content, %	<1	<1	<1
Shelf Life at 0°F (-18°C), months	>12	>12	>12
Tack Life at 68°F (20°C), days	>10	>10	>10
Work Life at 68°F (20°C), days	12 – 15	12 – 15	12 – 15
Gel Time at 140°F (60°C), hours	12	12	12
Gel Time at 212°F (100°C), minutes	24	24	24
Cured Ply Thickness, autoclave, in (mm)	0.009 (0.23)	0.0095 (0.24)	0.026 (0.66)

[1] Primarily supplied by Cytec Engineered Materials US facilities

[2] Primarily supplied by Cytec Engineered Materials European facilities

Table 2 | Carbon Tooling Laminate Properties

Property			Value
Tg, °F (°C) *			385 (196)
Shrinkage, %			0.031
CTE, $°F^{-1}$ ($°C^{-1}$)			$1.4x10^{-6}$ ($2.5x\ 10^{-6}$)
Void Content: Autoclave, %			< 0.5
Void Content: Vacuum Bag, %			< 2.0
CP200 Quasi-isotropic Lay-up			
Flexural Modulus, Msi (GPa)	**After post-cure**	**at 68°F (20°C)**	6.7 (46)
		at 195°F (90°C)	6.5 (45)
		at 350°F (177°C)	5.5 (38)
	After thermal cycling[3]	**at 68°F (20°C)**	6.0 (41)
		at 350°F (177°C)	5.0 (35)

[3] Testing performed after 1500 thermal cycles as below
i) Heat to 350°F (177°C) at 3.6°F/minute (2.0°C/minute). ii) Dwell at 350°F (177°C) for 1 hour. iii) Cool to 68°F (20°C) at 5.4°F/minute (3.0°C/minute).

***** **NOTE:** Tg data is not applicable for U.S. export control classification or licensing. For export-related information please contact us.

Table 3 | Glass Prepreg Characteristics

Property	GPT 160	GPT 400	GPT 870
Weave Style	2x2 Twill	2x2 Twill	2x2 Twill
Fabric Weight, gsm	160	400	870
Warp, ends/in (ends/cm)	12.0 (4.72)	6.0 (2.36)	10.0 (3.94)
Fill, ends/in (ends/cm)	11.5 (4.53)	6.7 (2.64)	9.5 (3.74)
Prepreg Weight, gsm	281	635	1243
Resin Weight, %	43	37	30
Volatile Content, %	<1	<1	<1
Shelf Life at 0°F (-18°C), months	>12	>12	>12
Tack Life at 68°F (20°C), days	>10	>10	>10
Work Life at 68°F (20°C), days	12 – 15	12 – 15	12 – 15
Gel Time at 140°F (60°C), hours	12	12	12
Gel Time at 212°F (100°C), minutes	24	24	24
Cured Ply Thickness, autoclave, in (mm)	0.006 (0.16)	0.013 (0.33)	0.025 (0.64)

Table 4 | Glass Tooling Laminate Properties

Property			Value
Tg, °F (°C) *			385 (196)
Shrinkage, %			0.15
CTE, $°F^{-1}$ ($°C^{-1}$)			8.1×10^{-6} (14.6×10^{-6})
Void Content: Autoclave, %			< 0.5
Void Content: Vacuum Bag, %			< 2.0
GPT Quasi-isotropic Lay-up			
Flexural Modulus, Msi (GPa)	**After post-cure**	**at 68°F (20°C)**	3.7 (26)
		at 195°F (90°C)	3.4 (23)
		at 350°F (177°C)	2.4 (16)
	After thermal cycling[1]	**at 68°F (20°C)**	3.7 (26)
		at 350°F (177°C)	2.5 (17)

[1] Testing performed after 1500 thermal cycles as below
i) Heat to 350°F (177°C) at 3.6°F/minute (2.0°C/minute). ii) Dwell at 350°F (177°C) for 1 hour. iii) Cool to 68°F (20°C) at 5.4°F/minute (3.0°C/minute).

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MANUFACTURING PROCEDURES FOR AUTOCLAVE CURED LAMINATES

These procedures are 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 before deviating from these procedures.

Master Model Construction

- A master model constructed of epoxy modelling boards or epoxy composite is recommended
- If master models constructed from urethane or phenolic modelling boards must be used, a surface gel coat should be used as a suitable barrier material
- The master model should be soundly constructed to withstand the autoclave cycle. Solid models are preferred, but hollow models may be used if they are suitably sealed. Hollow models should never be enveloped bagged
- The master model should be cycled at temperature and pressure above that of the desired cure cycle before beginning lay-up of the tool. Any leaking, softening or out gassing of the master model during tool cure can degrade the performance of the finished product

Master Model Preparation Procedure

The following steps should be completed to prepare the surface of the master model for tool lay-up:

1. Seal the surface of master model with an epoxy surfacing resin such as CYFORM® CHP102

   NOTE: 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.
2. Thoroughly degrease the master model surface ensuring all solvent is removed

   Thorough degreasing may require use of elevated temperature.
3. Apply a semi-permanent, solvent-based release sealer such as Frekote® B-15 or Frekote® 700 NC to the master model surface following the manufacturer's instructions
4. Apply multiple coats of a suitable carnauba paste wax to the master model surface following the manufacturer's instructions
5. Apply 1/4 inch (6.0mm) perimeter dam of bag sealant tape to the master model surface to define the edge of the tool

Prepreg Thawing Procedure

- Allow the prepreg rolls to warm to room temperature before opening the protective bag

  Prepreg rolls are considered sufficiently warm when condensation is no longer visible on the outside of the bag.
- Do not remove the prepreg rolls from the freezer and leave them out overnight
- Ensure sufficient material is available to complete the job allowing for 10 – 15% scrap

General Lay-up Instructions

- Materials should be laid up in accordance with the laminate schedules in Figure 1 and Figure 2
- Cleanliness is very important during the lay-up procedure. Avoid introducing any contaminates 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
- To avoid wrinkling, ensure that prepreg is spliced in corners and any female tight radii
- Overlap joints of 1/8 inch to 1/4 inch wide (3.0mm to 6.0mm) are recommended on the first ply only. Butt jointing is preferable on subsequent plies but care must be taken so that the joints on each ply are staggered (do not occur above one another). If overlapping is unavoidable on subsequent plies ensure the overlap is a maximum of 1/8 inch (3.0mm) wide and that overlaps are staggered

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

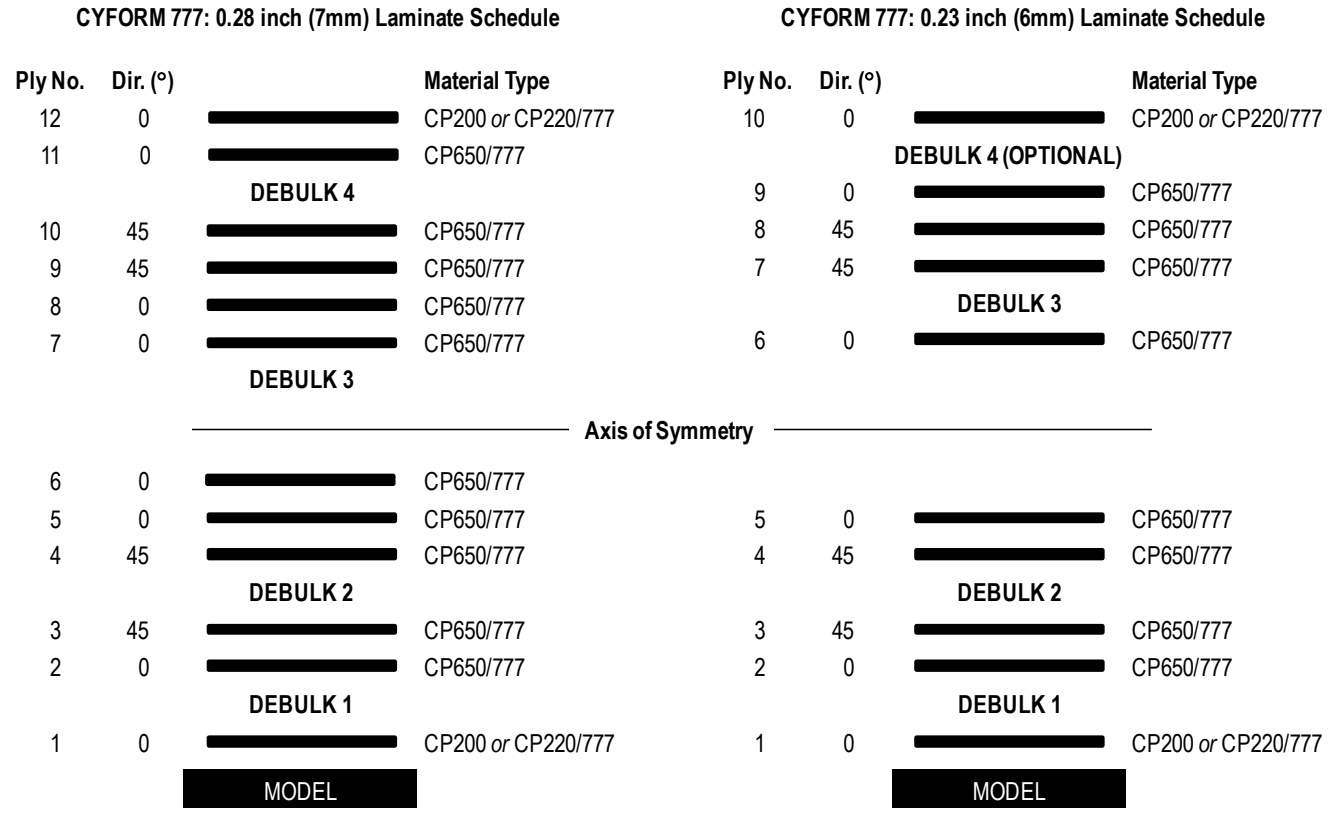

Figure 1 | Suggested Carbon Laminate Schedules

CYFORM 777: 0.24 inch (6mm) Laminate Schedule

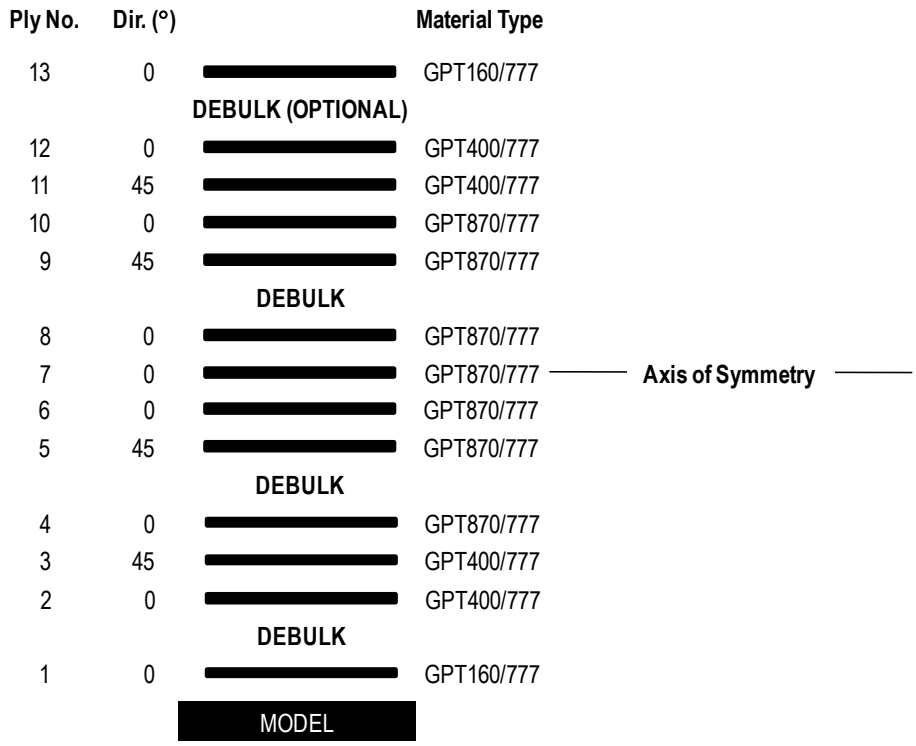

Figure 2 | Suggested Glass Laminate Schedule

Tool Lay-up Procedure

1. Lay the first ply of prepreg on the master model surface oriented at 0°

   The initial choice of which direction will be 0° is arbitrary, but, once chosen, subsequent angles must be measured relative to this direction.

2. Debulk the lay-up per the following steps:
   a. Cover the lay-up with a suitable (P3) pin pricked release film (e.g. FEP) ensuring no bridging
   b. Lay 7781, 7500 or equivalent glass fabric over the release film to act as a breather

      Ensure no bridging of the glass fabric by cutting the fabric to fit complex areas.

      Do not use a non-woven polyester breather unless a peel ply is first applied over the release film. Filaments from the polyester breather left in the laminate may cause premature tool failure.
   c. Apply a vacuum bag, pull a minimum of 25 inches Hg vacuum and hold as indicated in Table 5

Table 5 | Debulk Cycle Hold Times

Ply	Debulk Hold Time
First	60 minutes
Second through final	30 minutes

   d. Remove vacuum bag and breather materials and set to one side for future use

3. Lay the second and third plies of prepreg oriented at 0° and ±45°, respectively
4. Continue lay-up of plies per the appropriate schedule, debulking when called for as described in Step 2

Final Bagging Procedure

Bag the completed tooling laminate according to the following steps. Refer to Figure 3 for details.

1. Place two or more thermocouples into the prepreg between ply 1 and ply 2, ideally situated near the thickest part of the master model and in a trim area
2. If secondary bonding to the tool laminate is required, apply 1 ply of nylon peel ply to the lay-up, ensuring no bridging
3. Cover the lay-up with a solid release film and seal the film perimeter to the master model with sealant tape
4. Pin prick the solid release film every 4 to 6 inches (75 to 100mm) across the surface of the tool.

   The pin pricks allow vacuum connection between the laminate and breather pack.
5. Apply the breather pack according to the following steps:
   a. Cover the lay-up with a 10 ounce (280gsm) non-woven polyester fabric ensuring no bridging
   b. Lay 2 – 3 inch (50 – 75mm) wide glass fabric tape in a 2 ft x 2 ft (500mm x 500mm) grid over the polyester fabric to provide a good air path over the entire tool
6. Locate a minimum of two vacuum ports, on breather pads, for a laminate up to 20 square feet (2 square meters) and another port for each additional 10 square feet (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 master model or in tucks in the vacuum bag ensuring they are connected to the breather pack.
7. Cover the lay-up with a good-quality nylon bagging film, ensuring no bridging in the bag
8. Check the vacuum integrity by pulling a full vacuum (28” Hg) then disconnecting the vacuum source

   If the bag loses more than 2 inches of Hg in 15 minutes check and seal leaks.

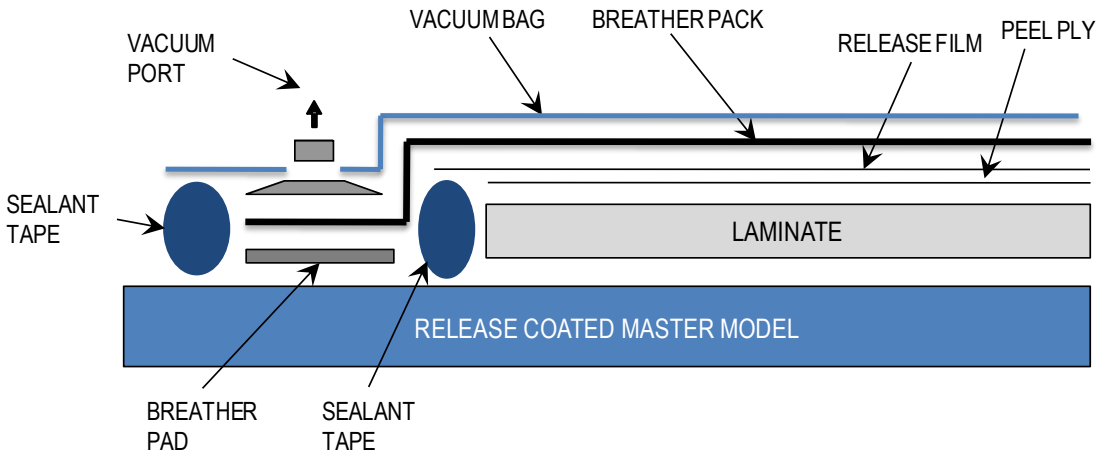

Figure 3 | CYFORM 777 Bagging Scheme

Recommended Cure Procedure

1. Apply a minimum of 26 inches of Hg vacuum
2. Apply 60 – 120 psi (4 – 7 bar) autoclave pressure [90+ psi (6+ bar) preferred]

   Vacuum may be vented at 25 psi (1 bar) if desired.
3. Heat the laminate at a rate of 1 – 3°F/minute (0.5 – 1.0°C/minute) until the lagging thermocouple reaches a cure temperature of 140 ± 2 °F (60 +3/-0°C)

   To promote even heat up do not allow autoclave temperature to exceed 10°F (5°C) above the cure temperature.
4. Hold the laminate at 140 ± 2 °F (60 +3/-0°C) for a dwell time of 14 hours minimum
5. Cool the laminate under pressure to 85°F (30°C) at 5°F/minute (3.0°C/minute) maximum rate

Alternative Cure Schedule

Alternatively, the laminate can be cured by following Steps 1 – 5 but using the cure temperatures and dwell times indicated in Table 6. For cure temperatures below 140°F (60°C) a modified post-cure is required. Please consult Cytec Engineered Materials for details.

Table 6 | Alternative Cure Schedules

Cure Temperature	Dwell Time
122°F (50°C)	48 hours
140°F (60°C)[1]	14 hours
158°F (70°C)	8 hours
176°F (80°C)	4 hours
194°F (90°C)	3 hours

[1] Preferred cure cycle

Release Procedure

1. Remove the bagging materials from the laminate

   Remove peel ply at this time only as necessary to allow backing structure attachment.
2. Attach support structure if desired

   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.

   - Egg crate structures: This kind of structure is prefabricated from either solid or honeycomb cored composite panels and can be applied before demolding or after post-cure. Attachment is by wet lay-up “cleats”, silicone RTV adhesive or mechanical fasteners. The structure should be spaced 1/8 inch (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-molding 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.
- 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.

3. Carefully release the laminate around its entire periphery and ease it 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.

Post-cure Procedure

Post-cure the laminate following the steps for either Post-cure A (preferred) or Post-cure B listed below. Refer to Figure 4 for details.

Post-cure A

1. Heat tool at 2 – 4°F/minute (1 – 2°C/minute) to 140°F (60°C)
2. Heat tool at 20°F/hour (10°C/hour) to 390°F (200°C) and hold for 5 hours
3. Cool tool to room temperature at 5°F/minute (3°C/minute)

Post-cure B

1. Heat tool at 2 – 4°F/minute (1 – 2°C/minute) to 140°F (60°C) and hold for 2 hours
2. Heat tool at 2 – 4°F/minute (1 – 2°C/minute) to 210°F (100°C) and hold for 2 hours
3. Heat tool at 2 – 4°F/minute (1 – 2°C/minute) to 285°F (140°C) and hold for 2 hours
4. Heat tool at 2 – 4°F/minute (1 – 2°C/minute) to 360°F (180°C) and hold for 2 hours
5. Heat tool at 2 – 4°F/minute (1 – 2°C/minute) to 390°F (200°C) and hold for 5 hours
6. Cool tool to room temperature at 5°F/minute (3°C/minute)

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

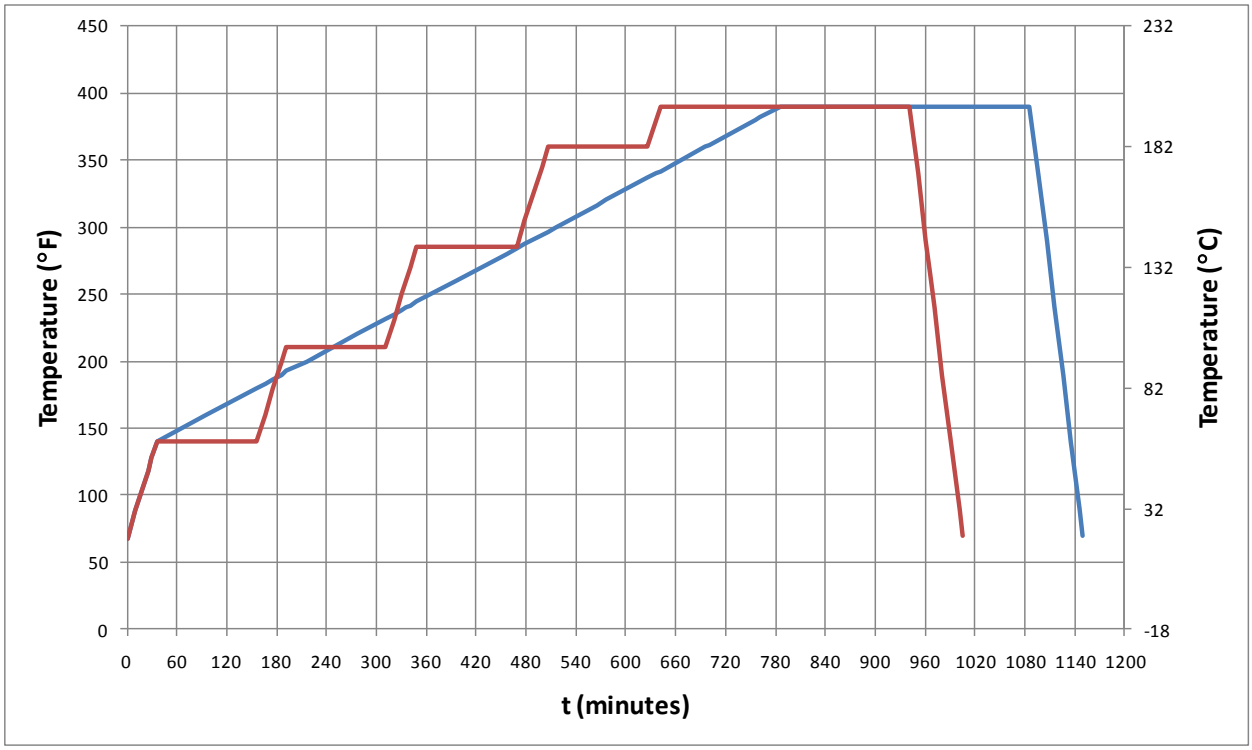

Figure 4 | CYFORM 777 Post-cure Profiles

Putting the Tool into Service

1. Clean the tool surface to remove all traces of the release used during manufacturing

   A cleaner such as a mild cutting/polishing compound is recommended (e.g., Frekote® PMC). Wiping with solvent will not remove wax.
2. For new tools and after refurbishment of older tools, apply 2 or 3 coats of a tool surface sealer such as Frekote® B-15 per manufacturer's instructions

   For best results cure the final coat of tool surface sealer at the end use temperature of the tool.
3. Apply a production release agent per manufacturer's instructions

The tool is now ready for 350°F (177°C) service.

PRODUCT HANDLING AND SAFETY

Cytec Engineered Materials recommends wearing clean, impervious gloves when working with prepreg materials to reduce skin contact and to avoid contamination of the product.

Materials Safety Data Sheets (MSDS) and product labels are available upon request and can be obtained from any Cytec Engineered Materials Office.

DISPOSAL OF SCRAP MATERIAL

Disposal of scrap material should be in accordance with local, state, and federal regulations.

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