DURATOOL DT450®

DURATOOL 450 is a proven, high-performance bismaleimide (BMI) resin/carbon fiber tooling system that is capable of continuous service at 190°C (375°F) and short cycle service at 204°C (400°F).

DURATOOL 450 allows high-quality tooling laminates to be produced directly from a high-temperature master models or a variety of intermediate materials. After autoclave processing for the initial cure, the tool laminate can be de-molded and post-cured **"**free-standing**"**.

DURATOOL 450 is supplied in roll form with a standard roll length of 50 meters (50yards). Standard material width is 1250mm (50inches). Materials are shipped frozen and in insulated boxes.

Features and Benefits

- 28 days tack life at 20°C (68°F)
- 45 days work life at 20°C (68°F)
- >24 months storage at -18°C (0°F)
- Contains no MDA or VCHDs
- Excellent tack and drape
- Excellent ambient temperature tack stability
- Initial cure temperature 175°C (350°F)
- Free-standing post-cure
- Maximum DMA E′ onset Tg of 257°C (495°F) after post-cure to 240°C (464°F) *
- Higher DMA E′ onset Tg attainable with alternate Postcures **
- Long Thermal Oxidative stability during 190°C (375°F) service

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

**Contact Solvay Industrial Materials Technical Staff for additional information for postcures >240°C (464°F)

SUGGESTED APPLICATIONS

Ideal for multiple-tool/high-production-rate manufacture of composite components

RELATED DOCUMENTS

- Procedure for inclusion of Inserts and other related features in Composite Mold Tools (TDS1004)

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CHARACTERISTICS & PROPERTIES

Table 1 | Carbon Prepreg Characteristics

Property	CP 200	CP 365	CP 3801
Weave Style	2x2 Twill	2x2 Twill	2x2 Twill
Fabric Weight, gsm	200	365	380
Warp, ends/cm (ends/in)	4.92 (12.5)	4.61 (11.7)	4.73 (12.0)
Fill (Weft), ends/cm (ends/in)	4.92 (12.5)	4.61 (11.7)	4.73 (12.0)
Prepreg Weight, gsm	345	562	593
Resin Weight, %	42	36	36
Volatile Content, %	<1	<1	<1
Gel Time at 177°C (350°F), minutes	10	10	10
Cured Ply Thickness, autoclave, mm (in)	0.23 (0.009)	0.36 (0.014)	0.38 (0.015)

1 Primarily supplied by Solvay Industrial Materials European facilities

Table 2 | Carbon Tooling Laminate Properties

Property	Value
Maximum attainable Tg (after full post-cure), °C (°F) *	296 (565)
Shrinkage, %	0.030
CTE, °C-1 (°F-1)	2.5x10-6 (1.4x10-6)
Void Content: Autoclave, %	< 0.5

* NOTE: Tg data is not applicable for U.S. export control classification or licensing.

For export-related information please Solvay Industrial Materials

** NOTE: Contact Solvay Industrial Materials Technical Staff for additional information for postcures >240°C (464°F)

STORAGE

Table 3 | Shelf life, Work life and Storage

Shelf life* at 20°C (68°F)	28 days
Work life** at 20°C (68°F)	45 days
Storage at -18°C (0°F)	24 months from date of manufacture

*Out life refers to accumulated time out of the freezer before the part is cured.

** Tack Life denotes maximum recommended point at which Autoclave cure should be commenced.

NOTE: The actual freezer storage life and out life are dependent on a number of factors, including; fibre type, format and application. For certain formats, it may be possible for the storage life and out life to be longer than stated. Please contact our technical support staff for advice.

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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 Solvay Industrial Materials before deviating from these procedures.

MASTER MODEL/INTERMEDIATE CONSTRUCTION

- A master model/intermediate constructed of monolithic graphite, epoxy composite or Invar® is recommended
- The master model/intermediate 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/intermediate should be cycled at temperature and pressure above that of the DURATOOL 450 cure cycle before beginning lay-up of the tool. Any leaking, softening or out gassing of the master model/intermediate during tool cure can degrade the performance of the finished product

MASTER MODEL/INTERMEDIATE PREPARATION PROCEDURE

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

1. Seal the surface of master model/intermediate with a high-temperature surfacing resin as required to eliminate any porosity
2. Thoroughly degrease the master model/intermediate 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 to the master model/intermediate surface
4. Apply multiple coats of a high-temperature release agent such as Frekote® 700 NC to the master model/intermediate surface following the manufacturer's instructions
5. Apply 6.0mm (1/4 inch) perimeter dam of silicone rubber/self-adhesive wax or similar to the master model/intermediate 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

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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, the use of 45degree strips detailed in Solvay Technical Datasheet TDS1004 is generally recommended.
- Overlap joints of 3.0mm to 6.0mm (1/8 inch to 1/4 inch) wide 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 3.0mm (1/8inch) 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.

TOOL LAY-UP PROCEDURE

1. Lay the first ply of prepreg on the master model/intermediate 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 release film (See Table 5) 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 or nylon breather unless a peel ply is first applied over the release film. Filaments from the polyester breather left in the laminate may cause adverse effects to the tool
   c. Apply a vacuum bag, pull a minimum of 25 inches Hg vacuum and hold as indicated in table 4

Table 4| 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 ply of prepreg oriented per the appropriate laminate schedule
4. Continue lay-up of plies per the appropriate schedule, debulking when called for as described in Step 2

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DURATOOL 450 10MM (0.40INCH) TOOL LAMINATE

Ply No.	Dir. (°)		Material Type
26	45		6K 365/380 2X2T
25	0		6K 365/380 2X2T
		DEBULK	
24	45		6K 365/380 2X2T
23	0		6K 365/380 2X2T
22	45		6K 365/380 2X2T
21	0		6K 365/380 2X2T
20	45		6K 365/380 2X2T
		DEBULK	
19	0		6K 365/380 2X2T
18	45		6K 365/380 2X2T
17	0		6K 365/380 2X2T
16	45		6K 365/380 2X2T
15	0		6K 365/380 2X2T
		DEBULK	
14	45		6K 365/380 2X2T
13	0		6K 365/380 2X2T
12	45		6K 365/380 2X2T
11	0		6K 365/380 2X2T
10	45		6K 365/380 2X2T
9	0		6K 365/380 2X2T
8	45		6K 365/380 2X2T
7	0		6K 365/380 2X2T
		DEBULK	
6	45		6K 365/380 2X2T
5	0		6K 365/380 2X2T
4	45		6K 365/380 2X2T
3	0		6K 365/380 2X2T
2	45		6K 365/380 2X2T
		DEBULK	
1	0		6K 365/380 2X2T
		MODEL	

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Figure 1 | Suggested 10mm (0.40 inch) Laminate Schedule for Tools with Machined Surface

DURATOOL 450 6.4MM (0.25 INCH) TOOL LAMINATE

Ply No.	Dir. (°)		Material Type
		DEBULK	
18	0		3K 200 2X2T
17	0		6K 365 2X2T
16	45		6K 365 2X2T
15	45		6K 365 2X2T
		DEBULK	
14	0		6K 365 2X2T
13	0		6K 365 2X2T
12	45		6K 365 2X2T
11	45		6K 365 2X2T
		DEBULK	
10	0		6K 365 2X2T
9	0		6K 365 2X2T
8	45		6K 365 2X2T
7	45		6K 365 2X2T
		DEBULK	
6	0		6K 365 2X2T
5	0		6K 365 2X2T
4	45		6K 365 2X2T
3	45		6K 365 2X2T
2	0		6K 365 2X2T
		DEBULK	
1	0		3K 200 2X2T
		MODEL	

Figure 2 | Suggested 6.4mm (0.25″) Laminate Schedule

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FINAL BAGGING PROCEDURE

Bag the completed tooling laminate according to the following steps. Refer to Figure 3 and Figure 4 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. Remove the perimeter dam from around the tool laminate

   Ensure the edge of the laminate is neatly trimmed to allow for breathing.
3. Create **"**breather dam**"** sections by wrapping EB520 75mm (3in) wide fiberglass boat cloth (See Table 5) around strips of bag sealing compound, leaving 50 – 60% of one side of the sealant exposed (Refer to Figure 3, steps a, b and c)
4. Place the **"**breather dam**"** in contact with the edge of the laminate securing it in place with the exposed portion of the sealing compound

   The loose boat cloth tape (EB520) should extend over the top of the sealing compound away from the tool laminate (Refer to Figure 3, step d)
5. Stack sufficient layers of **"**breather dam**"** on top of each other so that they extend 3.0mm (1/8 inch) higher than the laminate thickness (Refer to 4)

   As resin flows into the boat cloth during cure the vacuum paths will close eliminating excess resin bleed.
6. If secondary bonding to the tool laminate is required, cover the laminate with peel ply designed for use with BMI materials (see Table 5)

   Extend the peel ply to the edge of the laminate ensuring no bridging, always lay peel ply short of female radii in order to prevent bridging
7. Cover the layup with a continuous layer of non-perforated A5000 release film (See Table 5)

   Extend the release film over the breather dam sealing tucks and folds with high temperature adhesive tape.
8. Tape the release film in place ensuring a minimum of 25mm (1 inch) of boat cloth (EB520) from each of the **"**breather dam**"** layers is exposed so that it can contact the breather pack
9. Apply the breather pack using suitable breather (See Table 5) ensuring no bridging

   Ensure the breather extends over the boat cloth layers from the **"**breather dams**"**
10. Locate a minimum of two vacuum ports on breather pads, for a laminate up to 2 square meters (20 square feet) and another port for each additional 1 square meter (10 square feet)

    Do not locate vacuum ports directly on top of the laminate. Position them against the master model/intermediate or in tucks in the vacuum bag ensuring they are connected to the breather pack and always use an even number of vacuum ports.
11. Using a second non-perforated A5000 release film layer (See table 5), cover the tool and breather to protect the vacuum bag film

    Do not block the vacuum path from ports to the breather pack.
12. Vacuum bag the lay-up using a good quality BMI-resistant bagging film (See Table 5) ensuring no bridging
13. Check the vacuum integrity by pulling a full vacuum 950-980mbar (28-29**"** Hg) then disconnecting the vacuum source

    If the bag loses more than 70mbar (2 inches of Hg) in 15 minutes check and seal leaks.
14. Maintain 950mbar (28**"** Hg) vacuum and debulk the laminate for at least 12 hours for large tools

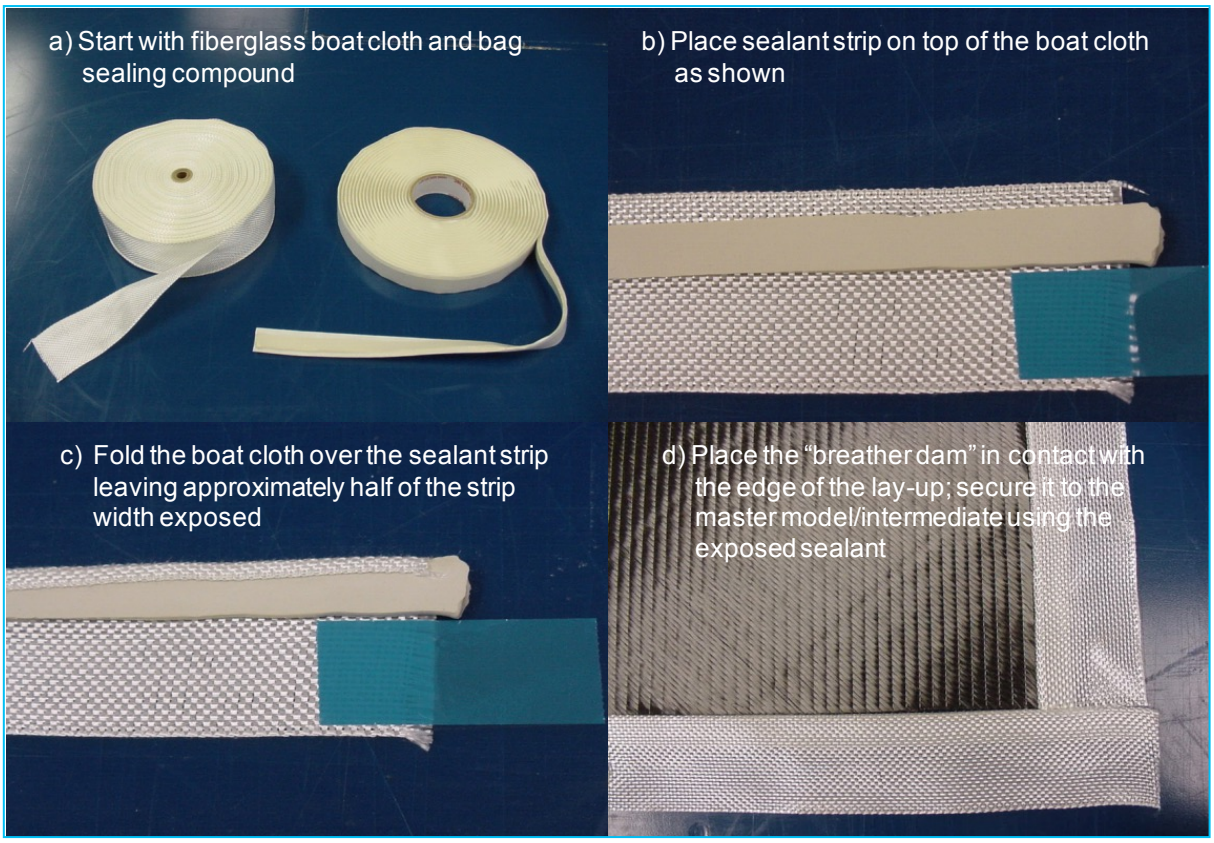

Figure 3 | Creation of "Breather Dam" Assembly

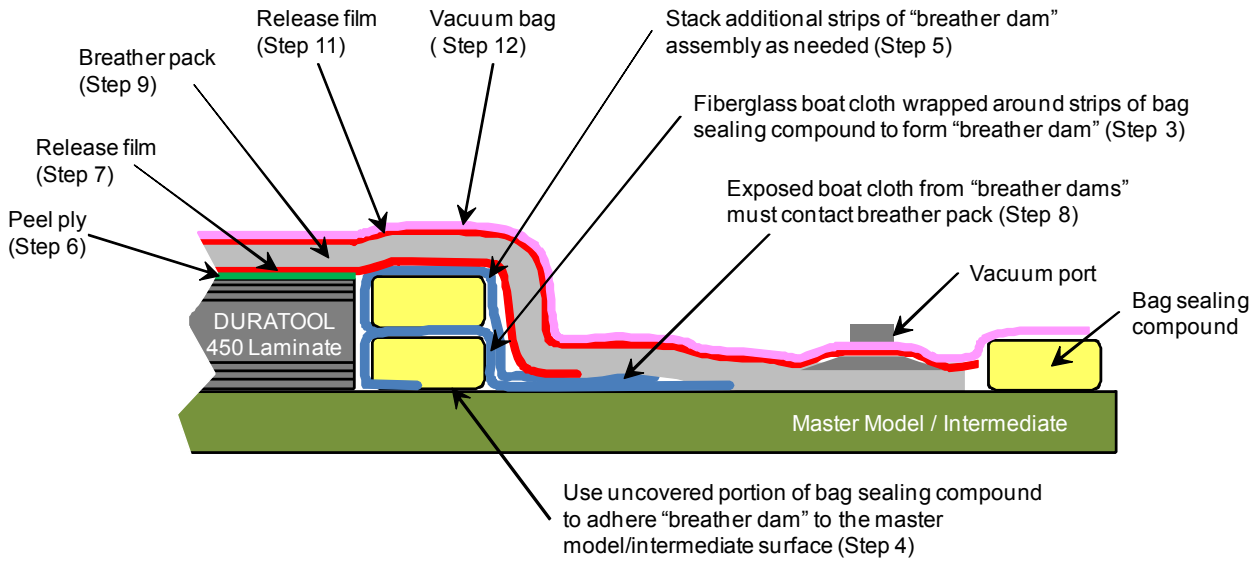

Figure 4 | DURATOOL 450 Bagging Scheme

NOTE: Step numbers refer to Final Bagging Procedure section, See Table 5 for details of Consumables to be used

CURE CYCLE SUMMARY

Autoclave cure

Vacuum bag pressure	Minimum of 950mbar (28”Hg)* †
Autoclave pressure	6.2 bar (90 psi)
Ramp rate	1 to 2°C (2 to 4°F)/minute
Recommended cure cycle	6 hours at 177°C, +3/-3°C (350°F, +5/-5°F)
Cool down (under pressure)	Maximum of 3°C (5°F)/minute to 60°C (140°F)

*This is the ideal vacuum level, however, it is recognised that it is not always possible to attain due to elevation. If in doubt, please contact our technical support staff for advice.

RECOMMENDED CURE PROCEDURE

1. Apply a minimum of 950mbar (28inch of Hg) vacuum
2. Apply a minimum of 6 bar (90psi) autoclave pressure [6+ bar (90psi +) preferred] with full vacuum
3. Heat the laminate at a rate of 1 – 2°C/minute (2-4°F/minute) until the lagging thermocouple reaches a cure temperature of 177 ± 3°C (350 ± 5 °F)

   To promote even heat up do not allow autoclave temperature to exceed 10°C (20°F) above the cure temperature.
4. Hold the laminate at 177 ± 3°C (350 ± 5 °F) for a dwell time of 6 hours minimum
5. Cool the laminate under pressure to 60°C (140°F) at 3.0°C/minute (5°F/minute) maximum rate

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/intermediate

   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 (SIMPLY SUPPORTED VS TIED-IN CONSIDERATIONS)

To achieve maximum stability DT450 must undergo a post-cure cycle in addition to the initial 177°C (350°F) cure to develop its maximum Tg and temperature resistance. For most postcures the tool skin should be lightly supported during the post-cure cycle the tool backing structure may be used as a cradle, but should not be rigidly attached to the tool skin. There are many schools of thought on merits of attaching (Tied In) backing compared with not attaching backing structure, we recommend you contact us to discuss the merits of each approach with respect to your application.

Ramp rate for “Lightly Supported”	0.3°C (0.5°F)/minute
Post-cure cycle	6 hours at 240°C (464°F)*
Cool down	Maximum of 1-2°C (2-4°F)/minute to 60°C (140°F)

* Temperature must be measured by the lagging thermocouple attached to the part

Notes:

- Large components should be adequately supported to avoid distortion.
- Other post-cure cycles to achieve a range of Tg’s are available. Please contact our technical support team for advice.

Ramp rate for “Tied In”	1-2°C (2-4°F)/minute
Post-cure cycle	6 hours at 226°C (440°F)*
Cool down	Maximum of 1-2°C (2-4°F)/minute to 60°C (140°F)

Temperature must be measured by the lagging thermocouple attached to the part.

Notes:

- Adequate considerations with respect to “Tied-in” structures and suitability of resin deployed for this purpose are critical, if in any doubt, use slow ramp for Lightly Supported Structures, 0.3°C (0.5°F)/minute. Always verify Dry Tg of attachment resins used for Tabs/Cleats.
- Other post-cure cycles to achieve a range of Tg’s are available. Please contact our technical support team for advice.Putting the Tool into Service

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. Wiping with solvent will not remove wax. The chemical resistance of the BMI tool surface is generally comparable to an epoxy system with one important exception – BMI resins are susceptible to high pH fluids. Check the pH of all cleaners used and avoid any product with a pH above 9.5.
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 190°C (375°F) service.

DISPOSAL OF SCRAP MATERIAL

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

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EXOTHERM

BMI prepregs are reactive formulations which can undergo severe exothermic heat up during the initial curing process if incorrect curing procedures are followed.

Great care must be taken to ensure that safe heating rates, dwell temperatures and lay-up/bagging procedures are adhered to. It is strongly recommended that trials, representative of all the relevant circumstances, are carried out by the user to allow a safe cure cycle to be specified. It is also important to recognise that the model or tool material and its thermal mass, combined with the insulating effect of breather/bagging materials can affect the risk of exotherm in particular cases.

Please contact our technical support staff for further information on exotherm behaviour of this prepreg.

HEALTH & SAFETY

Please refer to the product MSDS for safe handling, personal protective equipment recommendations and disposal considerations.

Table 5 | Consumables (Refer to Solvay Process Materials contact details below)

Type	Name	Operation	Comment
Sealant Tape	SM-5142	All Debulks and Final Bagging	
Bagging Film	VAC-PAC HS 6262	All Debulks and Final Bagging	Light Blue
Release Film	A5000	Final Bagging	Purple or White
Release Film	A6200 P3	Debulk Operations Only	P3 Blue
Nylon Breather Material	RC-3000-10NB	All Debulks and Final Bagging	
Peel Ply	60001/Style 56009	Final Bagging (if required)	
3” Dry Glass Tape	EB520	Final Bagging (edge breathing)	3” X 50 yards

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