USERS' MANUAL FOR LTM® PREPREGS AND ADHESIVE FILMS

This document contains important information regarding the usage and storage of LTM, low temperature moulding, prepregs and adhesive films. The LTM family of prepregs consists of several systems designed for the manufacture of composite parts or tooling. Each LTM material is designed to be cured to a demouldable condition at low temperatures (typically between room temperature and 80°C (176°F), with the capability of being used thereafter at higher temperatures, after a suitable postcure if appropriate.

The practices involved in using and processing these materials differ in some important respects from those of conventional, elevated temperature curing prepregs. Apparently trivial deviations from the procedures and practices described herein can yield unexpected and undesirable results.

This document has been designed to answer most of the more common questions regarding the usage of LTM prepregs and adhesive films. Additional information is given in the product data sheet for the specific resin system in question. The Advanced Composites Group also offers a comprehensive technical support service, provided by staff with a wide range of composites manufacturing experience which users of LTM and other ACG products are encouraged to use. Telephone support is available Monday through Friday between the hours of 8.00 am and 5.00 p.m. On site technical support is also available by arrangement.

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Contents

1 Tool or Master Model Requirements

LTM prepregs allow the use of low cost, low temperature service materials. In the case of composite tooling made from LTM prepregs, the same advantages apply to the selection of the master model or pattern materials. The terms "model", "tool", "master", "pattern" and "mould" will be used interchangeably throughout this document to describe the item or shape onto or into which the prepreg is to be laid up.

LTM prepregs can be cured against most non-porous materials (e.g. aluminium, closed cell syntactic foams) and some porous materials (e.g. wood, plaster) providing that a suitable sealant is applied in the latter case.

The tool or model must be constructed in such a manner as to possess perfect vacuum integrity and to withstand the pressure applied during cure. In some cases, LTM prepregs may be cured under oven/vacuum bag moulding conditions, the vacuum required varying from a few inches of mercury to full vacuum. In other cases, the materials may be cured under autoclave pressure, typically 90 psi. Whatever the cure cycle to be used, it is strongly recommended that the tool or model be subjected to a representative cure cycle, including representative bagging arrangement, prior to commencing lay-up.

The curing reaction of LTM prepregs can be inhibited when the material is moulded in contact with certain materials. Cure inhibition results in a sticky, uncured resin surface, which can be thin but sufficient to impair the cosmetic quality of the surface finish of the part or tool. Materials that are known to cause such a reaction are:

- Urethane based syntactic foams as used in some common machinable tooling boards
- Polyurethane based lacquers and sealants
- Some phenolic resins
- Some polyester resins.
- Some acrylic paints
- Acid catalysed resins and sealers

The preferred method of preventing cure inhibition when moulding LTM prepregs against such materials is the application of an approved barrier coating. ACG supplies two such barrier coatings, CS706-1, designed for use up to 80°C (176°F), and CS705, designed for use up to 60°C (140°F). **Whichever product is used, the application instructions as given in the appropriate ACG Data Sheet must be carefully observed as slight deviations from these instructions can render the barrier coating ineffective.**

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In instances where the use of a CS706-1 or CS705 barrier coating is not possible (for example where the tool or model has already been coated with a different sealer and/or has had release agent applied) ACG should be contacted regarding the availability of chemical surface pre-treatments which have in many cases been effective in eliminating or reducing the effects of inhibition reactions.

In all cases where there exists no prior experience of moulding LTM prepregs against specific tool or model materials, ACG should be consulted and if necessary a suitable trial conducted.

In many cases where no inhibition problems exist, for example where moulding LTM prepregs from ACG's epoxy based TB650 and TB620 syntactic foams, it may still be desirable to use a cosmetic coating to enhance the surface finish. CS706-1 and CS705 are both suitable for this purpose as are a number of alternative coatings such as ACG's **CS707-1** and **CS708**. It should be noted that these latter alternative coatings are cosmetic in nature and will not function as barrier coatings in cases where the substrate has the potential to inhibit the cure of the LTM resin system. These coatings must be applied in accordance with the relevant ACG Product Data Sheets.

Table 1 summarises the basic characteristics of the ACG coatings which are currently available and their intended application.

Table 1 Characteristics of ACG Model and Tool Sealers

	Maximum Service Temperature	Chemical Barrier	Typical Usage
CS705	60°C (140°F)	Yes	Syntactic foam master model/tool cosmetic sprayable sealant and chemical barrier
CS706-1	80°C (176°F)	Yes	Syntactic foam master model/tool cosmetic sprayable sealant and chemical barrier
CS707-1	180°C (356°F)	No	Syntactic foam master model/tool cosmetic sealer and composite tool repair sealer
CS708	205°C (401°F)	No	Wipe on sealer

A specific chemical interaction problem can occur with many cyanate ester based prepregs including those manufactured by ACG. Because of the tendency of most cyanate ester resins to be adversely affected by the presence of moisture during cure, it is recommended that such materials are not cured against tool materials which have the tendency to absorb moisture and then evolve it again during cure.

2 Tool/Master Model Preparation

Remove all traces of contamination and thoroughly degrease the surface using MEK, acetone or other suitable solvent. Apply a recommended release agent in accordance with the manufacturer's instructions. Suitable release agents for use with ACG's LTM prepregs are:

ACG RA815 wax based release agent, for use up to 80°C (176°F).
Frekote™ 44NC, suitable for use at temperatures in excess of 80°C (176°F).

Non-recommended release agents include materials such as PVA.

Whichever release agent is used, the tool should be baked at a temperature at least as high as, and preferably in excess of, the intended moulding temperature of the LTM prepreg and held at this temperature for sufficient time to allow any solvents or other volatiles in the release agent, sealer or tool material to be evolved.

3 Prepreg Thawing Procedure

LTM prepregs must be stored in sealed bags made of polyethylene or other impermeable materials when in frozen storage. To prevent the formation of condensation on the prepreg, LTM prepregs must be fully thawed prior to removal from the sealed bag. Unlike some epoxy resin systems, LTM epoxy based resin systems are not susceptible to adverse chemical interactions in the presence of moisture; however moisture is a volatile and its presence can in some circumstances result in highly voided laminates with pitted surfaces. Cyanate ester based LTM systems such as LTM110 are, in contrast to the epoxy based LTM systems, highly susceptible to adverse chemical interaction in the presence of moisture.

The correct thawing time will depend on factors such as the roll size and ambient temperature. After thawing, the material should no longer feel cold to the touch. A typical thawing time for a 25lm (82ft) roll of woven carbon fibre LTM prepreg would be of the order of 6 hours at 21°C (70°F), so that the inner wraps of material can reach ambient temperature. Because of the short outlife of some of the LTM prepreg systems, thawing times should obviously be the minimum necessary. In the event that prepreg is removed from the sealed bag before being properly thawed, additional protection is provided by the release materials with which the prepreg is supplied (paper and/or polyethylene) and these materials should only be removed once thawing is complete. It should be noted that the release materials alone do not constitute an adequate moisture barrier; they simply offer some additional protection in the event that proper thawing procedures are inadvertently not correctly followed.

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Occasionally, it may be necessary to store a completely or partially completed LTM prepreg lay-up under refrigerated or frozen conditions, for example to await processing equipment availability, without exceeding the material outlife. When doing so the precautions and practices pertaining to storing and thawing rolls of material should be used. It is recommended that lay-ups should be bagged and standard non-return type vacuum fittings used. Any excess air should be removed from the bag, which should be left under minimal vacuum (e.g. 5in Hg). It is neither desirable nor necessary to store lay-ups under frozen or refrigerated conditions in bags under high levels of vacuum, since any bag leakage will result in external, possibly moisture-laden, air being drawn into the bag. Under no circumstances should an unsealed or unbagged lay-up assembly be put into frozen storage.

4 Worklife, Outlife and Storage Life

The following definitions are used for LTM prepregs:

Worklife	The time at room temperature in which the material will retain tack and drape so that it may be laid up.
Outlife	The time at room temperature in which the resin will flow sufficiently for the laminate to consolidate properly if subjected to the recommended temperature and pressure.
Storage Life	The time in storage at -18°C (0°F) or lower, after which the material will retain at least half of the stated room temperature worklife and outlife.

- In many cases, outlife and worklife for a particular system may be the same. However it is possible for outlife to be greater than worklife; such that a material may become "boardy" but still flow under temperature and pressure.

- Because of the short worklife of some LTM prepreg resin systems, it is generally recommended that for these systems, sufficient material be removed from the freezer for that day's laminating only. Thus, fresh material is used for each day's laminating.

- When calculating residual worklife and outlife for material which has been removed from frozen storage for any period, any accumulated out-time must be deducted to determine the correct life remaining.
  Example: A roll of LTM12 prepreg with a stated worklife of 4 days and storage life of 6 months has been in frozen storage for the complete storage life of 6 months. The accumulated out-time is 1 day. The remaining worklife is (4 ÷ 2) - 1 = 1 day.

- Some of the LTM resin systems have worklife and outlife measured in days or even hours, so it is essential that rigorous out-time control and monitoring practices be maintained. An out-time log sheet is provided with each roll of material.

Appendix 1 summarises the storage life for the range of LTM resin systems.
Appendix 2 summarises the outlife and worklife for the range of LTM resin systems.

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The practical significance for outlife and worklife depends on specifically how the material is to be processed.

Pressure Assisted Cures (Autoclave or Heated Platen Press Moulding):

The material must be laid up within the worklife and must be cured within the outlife.

Vacuum Bag/Oven Cures:

The material must be laid up within the worklife. For most LTM systems the material must be cured within the outlife. However there are some exceptions to this; certain LTM prepregs are capable of flow at room temperature, such that providing fresh material is used each day and an overnight vacuum debulk carried out daily, the total lay-up time can exceed the stated outlife of the material. In this staged lay-up technique the first plies may cure before the later plies without detriment to the interlayer properties. The specific systems for which this technique can be used are LTM10, LTM20.

An alternative multi-stage curing technique can be used for circumstances where the total lay-up time exceeds the outlife of the material. In this technique, the lay-up is partially completed and before the material outlife is exceeded, a peel ply and vacuum bag is applied and the partial lay-up is cured (using oven vacuum bag or autoclave processing etc. as desired) at low temperature. The bag and the peel ply are then removed and the lay-up is continued with fresh material.

The peel ply should be non-released and may need to be resin impregnated by ACG in order to avoid extraction of resin from the prepreg. Many LTM systems are supplied at resin contents close to the minimum for the particular reinforcement type, such that any resin loss into the peel ply would result in starvation and voiding. It is essential that each cure stage be carried out at low temperature and that postcuring only be carried out after the whole lay-up has been completed, in order to achieve acceptable interlaminar properties. While this technique has been successfully used in the past on several occasions and has been found to give no detectable reduction in interlaminar properties (short beam shear strength and flatwise tension strength), it is strongly recommended that this is specifically verified by testing for each application. In effect, the boundaries between the stages should be treated for structural purposes as adhesive bonds, effected using an adhesive of undetermined properties and therefore requiring test data to verify strength properties.

All stated worklife and outlife values for LTM prepregs are at a reference temperature of 21°C (70°F). As a general rule of thumb, the outlife and worklife will approximately halve for each 10°C (50°F) increase of ambient temperature. Similarly, the worklife and outlife will approximately double for each 10°C (50°F) decrease in ambient temperature.

5 Tack and Handleability

LTM prepregs are supplied in a condition which gives the maximum amount of worklife and outlife for the system in question. In this fresh state, while many LTM systems possess excellent tack and handleability, some first generation LTM systems have very aggressive tack characteristics which may prove difficult for some applications. The user has the option of significantly improving the tack and handleability by means of staging the material at room temperature and sacrificing some of the worklife and outlife. For those systems listed in Table 2 below, this practice of staging material is strongly recommended wherever the full worklife and outlife are not needed.

The optimum staging time to give the best handleability is largely a matter of user preference and will vary with ambient conditions and age of the prepreg; however the following are suggested staging times based on experience within ACG.

Table 2 – Staging Times

Resin System	Staging Time
LTM10, LTM12, LTM110, LTM23	12 hours at 21°C (70°F)
LTM25, LTM26, LTM26EL, LTM45EL	24 hours at 21°C (70°F)

Note: Prepreg reactivity will increase and staging times will reduce with increasing ambient temperature. Users are encouraged to experiment to determine the optimum handleability for their needs.

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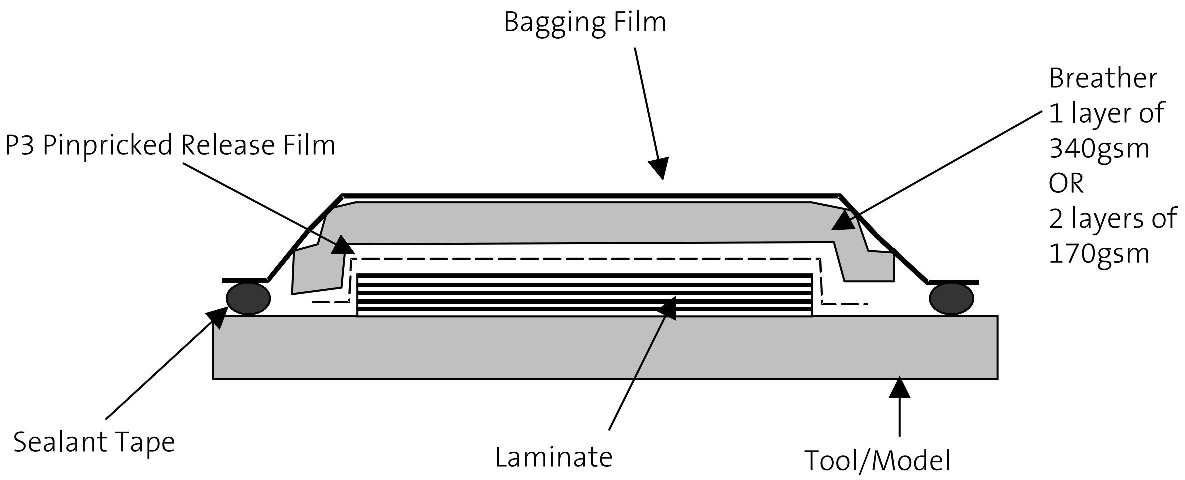
6 Part Lay-up

LTM prepregs should be laid up in accordance with all normal usage and health and safety practices for prepreg materials. It is recommended that the release materials be left in place and only removed immediately before laying up the material, in order to protect the material from contamination by foreign matter or atmospheric moisture. For those LTM prepregs and adhesive films which possess aggressive tack characteristics, polyethylene release materials may be difficult to remove. Removal of the polyethylene will prove easier if it is given a sharp pull parallel to the plane of the material. The use of freeze sprays or other such substances to initiate removal of the release material is not recommended because of the risk of moisture or other contamination. As with all organic resins, LTM resins should never be allowed to come into direct contact with the skin, eyes or other parts of the body and protective clothing and gloves must be worn at all times.

7 Debulk Procedure

Room temperature vacuum debulks are often required to ensure that the material conforms to the required geometry and to ensure that there are no large areas of entrapped air between the plies. Experience has shown however, that for both oven/vacuum bag and autoclave moulding, debulks play little role in determining the level and distribution of internal voiding and if too frequent or long in duration may actually be detrimental to laminate quality. For this reason, it is recommended that debulks be no longer than 15 minutes duration and should be carried out approximately every 4 plies. There are specific exceptions to this, which are explained in the individual data sheet for the product in question. Additionally for complex part geometry, more frequent debulks may be necessary. In cases where it is necessary to leave a partially completed lay-up unattended for any length of time (e.g. overnight), it is recommended that a standard 15 minute debulk be carried out under full vacuum and the vacuum then reduced to minimal level (5in Hg). A 15 minute debulk under full vacuum can be carried out prior to recommencement of laminating if necessary.

Figure 1 - Bagging for Vacuum Debulk – Method A
(Also Bagging for Cure for Some Systems)



Note: If this bagging method is used for final cure, a peel ply may be used between the lay-up and the P3 release film. The peel ply must either be pre-impregnated with the appropriate LTM and obtained from ACG, or the prepreg ordered with sufficient excess resin to compensate for that which may be lost into the peel ply.

Debulk Procedure:

1 Apply 1 layer of P3 pin pricked release film (hole spacing 10mm (0.4in), minimum hole size 0.5mm (0.02in)). Cut and splice the material to avoid bridging.

2 Apply a non-woven breather of suitable conformity. Use one layer of 340gsm or two layers of 170gsm breather. Cut and splice the material as necessary to avoid bridging.

3 Apply a vacuum bagging film to the lay-up, ensuring sufficient slackness is provided to avoid bridging.

4 Apply a full vacuum (minimum 25in Hg) for approximately 15 minutes, unless stated otherwise in the specific product datasheet, which takes precedence over this generalised statement.

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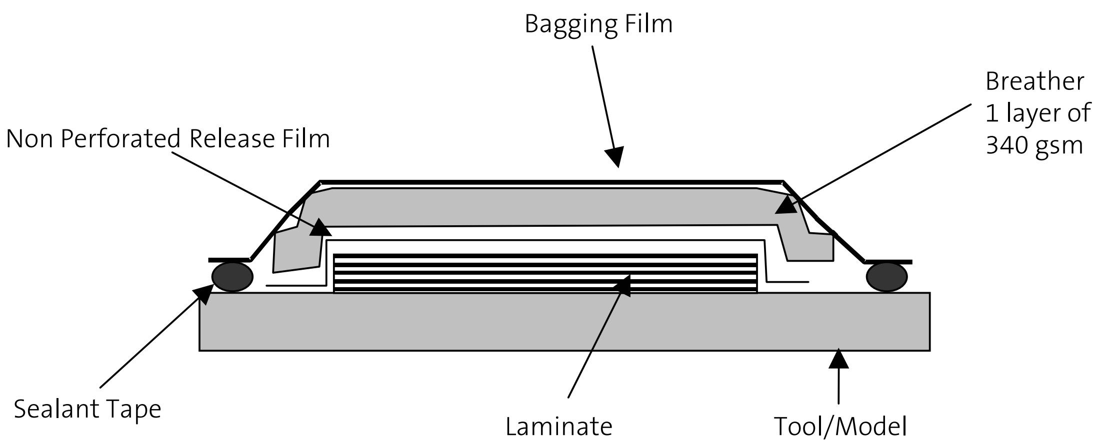
8 Bagging for Cure – Basic Arrangements

A final vacuum debulk in accordance with Section 7 above, should be carried out immediately prior to bagging the lay-up for cure. The bagging procedure to be used for curing depends on the specific LTM prepreg system being used. Figure 1 above defines bagging method A, used for debulks and for cure bagging for certain systems. Figures 2 and 3 define two additional bagging methods, designated as B and C respectively. Table 3 specifies the cure bagging method to be used for specific LTM prepreg systems.

LTM prepregs are usually supplied as zero bleed systems and must not be inadvertently bled by using the wrong bagging arrangement or by using a dry, non-impregnated peel ply where not otherwise specified. Impregnated peel ply is available from the Advanced Composites Group. Alternatively the prepregs themselves may be supplied with additional resin to compensate for possible loss during cure.

Figure 2 – Bagging Method B

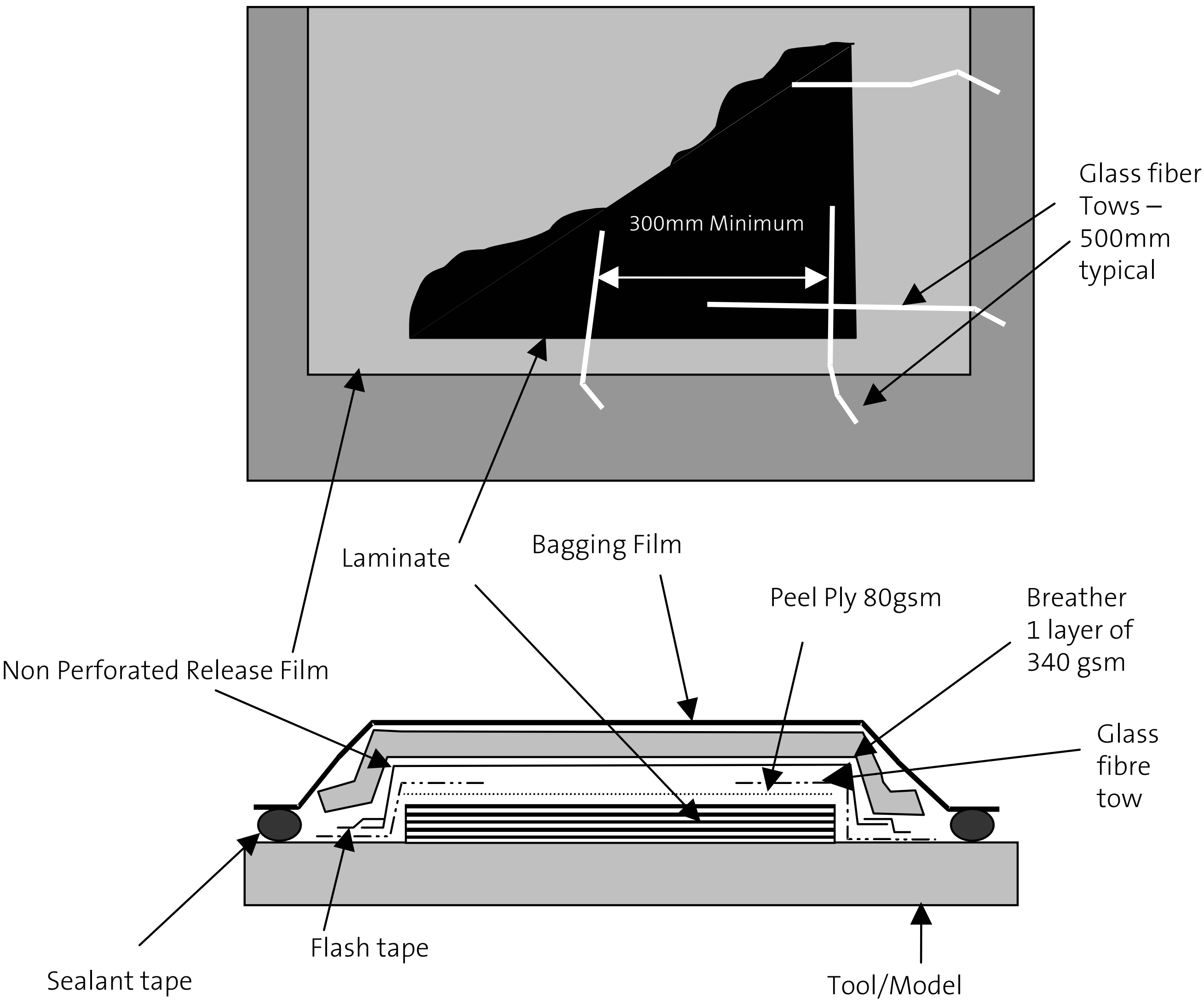


Notes:

(i) The use of glass fibre strings (as illustrated for bagging method C, Figure 3) is also permissible with this method.

(ii) A peel ply may be used between the lay-up and the non-perforated release film. This peel ply must be pre-impregnated with the appropriate resin and obtained from ACG, or alternatively the prepreg must be ordered with sufficient excess resin to compensate for that which will be lost into the peel ply.

Figure 3 – Bagging Method C



Notes:

(i) The glass fibre strings must extend beyond the non-perforated release film and be in contact with the breather.

(ii) The peel ply should be of the non-released polyester type and be not greater than 80gsm areal weight.

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Table 3 – Standard Bagging Methods for LTM® Prepreg Lay-ups

Resin System	Oven/Vacuum Bag Cure	Autoclave Cure
LTM10, LTM12, LTM16	A	B
LTM20, LTM23, LTM25, LTM26, LTM26EL	A	B
LTM24ST	A	B
LTM45EL	A	B
LTM45-1	C	C
LTM211, LTM213, LTM216ST, LTM217	C	C
LTM233, LTM237	C	C
LTM110, LTM110-1, LTM123	B	B

Position thermocouples between the first two plies of the lay-up (usually outside EOP – i.e. in an area that will be trimmed and removed after cure).

Apply the ancillary and bagging materials as specified by the appropriate method and in accordance with normal practice for the application of vacuum bags. The release film should extend beyond the edge of the lay-up by approximately 13mm (0,5in). Glass fibre strings, if used, must extend beyond the release film and be in contact with the breather. All ancillary materials should be cut and tailored to avoid bridging. Similarly the bag itself should be sufficiently slack to avoid this problem. Apply using a vacuum pump, vacuum gauge and non-return type vacuum fitting, a full vacuum (25in Hg minimum) or the highest level of vacuum permitted by the particular tool construction. Remove the vacuum pump and check for leaks for at least 20 minutes. Ideally the gauge should indicate no noticeable drop in vacuum during this period. This is extremely important, since although the vacuum pump might be capable of maintaining the required level of vacuum despite the presence of a leak in the tool or bag, this can often simply result in air being drawn into or through the lay-up, resulting in a voided part.

For practical part construction, deviations from these basic arrangements will on occasion be necessary, for example where a caul sheet is to be used or where the structure contains honeycomb or other core materials. The Advanced Composites Group should be contacted for specific advice in such cases.

9 Initial Cure – Oven/Vacuum Bag or Autoclave Curing

The information given in this section is concerned with the procedures necessary to cure LTM prepregs to a solid demouldable but partially cured condition. In many but not all cases, a postcure may be required to complete the curing reaction and generate the optimum level of mechanical and thermal performance. In most cases, the initial cure cycle consists of a ramp from room temperature to some specified temperature, followed by a dwell at that temperature. Table 4 specifies the ramp rates which are typically used, and Table 5 specifies dwell times at specific temperatures for the various LTM resin systems. In cases where a subsequent postcure is to be carried out, Table 5 specifies the minimum dwell time at a given cure temperature, after which the curing reaction will be at least 50% completed and the moulding is demouldable with care after cooling to room temperature. These dwell times are designated as “Minimum Cure Times” in Table 5. These minimum cure times should always be used in cases where the multi-stage curing technique described in Section 4 above is to be used, in order to ensure the maximum amount of residual surface reactivity and to achieve the optimum bond between each stage.

Alternatively, a longer dwell time can be used which allows the reaction to continue to completion at that temperature such that a Tg higher than the cure temperature is achieved. These times are termed “Optimum Cure Times” and should always be used where hot demoulding is required without cooling to room temperature. In addition, for those systems where postcuring is optional and it is elected to dispense with the postcure (i.e. where, after initial cure, satisfactory mechanical performance is achieved up to the initial cure temperature and where the only requirement for postcuring is to achieve performance at temperatures in excess of this temperature) the optimum cure times should always be used.

<u>EXOTHERM POTENTIAL</u>

LTM prepregs contain highly reactive resin systems which can undergo severe exothermic heating during the initial curing process if the recommended curing procedures are not followed. It is important to recognise that laminate thickness, reinforcement type, resin content, tool/model material and thermal mass and the insulating effect of the breather/bagging materials, are all factors which significantly affect the cure behaviour and the risk of an uncontrolled exothermic reaction. For this reason it is not possible to give definitive processing parameters necessary to avoid an uncontrolled exotherm and the data which follows is for general guidance only. Where no prior experience exists, a representative trial is recommended to assess the risks involved. In cases where an exotherm risk exists, the use of an intermediate dwell is recommended.

Table 4 lists the recommended heat-up rates during initial cure for the various resin systems and an approximate temperature above which an exotherm risk may exist and where the use of an intermediate dwell may be required. It must be emphasised that this table is for general guidance only and that the number of parameters which affect the risk of exotherm mean that this information must be used with caution. It is most certainly possible for an exotherm to occur below the stated temperature value. The dwell times for different initial cure temperatures, necessary to achieve either minimum or optimum cure condition, are given in Table 5.

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The following statements should also be noted related to the effects of heat up and cool down rates for component manufacture: -

INITIAL CURE-- HEAT UP RATE STATEMENT.
Heat up rate may be varied to suit the size and thickness of the tool and the component lay up. Typically, heat up rates between 0.5°C and 5°C (0.9°F and 9°F)/minute will probably be suitable for most components. Cure temperature may be varied to suit the particular application or production schedule.

INITIAL CURE-- COOL DOWN RATE STATEMENT.
It is preferable to initially cool under vacuum only for all bagged applications. Autoclave pressure may be released at the onset of cool down. In general, for solid laminates, the vacuum may be vented and debagging commenced when part temperature has fallen by 20°C (68°F) from the specified cure temperature. Sandwich panels may require cooling to a lower temperature to avoid skin to core bond failure. Cooling to lower temperatures should also be adopted in <u>any</u> application where ultimate component accuracy is required.

Table 4 – Initial Cure Parameters – Typical Heat-up Rates and Intermediate Dwells

Resin System	Typical Heat-up Rate	Intermediate Dwell may be Required to Avoid Exotherm Above:
LTM10	0.5°C (0.9°F) per minute	71°C (160°F)
LTM12	0.5°C (0.9°F) per minute	80°C (176°F)
LTM16	0.5°C (0.9°F) per minute	85°C (185°F)
LTM23	2-5°C (3.6 -9°F) per minute	71°C (160°F)
LTM25, LTM26, LTM26EL	1°C (1.8°F) per minute	80°C (176°F)
LTM45EL, LTM45-1	2-5°C (3.6 -9°F) per minute	80°C (176°F)
LTM211, LTM213, LTM217,	2-5°C (3.6 -9°F) per minute	71°C (160°F)
LTM110, LTM110-1, LTM123	2-5°C (3.6 -9°F) per minute	93°C (199°F)

In all cases, the oven or autoclave temperature should be controlled by a thermocouple or thermocouples which measure <u>air temperature</u> around the part. The commencement of the dwell <u>time</u> (as specified in Table 5) should be determined by the lagging thermocouple within the vacuum bag. However, under no circumstances must a thermocouple within the bag be used to control temperatures or ramp rates. For oven/vacuum bag curing, the required level of vacuum (usually 25in Hg minimum) is applied to the bag and maintained throughout the cure cycle. For autoclave and heated platen press moulding, additional information is given in Sections 10 and 11 below.

10 Procedures Specific to Autoclave Curing

Table 5 summarises initial cure procedures to be used for autoclave processing of LTM prepregs.

Table 5 – Autoclave Processing Parameters

Resin System	Vacuum	Pressure Application
LTM10 Series	25in Hg throughout	From commencement of heating
LTM20 Series	25in Hg throughout	From commencement of heating
LTM45EL	25in Hg throughout	From commencement of heating
LTM45-1	25in Hg throughout	When autoclave temperature has reached minimum moulding temperature for the resin system if >30 minutes, or at 1 hour from the start of the heating cycle if the minimum cure temperature has not been reached by that time.
LTM211, LTM213, LTM217	25in Hg throughout	
LTM110, LTM110-1, LTM123	25in Hg throughout	

11 Procedures Specific to Heated Platen Press Moulding

Heated platen press moulding differs from autoclave and vacuum bag moulding in that the press platens and tooling (if metallic) generally possess a very substantial heat capacity. For this reason it is often possible to cure even quite thick laminates very rapidly, at temperatures which under oven vacuum bag moulding conditions would very likely cause a severe exotherm. ACG should be consulted for advice on specific cure cycles for the different resin systems. Table 6 gives some examples of cure cycles which have been successfully used. Certain of the LTM resin systems as listed in Table 6 may be subjected to full platen pressure from the start of the cure cycle. For all other LTM resin systems, it is usually necessary to dwell under contact pressure only until the resin begins to string when touched with a probe, after which full pressure may be applied without generating excessive edge bleed. The nature of the tooling obviously has a strong influence on the necessity or otherwise for this practice and it may be possible in a truly enclosed moulding situation to apply pressure from the start.

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Table 6

Resin System	Pressure Application	Example Cure Cycles
LTM23	Full pressure from start	25 minutes at 110°C (230°F)
LTM26	Full pressure from start	
LTM26EL	Full pressure from start	
LTM45-1	Full pressure from start	
LTM210 Series	Full pressure from start	
All other LTM prepreg systems	Contact pressure until resin begins to string, then full pressure application	

12 Postcure Procedures

The following statements should be noted related to the effects of heat up and cool down rates for component manufacture: -

POSTCURE-- HEAT UP RATE STATEMENT.

Parts may be loaded into an oven that is pre-heated to the original initial cure temperature. Heat up rates from the initial cure temperature to the post-cure temperature should be between 0.33°C (0.6°F) and 5°C (9°F) per minute dependent on the resin system, part size, thickness, accuracy requirements, and the complexity of the component.

POSTCURE-- COOL DOWN STATEMENT

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In some circumstances it may be possible to employ a rapid cool down by switching off the heating and opening the oven doors. The part(s) may then be removed from the oven when they can be safely handled. However, controlled cool down rates are normally recommended, particularly when curing from a master model (which may fracture if cooled too quickly), and when postcuring components that are complex in shape or more than 2mm in thickness.

Table 7 – Typical Postcure Parameters

Resin System	Typical Postcure Cycle	Minimum Cure/Postcure Temperature	
		For Room Temperature Service	For Trimming and Machining
LTM10 Series, LTM216ST	RT-200°CF at 20°C per hour Dwell 15 minutes at 200°C Then dwell 8 hours at 190°C Cool at 3.3°C per minute	80°C (176°F)	80°C (176°F)
LTM20	Optional: RT-120°C at 2 to 5°C per minute maximum Dwell 30 minutes at 120°C Cool at 2 to 5°C per minute	30°C (86°F)	30°C (86°F)
LTM23, LTM24ST, LTM25, LTM26, LTM26EL	Optional: RT-50°C at 2 to 5°C per minute (omit this step if initial cure temp was at least 50°C) 50-120°C at 2 to 5°C minimum Cool at 2 to 5°C per minute	50°C (122°F)	50°C (122°F)
LTM45-1, LTM45EL	RT-175°C at 20°C per hour Dwell 2 hours Cool at 2 to 5°C per minute	60°C (140°F)	80°C (176°F)
LTM210 Series	RT-200°C at 40°C per hour Dwell 15 minutes at 200°C Then dwell 8 hours at 190°C Cool at 3.3°C per minute	80°C (176°F)	80°C (176°F)
LTM110	RT-250°C at 20°C per hour Dwell 8 hours Cool at 2 to 5°C per minute	120°C (248°F)	120°C (248°F)

The postcures in Table 7 have been devised such that the glass transition temperature of the resin steps ahead of the applied temperature, permitting the part to be postcured after demoulding in a free-standing state, without risk of distortion. The part should be supported during the postcure in such a way as to minimise distortion under self-weight.

Small dimensional changes will occur during the postcure procedure which will be manifested as both linear shrinkage and springback. ACG should be consulted for specific data relating to the dimensional accuracy of LTM prepreg parts and tools.

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It should be noted that different postcure temperatures may be used depending on the service temperature requirement of the part. It is common with LTM20 series prepregs to dispense with the postcure altogether if the item is to be used at temperatures at or below the initial cure temperature and there is no requirement to operate at temperatures in excess of this. LTM216ST is a surfacing material which is often used in tooling applications combined with LTM10 series, prepregs in the same laminate. In such cases, the postcure cycle used should be that of the prepreg that is used with LTM216ST.

Postcuring alters the structure of the prepreg resin and affects not just elevated temperature performance but can also affect mechanical performance at lower temperatures. In many cases, better room temperature performance may be achieved without postcuring or by truncating the postcure at a lower temperature than given in Table 7.

Appendix 1 Storage Life of LTM® Prepregs & Adhesives

Resin System	Storage Life at -18°C (0°F) (months)
LTM 10	12
LTM 12	6
LTM 13	12
LTM 16	12
LTM 16 EL	12
LTM 17	12
LTM 20	3
LTA 23	6
LTM 24 ST	6
LTA 25	6
LTM 25	6
LTM 26	6
LTM 26 EL	12
LTA 26	6
LTS 26	6
LTX 26	6
LTM 26ELFR	12
LTM 26ELFS	12
LTA 45	6
LTM 45-1	12
LTA 45-1	6
LTM 45 EL	12
LTM 45 ELFR	12
LTM 110	6
LTA 1 10	6
LTM 211	12
LTM 213	12

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Appendix 2 Worklife and Outlife of LTM® Prepregs and Adhesive Films. **(Note: - For fresh material with no accumulated out time & storage life)**

Resin System	Maximum Work Life (days) (ambient temperature of 21°C(70°F))	Autoclavable Outlife (days) (ambient temperature of 21°C(70°F))
LTM 10	2-3	2-3
LTM 12	3-4	3-4
LTM 13	3-4	3-4
LTM 16	7-8	7-8
LTM 16 EL	10-12	10-12
LTM 17	8-10	8-10
LTM 20	1	1
LTA 23	1-2	1-2
LTM 24 ST	2-3	2-3
LTA 25	3-4	3-4
LTM 25	5-6	5-6
LTM 26	3-4	4-5
LTM 26 EL	5-6	5-6
LTA 26	2	2
LTS 26	4	4
LTX 26	4	4
LTM 26ELFR	5-6	5-6
LTM 26ELFS	5-6	5-6
LTA 45	1-2	1-2
LTM 45-1	5-6	5-6
LTA 45-1	1-2	1-2
LTM 45 EL	5-6	5-6
LTM 45 ELFR	5-6	5-6
LTM 110	2-3	2-3
LTA 110	2-3	2-3
LTM 211	2-3	3-4
LTM 213	3-4	5-7

Appendix 3 Cured Densities of LTM® Resins

Resin System	Cured Density (gm/cc)
LTM 10	1.22
LTM 12	1.22
LTM 13	1.20
LTM 16	1.21
LTM 16 EL	1.21
LTM 17	1.22
LTM 20	1.24
LTA 23	1.19
LTM 24 ST	1.18
LTA 25	1.19
LTM 25	1.18
LTM 26	1.18
LTM 26 EL	1.18
LTA 26	1.19
LTS 26	0.65
LTX 26	1.18
LTM 26ELFR	1.39
LTM 26ELFS	1.44
LTA 45	1.21
LTM 45-1	1.22
LTA 45-1	1.22
LTM 45 EL	1.21
LTM 45 ELFR	1.39
LTM 110	1.28
LTA 1 10	1.28
LTM 211	1.22
LTM 213	1.22

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