Out-of-Autoclave Tooling Prepreg System

XT135 Processing Guide

Introduction

XPREG® XT135 is a tooling prepreg system designed for low-temperature out-of-autoclave cure.

XPREG® XT135 XT135 is a specialist tooling prepreg system designed to produce dimensionally accurate carbon fibre composite moulds using vacuum bag and oven cure only (out-of-autoclave).

To achieve the highest possible quality of mould-tool, XPREG® XT135 needs to be processed correctly. The key areas of importance being the pattern surface compatibility, the layup and bagging procedure and the cure and post-cure cycles. The aim of this guide is to explain in detail the recommended procedure in each of these areas and to also provide additional processing information that may be required in certain circumstances along with defect diagnosis and remedy.

This document will be kept up to date with the latest information and findings.

Pattern Preparation

Compatible Pattern Materials

Fully Compatible

XPREG® XT135 tooling prepregs are suitable for use with chemically compatible pattern/tooling materials with a suitable service temperature; these include:

- Epoxy tooling board such as the Easy Composites EP700
- Epoxy resin surfaces such as gel-coat or prepreg components
- Aluminium/steel
- Glass platens

NOT Compatible

XPREG® XT135 is NOT suitable for use with the following tooling materials due to either service temperature or chemical compatibility constraints:

- Polyester pattern surfaces, such as those used for traditional 'fibreglass/GRP' moulds
- Polyurethane model/tooling board (due to cure inhibition of epoxies by polyurethane at elevated temperature)

All patterns should be post-cured (if required) before use to ensure that their full service temperature is realised. If in doubt of the compatibility of any mould material, we would strongly advise conducting a test prior to component manufacture.

Release Agent

We recommend the use of chemical release agent, particularly *Easy-Lease™ Chemical Release Agent* which has proven to be perfectly reliable when used with XPREG® XT135 compatible mould surfaces. The release agent should be designed for use at elevated temperatures and compatible with both epoxy prepregs and the pattern surface.

Traditional mould release waxes or PVA will not provide a release for prepregs and should NOT be used. If in doubt, conduct a trial to test for suitability.

Porous pattern surfaces such as epoxy model board should be sealed using *S120 Advanced Board & Mould Sealer* or similar prior to release agent application.

New mould surfaces should have at least 6 applications of *Easy-Lease™* prior to layup, please refer to application guidelines for further information. 1 further application is recommended between every component release, especially for complex components.

Layup & Bagging

Laminating

Laminating should be conducted in a clean and dry working environment at 17-20°C this temperature range provides the optimum tack level and workability for the material.

XPREG® XT135 comprises of a surface ply (XT135/S) and backing plies (XT135/B) the surface ply can be identified by the combination of red and blue protective film and has a fine glass fibre scrim on one side. The backing material has a blue film and white paper combination and has one very resin-rich side (black/tacky) and one fairly dry carbon fibre side.

The surface ply should be laid glass scrim (blue film) side down against the face of the pattern, subsequent backing plies can then be laid resin-rich side down up to four layers, in smaller tools 2 backing plies is usually sufficient to produce adequately stiff moulds.

Balancing

Although in the majority of applications it is not necessary where dimensional accuracy and flatness is of paramount importance the plies should be mirrored around the centre plane to produce a fully balanced laminate. In the case of a laminate of 4 backing plies the surface ply and first two backing plies should be laid as normal then the following 2 backing plies should be inverted (resin rich side facing away from the mould) this is then be backed with another surface ply laminated with the glass scrim facing out. On complicated mould tools is may be necessary to use an epoxy compatible spray adhesive such as FusionFix or a layer of XA120 adhesive film to tack the 2 ‘dry’ sides of the backing plies together to make the laminating process easier.

The laminating procedure is similar to that of all common prepreg systems; The plies of material should be positioned into the mould as required, great care must be taken to ensure complete and proper conformity to the mould surface without bridging is achieved, the use of rollers and blunt ‘dobber’ tools can assist with achieving proper placement and consolidation but care must be taken not to damage the fibres. Gently heating the material using a low-temperature heat-gun or a hair-dryer can aid to soften the resin system allowing the material to conform and drape more easily. Care must be taken to ensure that the material is not overheated as this may lead to partial curing of the resin or the resin becoming displaced. To speed up the laminating process the backing plies may be cut into tiles and joined with a butt-join (no overlap) subsequent plies should be offset so that the joins do not overlap.

Debulking

Debulking will help to improve consolidation and therefore reduce the likelihood of voids therefore we recommend a standard debulk procedure on the surface ply and after the second backing ply when more than 2 backing plies are be laminated ; Apply P3 perforated release film followed by a breather cloth, vacuum bag and hold at full vacuum for 20mins, remove vacuum bagging stack and proceed with subsequent plies of XPREG® XT135.

Vacuum Bagging

Consumable Stack

- Vacuum bagging film: *Aerofilm® VB160 Vacuum Bagging Film*
- Sealant tape: *ST150 Vacuum Bag Sealant Tape*
- Breather layer: *BR180 Breather Layer Cloth*
- Release Film: *Aerofilm® R120 P3 Perforated Release Film*

Release Film

A P3 perforated release film with suitable service temperature should be applied onto the entire open surface of the prepreg, care should be taken to ensure an intimate contact without bridging is achieved. If required, the loose film around the perimeter of the part can be occasionally secured in place using flash/release tape.

Breather

Breather should then be draped over the perforated release film over the entire area of the laminate and underneath the through-bag connector in such a way as to ensure an air path from the connector to the laminate surface.

If multiple moulds are being cured in the same bag then breather should be used between each laminate to ensure a continuous air path between them.

Vacuum Draw-down

The vacuum bag can then be applied and vacuum should be drawn gradually, taking time to position and reposition the bag as air is removed.

It is essential to the quality of the end result that during the pull-down the bag should be adjusted and positioned such that it does not bridge or stretch anywhere on the component's surface. This is a critical step to ensure proper consolidation of the laminate. Air may need to be re-introduced to allow repositioning if bridged or stretched areas are identified.

Hand tools (sometimes referred to as 'dobbers') should be used to to push the vacuum bag firmly into the inside of tight corners or details. After correct layup, consolidation and bagging, it should be impossible to feel any 'bridging' or movement when pressing a suitably shaped hand tool into corners or details of the moulding.

Towards the end of the bagging process, if there is any doubt over whether the vacuum bag is sufficiently large to to avoid bridging then the bag should be abandoned and a new larger bag made.

Cure Cycle

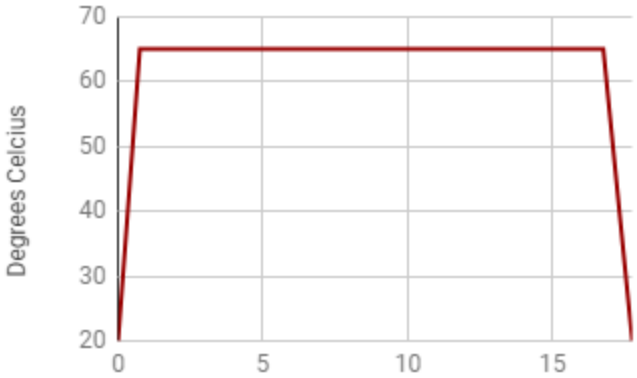
To achieve optimum surface finish and mechanical performance from XPREG® XT135 it is essential that the proper cure cycle is used.

The cure cycles specified are for oven air temperature, these allow for typical lag caused by standard composite tooling. If particularly bulky or heavy mould tools are used the tool surface temperature should be monitored to ensure that the lag does not go beyond acceptable limits. Temperatures should be held +/- 3°C where possible. Ovens should be periodically checked to ensure that they are achieving the required levels of accuracy and stability.

Controlled Ramp-Rate Cycles

Initial Cure Cycle

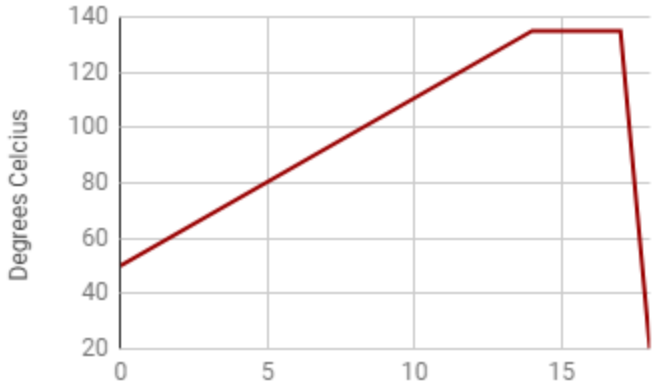
This initial cure cycle is recommended in all tooling applications this low temperature cure on the pattern ensures optimal dimensional accuracy and exceptionally low void content. This should be conducted for a minimum of 16hrs, increasing the soak time from 16hrs to upto 48hrs can reduce the effects of surface print-through.



Step #	Start Temp	Ramp Rate	Time	End Temp	Elapsed Time
1	~20°C	1°C /min	00:45	65°C	00:45
2	65°C	Soak	16:00(min)	65°C	16.45
3	65°C	Natural Cool	--	~20°C	17.30

Post Cure Cycle

The post cure cycle is required to achieve the full service temperature of the mould. A slow and controlled ramp is essential to ensure best surface finish and dimensional stability. The post cure should be conducted free-standing (off the pattern) for large mould structures it may be advantageous to support the mould during post-cure to minimise the risk of warping.



Step #	Start Temp	Ramp Rate	Time	End Temp	Elapsed Time
1	50°C	0.1°C /min*	14:10	135°C max **	14:10
2	135°C **	Soak	3:00	135°C **	17:10
3	135°C **	Natural Cool	--	~20°C	18:40

**Faster ramp rates up to 0.5°C/min are possible but may lead to increased surface 'print-though' and increased risk of warping.*

*** The final cure temperature should be set to the final operating temperature for the mould (to a maximum of 135°C) for instance if the final service temperature required is 120°C then this should be the upper temperature used, conducting the final cure at lower temperatures has the advantage of reducing the effect of 'print-through' on the mould surface.*

Switched Cycles

Switched cycles should only be used where your oven controller does not have ramp control. This does not provide optimal flow or cure control but will still in many cases offer excellent results. The cycles are essentially the same ramp controlled cure cycles with switched steps to replicate the ramps as closely as possible, This processing method allows simple control by timer switches or manual control.

Initial Cure (Switched) (only for use when oven ramp control is not available)

The initial cure can be conducted by simply loading the laminate into a cold oven and switching on at 65°C and allowing the oven to ramp naturally the soak for a minimum of 16hrs should be held as-per the recommended initial cure.

Post Cure (Switched) (only for use when oven ramp control is not available)

The post-cure should be switched in as many steps as is reasonably practical starting at 50°C and switching the temperature up every hour by 5°C to the final cure temperature will provide excellent results, if it is not practical to to this every hour then any/every single step can be run for an extended time without adverse effects.

Repairing and Finishing

Surface flatting and finishing

Although rarely necessary, when required, any slight impression left by weave print-through can quickly and easily be flatted from the mould surface using 1200 grit abrasive paper this can be done either wet or dry using conventional colour sanding techniques. This operation should only be carried out after a full post cure has been conducted and great care must be taken not to sand beyond the surface scrim.

Due to the nature of prepreg materials have reinforcement on the laminate surface is is not possible to simply polish the mould surface to a gloss using compound (unlike a gelcoated surface) therefore after sanding, if a gloss mould surface is required, this should be achieved by careful application of an advanced board/mould sealer such as the Easy Composites S120 sealer this will restore a full gloss finish quickly and effectively.

Repairing mould damage or defects

The affected area should be cleaned of any contamination, release agent and any loose material should be removed, the area should then be sanded with 120grit abrasive paper to provide a key. The affected area can then be built up using a high temperature epoxy gel-coat such as the Easy Composites EG160. On deep repairs it may be necessary to build up in a number of applications this should be done while the previous layer is still ‘tacky’ or against a sanded key. After the gelcoat has initially cured it should then be post-cured at the service temperature of the mould, ramping the temperature is not usually required. Once fully cured the repair can be sanded level and refinished using S120 sealer or equivalent.

Storage and Handling

Shelf-life

XPREG® XT135 has a shelf-life of 12months from date of manufacture, this is subject to a storage temperature of -18°C to -25°C. For structurally critical applications this expiry period should be adhered to. It is often possible to have the life of a particular batch extended if this is needed please contact Easy Composites for further details. In the case of non-critical applications normally the specified shelf life can be exceeded greatly, it is recommended that customers conduct their own trials to establish whether the systems is still performing as required.

The prepreg is delivered in sealed packaging suitable for freezing, upon removal from frozen storage the material should be allowed to defrost and reach room temperature before removal from the sealed packaging a short 1m roll may take as little as 1hr where as a full 30m roll may take upto 8hrs. The reason for the sealed defrost is to ensure that water condensation does not form directly on the material itself, also disturbing the frozen and embrittled resin can cause damage to the fibres and resin distribution.

Prepregs can be re-frozen multiple times but this must always be done in sealed packaging, ideally a log should be kept to keep track of the sum total hours of outlife accrued.

Out-life

The out-life of the system is 21 days at an ambient temperature of 20°C beyond this time the resin systems cure and flow characteristics will be compromised, it may be possible to moderately exceed this expiry period for non-critical/cosmetic applications. The storage temperature should not exceed 20°C, higher temperatures will dramatically reduce the out-life of the system. As the system takes advantage of a relatively dry glass-fibre scrim for the surface ply the material with perform as its absolute best when this scrim remains dry, after several days at ambient temperature the resin matrix will begin to ‘wick’ into the scrim reducing the surface air-path, in some cases this can lead to an increased likelihood of surface pinholes so we recommend keeping the outlife to a minimum.

Typically material that has surpassed its outlife will exhibit reduced resin flow leading to increased void content and surface pinholes, if outlife is a suspected cause of defects a side-by-side trial with fresh material should be conducted.

Defect Diagnosis

Defect: **Pinholes/voids in negative features**

This is the most common issue found in prepreg laminates, its root cause can be one or a number of the following factors:

(listed in order of likelihood)

- **Improper layup, bridging in corners**
  Ensure that the layup is properly consolidated into the corners, relieving potential bridging areas with cuts/joins may help.
- **Improper vacuum bagging**
  Ensure that both the release film and the bag fully conform against the laminate without bridging or stretching. If breather is used between the vacuum bag and release film then eliminating it from complex areas may help to get better conformity from the vacuum bag.
- **Incorrect cure cycle**
  Ensure that the cure profile is being accurately followed by the oven controller. Check that the temperature lag to the tool is within acceptable limits. If the 'Normal' cure cycle is being used try running the 'Extended' cycle as it may help to improve flow in complex geometries.
- **Insufficient debulking on thicker laminates**
  Ensure that the proper debulking procedure has been followed, this is especially important for female mould tools and geometries, in some cases increasing the number of debulk stages may prove advantageous.
- **Expired material**
  Ensure that both the shelf-life and outlife have not been exceeded (out-life is a much more likely cause of defect above shelf-life) if you are uncertain of storage condition and times a side-by-side trial with fresh material should be conducted.

Defect: **Pinholes/voids in all / most areas**

Pinholes and voids in most or all of the part are rarely caused by laminating or vacuum bagging error but normally indicate a more general problem, its root cause can be one or a number of the following factors:

(listed in order of likelihood)

- **Incorrect cure cycle**
  Ensure that the cure profile is being accurately followed by the oven controller. Check that the temperature lag to the tool is within acceptable limits. If the 'Normal' cure cycle is being used try running the 'Extended' cycle as it may help to improve flow in complex geometries.
- **Incompatible pattern surface**
  Ensure that the pattern is made from a compatible tooling system, (please refer to the 'Compatible pattern materials' section) the most common mistake is using polyurethane model-board which inhibits the cure of epoxy prepreg systems.
- **Insufficient debulking on thicker laminates**
  Ensure that the proper debulking procedure has been followed, this is especially important for female mould tools and geometries, in some cases increasing the number of debulk stages may prove advantageous.
- **Expired material**
  Ensure that both the shelf-life and outlife have not been exceeded (out-life is a much more likely cause of

defect above shelf-life) if you are uncertain of storage condition and times a side-by-side trial with fresh material should be conducted.

Defect: **Wrinkled ‘stress’ marks on angular features**

Marks such as these are caused by fast ramp rates or inaccurate or fluctuating temperature control which caused the pattern to expand and contract, ensure that your oven is maintaining accurate and stable temperature control. In some rare cases the ‘switched’ cure cycles may generate this defect.

Defect: **White hazy areas**

Hazy or milky patches or areas may be caused by release agent build-up on the pattern, inspect the pattern surface and clean/polish if identified. Another possible cause is moisture contamination either during material storage or during layup, ensure that proper storage procedures and clean working environments are upheld.

Defect: **Mild print-through of weave on the surface**

A small amount of print-through of the reinforcement’s weave pattern onto the surface of the part is perfectly normal. Surface print-through will be more obvious when higher temperature post-cures are conducted. Print-through can be greatly reduced by slowing the temperature ramp-rate.

Disclaimer

This data is not to be used for specifications. Values listed are for typical properties and should not be considered minimum or maximum.

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