INSTRUCTIONS

PREPREG CARBON FIBRE EVALUATION KIT

Introduction

Our XC110 Prepreg Carbon Fibre Evaluation Kit has been put together to allow those wishing to experiment with prepreg, or verify the claimed performance and results of the XPREG XC110 'out-of-autoclave' system, to do so with the minimum possible investment.

Apart from a vacuum pump, oven, and mould suitable for high temperature use, the kit includes absolutely everything necessary to laminate, vacuum bag and cure a small prepreg carbon fibre part.

The kit includes sample quantities of the industry-standard XPREG XC110 'out-of-autoclave' prepreg carbon fibre in 210g 3k surface ply and 416g 6k backing ply. This specialist prepreg has been developed specifically to be cured under vacuum pressure only in an oven, avoiding the need for a highly costly autoclave. When used as recommended, XC110 can produce pinhole-free, professional-quality, high-performance carbon fibre parts using only a vacuum pump and a 120°C (248°F) oven.

Kit Contents

- 2x 40x30cm Samples of XC110 210g 3K 2x2 Twill Prepreg Carbon Fibre
- 2x 40x30cm Samples of XC110 416g 6K 2x2 Twill Prepreg Carbon Fibre
- TBC2 Through-Bag Connector + ¼ Turn Valve + 8mm Hosetail Barb
- 1.5m 8mm ID Silicone Vacuum Hose
- Oven Seal Vacuum Breach Line
- 100cm x 152cm VB160 Vacuum Bagging Film
- 50cm x 153cm of R210 Unperforated Prepreg Release Film
- 50cm x 153cm BR180 140g Breather layer Cloth
- 50cm x 150cm R120 P3 Perforated Release Film

Requirements

Suitable Moulds

In order to laminate and cure prepregs successfully, it is essential to have a mould that is both compatible with epoxy and also suitable for use at elevated temperature.

Composite moulds are most often used with prepregs, although moulds can be made from other materials such as aluminium or stainless steel. In all cases, the mould must be made from a material capable of withstanding 120°C (248°F) without softening or distorting. Moulds made from polyester resin are NOT compatible with epoxy-based prepregs and should not be used.

For best results, we would recommend moulds made using a high-temperature epoxy, such as our EG160 Tooling Gelcoat, EL160 Laminating Resin or EMP160 Laminating Paste, or a tooling prepreg such as XT135. For convenience, our High Temperature Epoxy Mould Kit includes everything necessary to make a small, high temperature mould, ideal for use with the XC110 prepregs.

In all cases, moulds will need to be prepared with a compatible release agent, suitable for high temperature use (not included). For most mould materials, we recommend CR1 Easy-Lease Chemical Release Agent.

Vacuum Pump

To use the kit, you will require a vacuum pump. For reliability, safety and performance, we would recommend a good quality pump intended for continuous use, such as our EC4 Composites Vacuum Pump. However, particularly during the evaluation stage, any vacuum pump suitable for continuous use and capable of achieving a final pressure of 2 millibar / 99.8% vacuum / 1500 microns could be used.

Oven

The XC110 prepreg included in the kit is designed to be cured in an oven, under vacuum pressure. To achieve the best results, an accurately controlled 'cure cycle' should be followed, which involves a lower temperature 'soak' followed by a higher temperature final cure.

The easiest and most reliable way to follow this cure cycle is using an industrial oven with PID 'ramp and soak' control. However, as ovens of this type represent a significant investment, guidance is provided in these instructions and the accompanying video tutorial on how to affect a similar cure in a basic domestic (kitchen) oven, using a thermometer and some careful temperature adjustments.

A second requirement for the oven is a means of having an active vacuum connection to the vacuum bag for the duration of the cure. In an oven not designed for composites, this can be achieved using the Oven Seal Vacuum Breach Line included in the kit. The breach line uses a microbore PTFE tube that can go past a typical oven and still allow the door to be closed properly, without damage or modification to the oven.

Storage & Handling

The prepreg carbon fibre included in the kit is a perishable material and for long-term storage should be kept in a freezer at -18°C (0°F). However, the 'out-life' of the XC110 prepreg (the amount of time it can safely spend out of the freezer) is 4-6 weeks at 20°C, meaning that if you plan to use the material within a few weeks, it can be stored at room temperature.

If the prepreg has been stored frozen, allow the material to thaw to room temperature before opening the material. The small sample pieces in the kit should thaw to room temperature in about 30 minutes.

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Step By Step Guide

This example project demonstrates how to use the materials in this kit together with a compatible high temperature mould, vacuum pump and oven to make a cured, prepreg carbon fibre component.

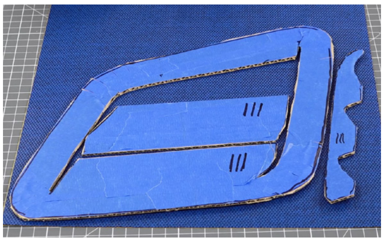
1. Preparing the Mould

The first step is to treat the surface of the mould with an appropriate release agent such as our CR1 Easy-Lease Chemical Release Agent. CR1 should be methodically wiped over the surface of the mould, ensuring that the entire face is coated with an even layer. This should then be left to cure for 15 minutes and repeated for a total of 6 coats, using a fresh piece of cloth for each coat will ensure that the surface isn't contaminated with old release agent. Once the final layer has been applied, CR1 should be left for an hour to fully cure before moving onto the next step.

2. Templating

The initial step in the kitting process is to make an accurate set of templates, the easiest method is to apply masking tape to the mould surface and mark up where the cuts need to be made.

Where fibre alignment is important for either aesthetic or structural reasons, the required fibre orientation can be marked on the template and then used to orient the template on the reinforcement before cutting.



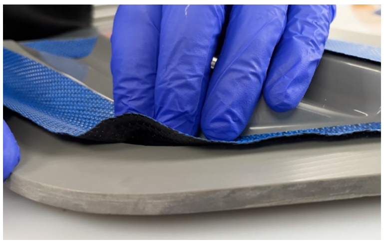
Masking tape templates are then transferred to a sheet of card and slightly oversized by ~5mm to allow for some overlap.

3. Cutting the Prepreg

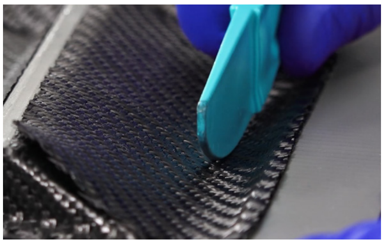
If stored frozen, the prepreg should now be thawed to room temperature before removal from its packaging.

The card templates can then be 'nested' onto the prepreg for best material utilisation and fibre orientation, outlined with a marker and then cut out with a sharp blade or good quality scissors.

4. Laminating Surface Ply

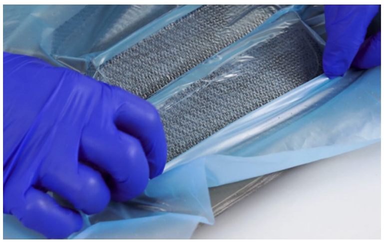


The prepreg patterns can then be placed into the mould, generally the paper side of the material goes face down onto the mould. Leaving the plastic backing on for the initial placement stabilises the material to prevent distortion, keeping the surface tack free also makes handling easier.



Once in position, the film can be removed and the material firmly pressed into the mould contours with a blunt dibber tool. This is the most critical aspect of laminating with prepregs in order to ensure that there is no bridging of the fabric over any of the mould detail. Any areas where this does occur would produce voids in the finished part, resulting in both structural and cosmetic defects. These areas can often be located by tapping the material with the dibber, a dull sound will identify the presence of a void and further consolidation will be required.

5. Debulking



A debulk helps to consolidate and compress the material against the surface of the mould whilst also evacuating any air from the layup.

A layer of the perforated release film should be cut to size and pressed onto the surface of the material.

Next, a layer of breather cloth is placed over the entire mould before the whole work piece is placed into an envelope vacuum bag and sealed with the through bag connector in place. This is then connected up to a vacuum pump and the vacuum applied, as the vacuum is drawn the bag can be slid into position to ensure that there is no bridging. Full vacuum should be held for 20 minutes to ensure that the material is fully pressed onto the surface.

The vacuum can then be switched off and the bag carefully cut open down just one side so that it can be reused for the main cure.

The perforated film and breather should be removed, and stored for future use.

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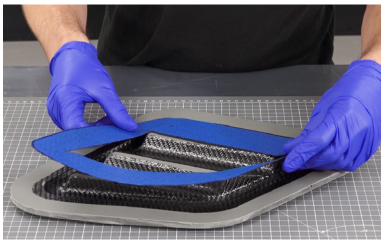
6. Laminating Backing Ply



The heavier backing ply can then be patterned, cut and laminated in the same way as the surface ply. Much like the first layer, it is very important to ensure that the material is pressed down onto the previous layer to reduce any voiding between the layers which can later lead to delamination.

7. Vacuum Bagging

The part can now be placed in a vacuum bag in a similar way to when doing the debulk. The main difference being the use of an unperforated release film which will preserve the resin to fibre ratio, keeping it balanced throughout the cure.

Placing breather on the underside of the mould only, allows the bagging material to follow the contours of the part better and should result in a higher quality finish. A full vacuum is then again drawn and the bag positioned at intervals to ensure it follows the contours as the bag tightens.

8. Drop Test

Good practice is to perform a drop test which will highlight any leaks within the system. Leaks in the system will not only compromise the final part but can also damage your vacuum pump, so they are best to be avoided if possible.

Without a gauge, the drop test can be done by isolating the bag at the connector and turning off the pump, it's then left for 30 minutes to settle. The bag should remain tight to the surface but If the bag has slackened after this time then the leak will need to be located and addressed.

BREACH LINE

If using a domestic oven or one which hasn't been set up for composites with vacuum ports, then the breach line allows for vacuum to be maintained, without the need to drill holes and compromise the oven itself. The breach line can be connected up to the vacuum pump and the part then the microbore passed between the oven door seals.

9. Final Debulk

Before placing in the oven to cure where the resin will start to flowing, the part should be held under vacuum for 1 hour as a final debulk. This will allow the laminate to consolidate even further and help to remove any air from the laminate.

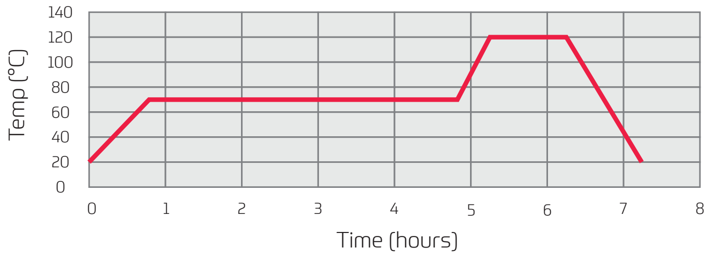
10. Curing

The next stage is the curing process itself, this is done in two stages. The initial phase at 70°C allows the resin to liquify and flow freely through the reinforcement, fully saturating the fibres. Then after 4 hours, the temperature is increased to 120°C and held for an hour to fully cure the resin.

For best results, an accurately controlled multi-stage temperature cycle with final cure temperature of 120°C should be followed:

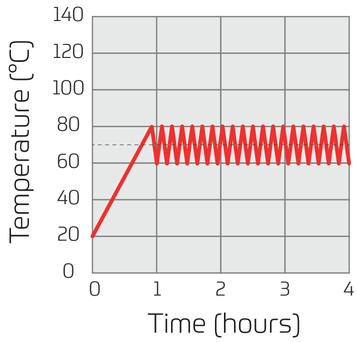
CURING IN A COMPUTER CONTROLLED OVEN

Step	Start Temp	Ramp Rate	Duration	End Temp	Elapsed Time
1	~ 20°C	1°C /min	00:50	70°C	00:50
2	70°C	Soak	04:00	70°C	04:50
3	70°C	2°C /min	00:25	120°C	05:15
4	120°C	Soak	01:00	120°C	06:15
5	120°C	Natural Cool	--	~20°C	07:15



CURING IN A REGULAR OVEN (NO COMPUTER CONTROL)

Unfortunately, regular thermostatically controlled ovens don't have the luxury of a controlled ramp rate and rarely sit at the temperature that they are set too. Typically, the temperature inside the oven will cycle a few degrees above and below the set temperature as the thermostat cycles on and off. This creates a less than ideal sawtooth profile, as seen in the graph opposite. In the example shown, the temperature in the oven is set to 70°C but inside the oven cycles between 60°C and 80°C; the 80°C spike being too hot for this stage of the cure.



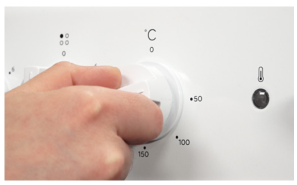
OVEN PROFILING

Every oven will be different, so you will need to profile the oven that you intend to use, in order to find the difference in temperature caused by the lag from the thermostatic control.

The recommended method for this uses a digital thermometer with a remote probe and is undertaken with the following steps.

1. With the probe of the thermometer in the centre of the oven the temperature can be set to around 100°C.

2. Monitor the temperature displayed on thermometer until it reaches 50°C, at this point turn the temperature down until the thermostat just switches off. This is usually indicated by the display light switching off and there may be a slight click.



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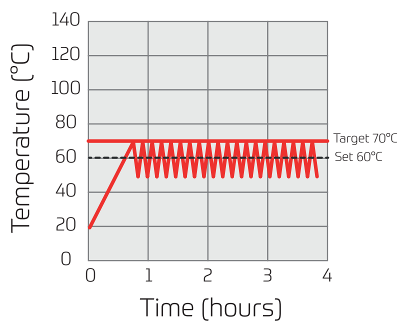
3. With the heating element turned off, the recorded temperature in the oven should still rise for a short period of time. Again, monitor the thermometer to see what the maximum temperature reaches, before it begins to drop. In our case this was around 10°C higher and peaked at 60°C.



From this test we know that our oven peaks roughly 10°C higher than the set temperature, so in order for us to cure the prepreg with the peak temperature not exceeding the target temperature, we will need to set the oven temperature 10°C lower than the target temperature.

ADAPTED CURE CYCLE

As shown in the 'CURING IN A COMPUTER CONTROLLED OVEN' section, we know that XC110 requires an initial cure at 70°C for 4hrs, followed by a final cure at 120°C for 1hr.

In order to avoid achieving a peak temperature in excess of these target temperatures, the oven profiling done in the previous section suggestions that for our oven, the temperature should be set to 10°C below the target temperature.

Because the actual temperature will fluctuate below the target temperature, when curing in this type of oven the final 120°C cure time should be increased from 1 to 1½ hrs, to ensure a full cure is still achieved.

1. Set the oven temperature so that its peak temperature is 70°C (in our case, this meant setting the oven to 60°C).

2. After 4 hrs, increase the oven temperature so that its peak temperature is 120°C (in our case, this meant setting the oven to 110°C).

3. After 1½ hrs, switch the oven off and allow the part to cool.

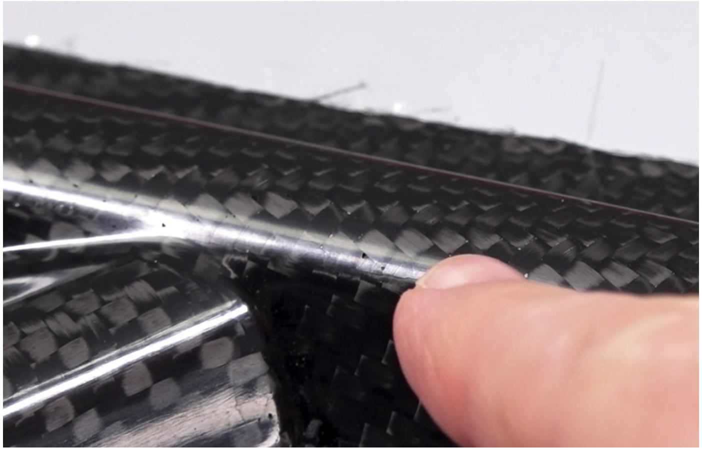
11. Demould & Trim

Once the part has naturally cooled, the vacuum pump can be turned off and the part can be taken out of the oven. It can then be removed from the bag and other consumable items discarded. Quite often the difference in thermal expansion between the mould tool and the part will do most of the demoulding for you and the two should separate easily.

Carbon fibre parts like this can be trimmed really easily with a Perma-Grit wheel on a rotary cutting tool. A quick polish with a polishing compound will help to remove any residue or dullness left behind from the release agent and leave your finished composites part with a high gloss shiny finish.

12. Pinholes

If all steps have been followed correctly and a skilled job has been made of the laminating and vacuum bagging, XC110 prepreg should produce pin-hole free results for 1-2 ply laminates when cured accurately in a computer controlled oven.



However, due to the inherent inaccuracy of curing in a conventional thermostatically controlled oven, components cured in this way may exhibit some minor pin-holes under close inspection.

Whilst their impact would be negligeable to the performance of the part and only visible under close inspection they could be filled with a composite clear coat to product the perfect cosmetic finish.

This situation may be improved by making some minor adjustments to the set temperatures but for reliable results in the long term, a computer controlled industrial oven, such as the OV301 from ECP, is highly recommended.

Disclaimer

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