



Beginners' Guide to Out-of-Autoclave Prepreg Carbon Fibre

Explanation of this Guide

One of the most advanced techniques for making composite components is by using prepreg carbon fibre reinforcement, cured under heat and pressure to produce professional quality parts with a high quality surface finish, low resin content and excellent structural performance.

Uncured prepreg carbon fibre is easy to handle and can be cut and laid precisely into detailed and intricate moulds making the process ideal for smaller, complex parts that might be very difficult using alternative processes such as traditional laminating, vacuum bagging or resin infusion. The ease and accuracy with which the material can be templated and cut means that material can be used very efficiently; significantly reducing waste compared to other manufacturing techniques. Prepreg laminating is also a very clean, odourless process.

Despite the many advantages to prepreg production and its potential for delivering excellent results on difficult mouldings, it is a process that is widely misunderstood and often overlooked or dismissed by smaller composites companies or individuals who do not realise that *with the right materials and advice* it is a process that can be undertaken and mastered with very little specialist equipment. The purpose of this guide is to show you how.

Introduction to Prepreg

What is 'prepreg'?

Prepreg is the name given to composite reinforcement materials, such as carbon fibre, that have been pre-impregnated with activated resin. The resin system used is almost exclusively epoxy resin, which has already been mixed with its hardener at the manufacturing stage, before being impregnated into the dry reinforcement fabric to make the 'prepreg' reinforcement.

The most common way to make a composite part from prepreg reinforcement is to layer the uncured prepreg reinforcement into a mould, vacuum bag the mould and laminate and then cure it in an autoclave or an oven. Although autoclaves are beyond the budget of individuals and most small businesses, curing prepregs in an oven, known as 'out-of-autoclave' or 'oven-only' curing, is a very effective and accessible way to use prepreg technology that almost anyone can use.

Shelf-Life and Out-Life

Special formulation of the epoxy ensures that at ambient temperature the curing process is incredibly slow (often several weeks) and that at freezing temperatures (typically -20°C) the process is halted almost completely. The amount of time the resin system can spend at room temperature before noticeable partial curing of the resin takes place is known as the material's 'out life' whilst the time that the prepreg can be stored in the freezer and remain useable when thawed-out is known as its 'freezer life' or 'shelf-life'.

Handling Prepreg

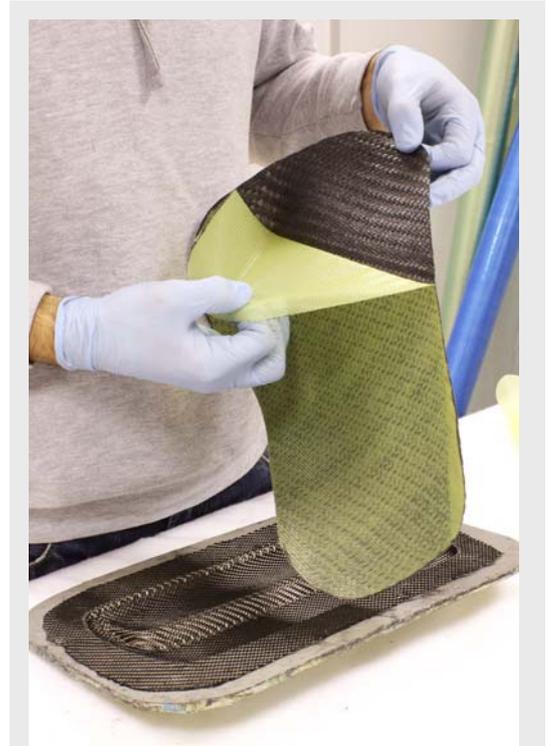
At room temperature, prepreg resin systems have such a high viscosity that, even though they are made of uncured resin, they can easily be handled. Such is the firmness of prepreg resin systems when they are handled that prepreg carbon fibre is sometimes referred to as 'dry carbon'; although as descriptions go, this one is particularly confusing.

Tack Level

The viscosity at room temperature and other properties of a specific resin system determine the level of 'tack' of the prepreg. Tackier prepregs require more delicate handling but will easily stick to mould surfaces, less tacky pre-pregs are easier to handle but may not stick as easily to a mould's surface.

Curing Prepreg

Only at elevated temperatures, known as the cure temperature, does the resin really start to react and cure properly which is why prepregs must always be cured in an oven of some description. Typical cure temperatures for prepregs range from 60°C up to around 180°C with the most common cure temperature for out-of-autoclave pre-pregs being around 100°C. Temperatures such as these can easily be reached by domestic and commercial cooking ovens as well as other types of oven including paint drying and powdercoating ovens. Although it is *possible* to successfully cure a prepreg part without having an active vacuum line inside the oven, it is certainly preferable.



Backing film is removed from prepreg carbon fibre before laminating.

Getting Started

As with many composites processes, the key to successfully making prepreg carbon fibre parts is in using the right materials and techniques *throughout the process*. Changing something as simple of the type of release film or release agent and certainly changing something significant like the type of prepreg carbon fibre used can have a big impact on the end result and so we would suggest that for the best results, particularly at first, you stick with all the materials we list in this guide.

Pre-requisites

Our out-of-autoclave prepreg carbon fibre process requires very little by way of specialist equipment but will require an oven of some description to cure the parts in, an appropriate mould and some basic tools.

Curing Oven

To follow this guide it is essential that you have an oven of some description which will allow you to set and maintain a temperature of 100°C. The oven may be a domestic or catering oven designed for food, or an industrial oven designed for paint, powdercoating or specifically for composites. The most important thing is that the oven is safe and reliable and that it can reach and maintain the required temperature.

You will only be able to make parts as big as those that can comfortably fit inside the oven so if you are only using a standard domestic oven you will be limited to making quite small parts. As you develop your use of prepregs you can upgrade to larger or more sophisticated equipment but to start off, most ovens will do.

Although it is not essential, it is certainly advantageous (and standard practice) to have a hole through the side or back of the oven through which a vacuum hose can be passed enabling a vacuum connection to the parts to be maintained during their cure. If this is not an option then it is *possible* to cure a part without a vacuum connection inside the oven providing that the part has been vacuumed-down outside of the oven and that the vacuum bag is *perfectly* sealed. It is then also essential that the bag does not develop a leak or lose vacuum pressure during the full curing cycle.

Mould

Because the prepregs used in this guide need to be cured at, or around, 100°C, it is essential that the mould the prepreg will be laminated into is able to withstand this temperature without softening, distorting or deteriorating. The resin system used in the prepreg is epoxy and so it is also important that the mould material is compatible with epoxy resin. For these two reasons, standard polyester moulds are not suitable for use in making prepreg carbon fibre parts and should not be used. Instead, moulds can be made from high temperature epoxy, metal (such as aluminium or stainless steel) or a high temperature vinylester tooling system such as Uni-Mould.

IMPORTANT

For high temperature use, Uni-Mould™ moulds need to be post cured prior to use.

For pre-preg use at 100°C cure our recommended post-cure cycle for a new Uni-Mould mould would be 8hrs at 60°C, 4hrs at 80°C and 2hrs at 100°C.

If you are in any doubt we would suggest Uni-Mould™ because of its excellent compatibility, low cost and polishability. For the purposes of this guide we will be using a mould made using the Uni-Mould system.

Tools

To work with prepregs, you will also require:-

- Marker pen
- Stanley knife
- Scissors
- Heat gun
- Masking tape

Materials & Equipment

To ensure the best possible results from your out-of-autoclave prepreg carbon fibre we will be using carefully selected products from the Easy Composites range.

Most prepregs are intended for curing at very high pressure in an autoclave and under these conditions will yield an excellent, pin-hole free, surface finish. Unfortunately however, these same prepregs, when cured under vacuum pressure only in an oven will result in a pin-holed surface finish that many people would find unacceptable. For this reason, Easy Composites' purpose developed 'Easy-Preg' out-of-autoclave surfacing prepreg is used as the surface ply. This special prepreg has a solid resin film layer on one side of the material which makes full and intimate contact with the mould surface and a dry fabric on the reverse to facilitate complete air removal under vacuum. This special surface layer is then combined with one or more layers of our Vari-Preg prepreg which is designed to co-cure perfectly with the Easy-Preg with a perfectly clear resin system further enhancing the appearance of the cured laminate.



Easy Composites' Easy-Preg surfacing ply has a special solid resin film on one side only which is laid against the mould surface.

With this special combination of Easy Composites prepregs it is perfectly possible to achieve professional finish quality carbon fibre parts using only vacuum pressure and an oven cure.

In this project we will be using a single layer of the 240g Easy-Preg surfacing prepreg backed up with a single layer of 400g Vari-Preg. This will result in a cured laminate thickness of around 0.75mm which is an ideal thickness for many non-structural or semi structural parts such as scoops, ducts, interior trim, cases and covers. For thicker, more structural parts simply add additional layers of the backing ply to achieve the desired thickness.

Materials:

- Easy-Preg 240g Surfacing Prepreg Carbon Fibre
- Vari-Preg 400g Backing Prepreg Carbon Fibre
- Unperforated Release Film
- Vacuum Bagging Film
- Vacuum Bagging Gum Tape
- Vacuum Bagging Breather Cloth
- Easy-Lease Chemical Release Agent

Equipment:

- Composites Vacuum Pump
- Through-Bag Connector
- 8mm ID Silicone Vacuum Hose
- 2x 8mm ID Hosetail Barb Connectors

For the easiest and most reliable start possible to your prepreg carbon fibre laminating, all of the above materials and equipment can be purchased together in our Prepreg Carbon Fibre Starter Kit.

Handling Prepreg:

Easy Composites' Easy-Preg and Vari-Preg prepregs should be stored frozen (-18°C) in sealed bags. Before use the material should be removed from the freezer and allowed to come to room temperature still in the sealed bag (this prevents condensation from forming on the prepreg). Once at room temperature the material is ready to use and can be stored at room temperature for a number of weeks without deterioration or it can be re-bagged and put back into long term storage in the freezer.

For full details on storing and handling our range of prepreg carbon fibre materials, see the Technical Datasheets that accompany the products.

Step by Step Guide

1. Mould Preparation
2. Creating Cutting Templates
3. Cut Prepreg Material
4. Putting Down the Surfacing Ply
5. Adding the Backing Ply/Plies
6. Release Film
7. Breather Cloth
8. Make the Vacuum Bag
9. Loading the Parts and Positioning the Through-Bag Connector
10. Complete the Vacuum Bag
11. Vacuum Bag Pull-down
12. Vacuum Leak Drop-Test
13. Loading into the Oven for Curing
14. De-moulding



Throughout the guide you will see photos showing us making two different parts; both genuine parts taken from our manufacturing division, Carbon Mods' range of in-house performance parts. The two parts are a 12" Bonnet Scoop and a 50mm NACA Duct. The bonnet scoop is a relatively flat shape with some sharply defined detail whereas the NACA duct is a very contoured shape which shows how easily prepreg carbon fibre can conform to difficult shapes. Both of these parts are difficult or impractical to manufacture using any other technique.

1. Mould Preparation

Other than ensuring that the mould you will be using is made from a suitable material, mould preparation for prepreg laminating is much the same as for other processes.

Because curing will take place at around 100°C it is very important to use a release agent that will be effective at this temperature. Most mould release waxes will not perform well at this temperature and so we recommend never using mould release wax with prepregs. Instead, a chemical release agent such as Easy-Lease should be used. Having ensured the mould is clean and free from contaminants. Apply the release agent according to the product's instructions.



Easy Composites' Easy-Preg surfacing ply has a special solid resin film on one side only which is laid against the mould surface.

2. Creating Cutting Templates

One significant advantage of working with prepreg material is that the reinforcement for a specific part can be accurately cut from the roll with minimum wastage. The way this is done is by creating cutting templates for the different plies of material. You only need to create a template (or set of templates) for a specific part once; accurately made templates will make it much simpler the next time you make the same part again.

Cutting templates can be created in any of a number of ways. The first option is to start off with an oversized piece of prepreg and start laying it down onto the surface of the mould, softening and pulling it as required until it completely covers the surface of the mould before cutting off the excess all the way around and then removing the material from the mould, flattening it out again and tracing round the shape onto a piece of cardboard or similar to preserve the template for future use.



A soft material like Coremat is excellent for making templates for very contoured shapes.



Simple shapes like the bonnet scoop can easily be templated using a piece of cardboard.

Alternatively, templates can be created using a malleable fabric material (thin Coremat works well) which can be smoothed and stretched over the mould surface and then cut or marked to final size. This soft template can then either be used as it is or transferred to a more durable material. For more basic shapes, simple cardboard templates are easy to make.

In most cases, when laminating a part the surface ply should be made a few millimetres larger than the backing ply/plies. This is done to ensure that the air path that is created by the special dry side of the Easy-Preg Surfacing Prepreg is not maintained all the way out of the laminate ensuring that any air trapped in the reinforcement can be removed when the part is vacuum bagged. In practice, it is not necessary for the surfacing ply to extend beyond the backing ply all the way around the part but it should be aimed for as a matter of good practice. Although you could make templates, one for the surface layer and one for the backing layer, it is usually sufficient to simply mark out the surface layer by drawing slightly wider than the template when you transfer the template to the prepreg material, making a separate template for the surface layer unnecessary.



This close-up shows how later in the guide we will ensure that the backing ply/plies are slightly smaller than the surfacing ply, ensuring air paths to the surface are maintained.

3. Cut Prepreg Material

Once you are happy with your template (or templates if the part will be laminated in multiple pieces) you are ready to transfer the templates to the prepreg material itself. If you have been storing your prepreg in a freezer, before using it, ensure that you have allowed it to thaw to room temperature in a sealed bag before removing it from the bag.



Instead of cutting, a Stanley knife blade is used at a right angle to 'score' the Easy-Preg to mark it.



The backing ply can easily be marked using a permanent marker pen on the removable film.

Transfer the outline of the cutting template(s) first to the surfacing prepreg and then to the backing ply. The Easy-Preg surfacing prepreg only has a removable film on one side and the film itself is waxy and difficult to mark by pen so the recommended means of transferring the template to the surface ply is by scoring the dry side of the fabric with a blade or some other sharp object. Remember that the surface layer should be larger than the backing layer by a few millimetres all the way around to ensure that air can be fully evacuated from the laminate. To do this, simply mark slightly wider than the cutting template when marking the surfacing ply.

The Vari-Preg bagging ply has a removable film on both sides and so can easily be marked out using a marker pen directly onto the backing film. Unlike the surfacing ply, the backing ply is not 'sided' and so either side can be marked.



The Easy-Preg surfacing ply is easily cut with a pair of composites shears or normal scissors.

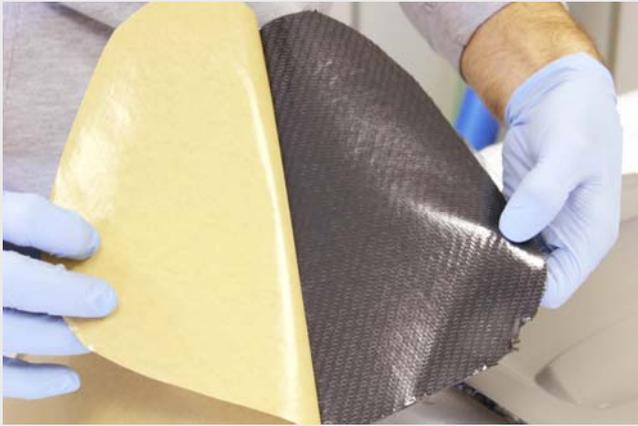


The backing ply is best cut using a Stanley knife on a cutting mat to avoid clogging shears.

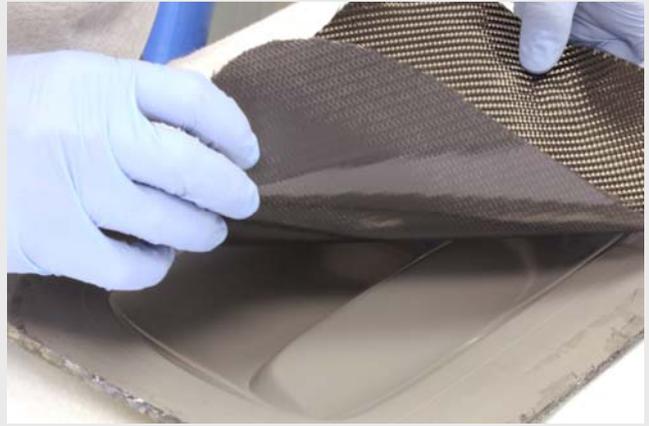
Once you've marked out the two pieces of material, cut them using a Stanley knife or pair of shears.

4. Putting Down the Surfacing Ply

Unlike most prepreg materials, Easy-Preg surfacing prepreg is 'sided' which is to say that it needs to be used a specific way round. The resin film side of the material must be laid down against the mould's surface with the dry side facing up.



Carefully peel the backing paper away from the Easy-Preg surfacing ply. Only one side has a resin film.



Gently lay the Easy-Preg down onto the mould, *film side down*.



Start conforming the prepreg to the mould by pressing and smoothing it down on the flatter areas of the mould.



Continue to work the prepreg, gently smoothing and shaping it into the contours of the mould.

To begin, peel the backing away from the prepreg carefully and then gently drape the material, film-side down, into the mould. Start by smoothing the prepreg gently onto a larger, flatter area of the mould and then gently pull and smooth the material over the more complicated areas of the mould. You may find it helpful to use a heat-gun or hair drying to soften the prepreg slightly so that it can be distorted and formed more easily. You may actually be surprised how malleable and resilient prepregs are in this respect, compared to dry fabrics, and with a little patience you should be able to put the Easy-Preg down over the whole surface of the mould.



Use blunt tools (often home-made) to press the prepreg firmly into any tight corners or angles of the mould.



Once down, trim off any excess material so that the prepreg does not reach the edge of the mould's flange.

The essential thing to ensure when putting down any layer of prepreg reinforcement (surfacing or backing) is that the material is firmly into all corners without any 'bridging' whatsoever. Because the prepreg has a precisely controlled amount of resin impregnated into it, there is no surplus resin to flow into and fill any gaps or voids so it is vitally important that when the prepreg is laid into the mould it is in intimate contact with the mould surface in all areas. The most likely problem you may encounter when you first work with prepreg is 'pitting' on tight corners where the prepreg itself or the vacuum bag has 'bridged'.

You may find a range of different shaped blunt tools useful to help you press the prepreg firmly into tight corners on your mould. Objects such as credit cards, ice scrapers, and even grouting tools are often used.



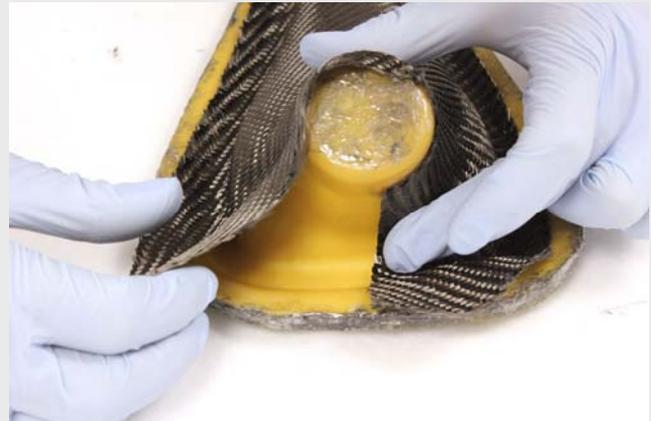
A very contoured shape like this NACA duct requires gentle application of heat to make the prepreg more pliable.



To create a perfectly straight seam at the back of the duct where the material meets, masking tape is used to mark a vertical line.



The surface ply can then be gently peeled away from the mould and cut perfectly along the tape line.



The other side then overlaps the cut edge, resulting in a perfect seam.



Composites Snips are useful for snipping off small excesses of material



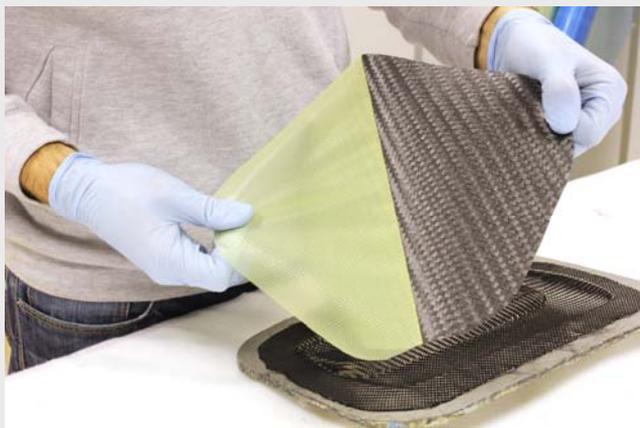
The natural tack of the Easy-Preg makes even a difficult shape like this NACA duct quite straightforward.

Because both our Easy-Preg and Vari-Preg have an excellent natural ‘tack’ you will find that it will stick to the mould surface without the need for any spray-tack or other adhesive. Warming the prepreg slightly will improve its tack, especially if you are laminating in cooler conditions.

5. Putting Down the Backing Ply

The backing ply or plies are laminated in a similar way to the surfacing ply however, because these layers will not be seen, careful alignment of the weave is not as important as it is (for cosmetic parts) for the surfacing ply.

You will also find, particularly if you’re using the heavier 400g Vari-Preg, that the material is even more robust and can be pulled, pushed and stretched almost with impunity until you are happy with how it has been laid down. You can also add more layers in areas that require more additional reinforcement and you can cut and overlap sections of the backing ply as required.



Remove the protective film from *both sides* of the Vari-Preg 400g backing ply.



Gentle use of a heat gun is recommended on the backing ply/plies to make the prepreg softer and more drapable.



Just like with the surface ply, blunt tools are recommended to press the prepreg firmly into any tight corners of the mould.



Having cut the backing ply smaller than the surface ply, a small amount of surface layer should extend past the backing layer all the way around the mould.

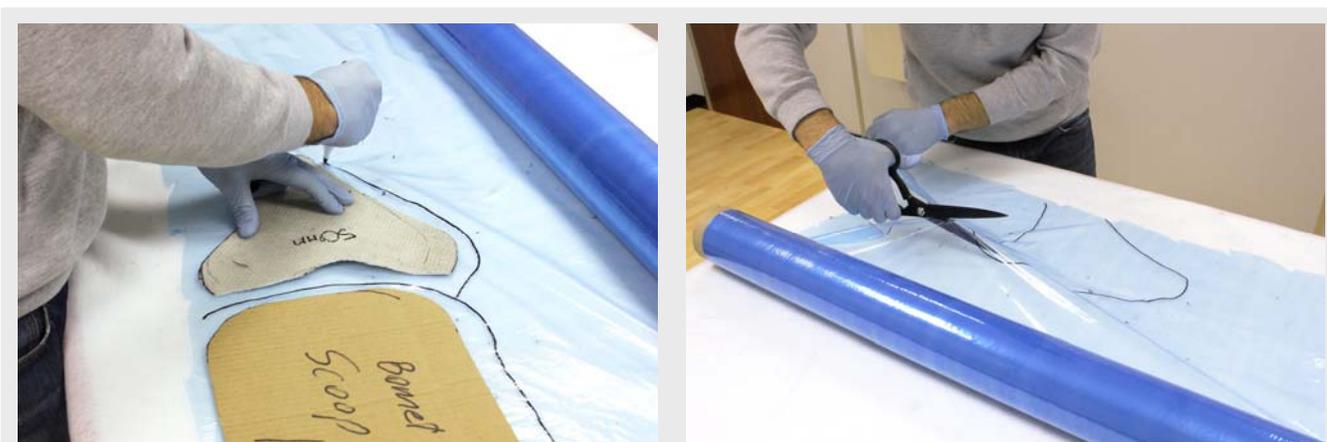
A heat gun is certainly recommended when putting down the backing ply or plies where you will find that lightly warming the prepreg before or whilst it is put down will soften the resin and allow the material to drape more easily.



Remember, just like with the surfacing layer it is essential that the backing layer or layers are firmly pressed down into all areas of the mould, especially tight or awkward corners. Take lots of time doing this as it will make all the difference between a perfect part and a failure.

6. Release Film

Once you have laminated all the plies of prepreg into the mould and you are confident that all the material is in intimate contact with the mould surface (particularly any tight corners) you are now ready to start the vacuum bagging process. The first layer of which is an unperforated release film.



Use your prepreg templates as a rough guide but ensure you cut the release film at least 25-50mm oversize.

Cut the film with shears or a craft knife.

Cut off an adequately sized piece of unperforated release film to cover the surface of your mould in one piece. If you like, use the cutting template created for the reinforcement as a guide but cut round the template making it 25-50mm larger than you cut the reinforcement.

Release filming your parts is a quick and easy process; simply press the film over the whole surface of the part so that none of the prepreg is exposed. Don't worry if the release film wrinkles and creases a lot as you do this, this is perfectly normal. The only important thing at this stage is that you ensure that the release film does not 'bridge' in any areas of the mould (just like you did with the reinforcement and will with the vacuum bag). Do this by ensuring there is plenty of surplus release film wrinkled into any difficult or tight areas of the mould.



The film should comfortably cover the whole part. Don't worry if it's oversized or wrinkled but ensure the film is not 'tight' and does not 'bridge' anywhere on the part.



Tape the edges of the release film onto the back of the mould with some masking tape to hold it in place.

Because you cut the release film some 25-50mm larger than the reinforcement, you should find that it overhangs past the edges of the laminate. Use this overhanging release film to wrap round onto the reverse of the mould and hold the film very loosely in place using masking tape. It is certainly not the right technique to pull the release film tight during the process of taping it in place as this would be likely to use up the excess of film that is preventing the film from bridging.

7. Breather Cloth

Cut a piece of breather cloth that is large enough to cover the whole surface of your mould in one piece, with a little surplus. Again, use the cutting template as a guide if you like or simply cut a much larger piece of cloth. Alternatively, if you are going to be curing a number of parts at the same time you can cut one large piece of breather cloth and use it to cover a number of parts. Adding the breather is straightforward and none critical, providing it is there and it covers the whole mould surface. Breather cloth can generally be reused so don't worry about using too much cloth.



Roughly cut pieces of breather to cover your part(s). The breather cloth should be cut at least 60mm oversized so that it can loosely wrap the part.



Use small pieces of masking tape to loosely hold the breather cloth in place by taping it to the back of the mould. This also prevents sharp edges on the mould from accidentally puncturing the bag.

When positioning the breather cloth over your parts, again you should pay attention to ensure that there is sufficient material, particularly in any difficult corners of the mould, to prevent it from bridging. The thick, felt-like nature of breather cloth makes precise positioning impossible so you only need to have the cloth in roughly the right place. Use some small strips of masking tape to secure the edges of the breather cloth to the reverse side of the mould to hold the cloth in place.

IMPORTANT

Because when envelope bagging parts the vacuum bag will be pulled tight against both the front and the rear faces of the mould it is very important before you begin the vacuum bagging process to ensure that the reverse side of the mould is free from any sharp edges, loose strands of reinforcement or anything else that might puncture the vacuum bag. If you realise too late that the reverse side of your mould might be in danger of puncturing your bag, you can always add a piece of breather cloth to the back of your mould on this occasion and then smooth and prepare the mould properly next time.

8. Make the Vacuum Bag

Explanation of Envelope Bagging

When making small to medium sized prepreg parts the easiest way to vacuum bag them is to do so using an 'envelope bag' which is to say that the vacuum bag encloses the whole mould, rather than being taped to the flange around the outside of it. There are several advantages to this method including the fact that large, airtight flanges are not required around the edge of prepreg moulds, split moulds do not need to be sealed together and multiple parts can easily be bagged and cured at the same time.

Some disadvantages of this method are that you will use more bagging film, you need to be more careful when handling the bagged parts and very large parts are not practical to bag in this way because they need to be lifted and loaded inside the bag. On balance, it is almost always right to envelope bag your prepreg parts, but be aware of these considerations.



An 'envelope bag' completely encloses the part(s) instead of bagging film being pleated and taped to the mould's flange.

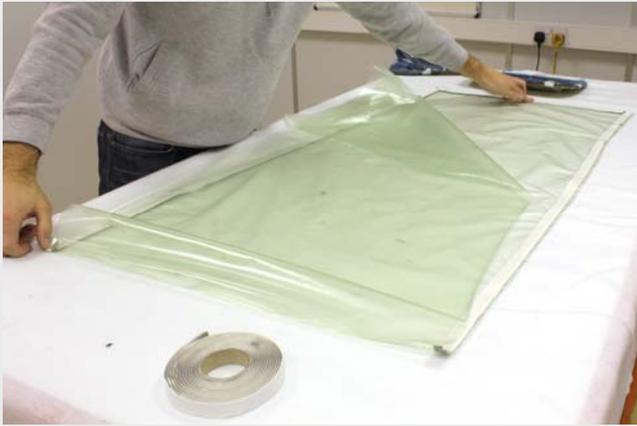
Bagging Technique

When you cut the bagging film to make your vacuum bag, be sure to cut *plenty* of material. If you've not done it before, you will be amazed by how much bag is needed to envelope bag one or more parts, especially considering that you will want lots of extra film in all the awkward corners of your moulds. A bag that starts off at least twice as big in all directions as the footprint of your part would be about right.

TIP

When envelope bagging parts, one likely way in which the vacuum bag can be accidentally punctured is when handling the vacuum bag and moving it around on your bagging table. For this reason, we suggest stretching a piece of breather cloth or some other soft material over the surface of your table when vacuum bagging. This makes accidental puncturing of the bag during handling much less likely and is a common sight in prepreg workshops. When the cloth becomes dirty, simply replace it.





Always ensure you make the bag much larger than the parts. When using lay flat tube (LFT) bagging film, use the ready-made edges of the film where possible.



At this stage, seal 3 of the 4 edges. Press and squeeze the bagging tape very firmly to ensure an airtight seal.

Cut a sufficiently large piece of bagging film, leaving it double sided, and then apply tape all around any unsealed edges. Next, starting in one corner, peel the backing off the tape and start to seal the top of the bagging film to the bottom of the bagging film. Complete this until you have three sealed edges and one unsealed edge that is large enough to be able to load the parts in through. Take your time to ensure the bag tape is firmly stuck to the bag all the way around and inspect the seal for any gaps or small voids that may prevent the tape from making an airtight seal.

9. Loading the Parts and Positioning the Through-Bag Connector



Load the part(s) into the envelope bag, facing upwards.



When bagging more than one part at the same time

Carefully place your part or parts inside your open vacuum bag through the one unsealed side. If bagging more than one part at the same time ensure there is plenty of gap between the parts to ensure they have a surplus of bag each.

BEFORE YOU DO

Ensure that the Through-Bag Connector is ready to connect directly to an 8mm ID Silicone Vacuum Hose.

If you've purchased the Through-Bag Connector as part of our Prepreg Carbon Fibre Starter Kit then the connector will already have been fitted with a 1/4 Turn Vacuum Valve and brass hose-tail barb for an 8mm ID hose but if you're using another connector or purchased the parts separately, ensure that you have an isolation valve (1/4 turn vacuum valve) and hose-tail barb for an 8mm ID hose already fitted to the Through-Bag Connector. Use PTFE tape when making any such connections to ensure an airtight seal. Without PTFE tape there is no way that the fittings will be airtight.

Clear PVC hose can be used during the pull-down but silicone hose must be used in the oven.

A Through-Bag Connector (sometimes known as a 'breach unit' or 'vacuum valve') is used to connect the vacuum pump to the vacuum bag. No resin will be drawn through this connection to risk fouling it so the Through-Bag Connector is a sturdy and well-engineered piece of equipment.

The Through-Bag Connector needs to be positioned on top of a piece of breather cloth which also leads to the breather cloth of the part or parts to be vacuum bagged. This ensures that air can flow freely from the Through-Bag Connector to the breather on the parts. If you are bagging several parts at once you can cut short strips of breather and use them to connect the Through-Bag Connector to the various parts.

Do NOT position the Through-Bag Connector directly on top of a part, instead sit it on a piece of breather in a gap in the vacuum bag.



Position the connector in a gap in the bag, on some breather connected to the part(s).



Make a 'peak' in the bagging film by pushing your index finger up from the inside of the bag.



Snip off the top 5mm of the peak to make a circular hole in the film of about 12mm.



Pass the threaded part of the connector through the hole in the film and place the other half inside the bag.



Screw the two halves together tightly to complete the through-bag connector fitment.

Use your fingers to make a small peak in the vacuum bag directly above where the Through-Bag Connector will be positioned. Use scissors to snip about 5mm off the top of the peak to make a small round hole in the vacuum bag.

Unscrew the two halves of the Through-Bag Connector. Put the wider, flatter section of the Through-Bag Connector inside the bag and then pass the threaded part of the upper section through the hole you cut in the bag. Screw the inside section back onto the outside section and tighten the connector firmly.

10. Complete the Vacuum Bag

Complete the vacuum bag by removing the backing from the vacuum bagging tape on the last remaining side of the bag and press the bag firmly onto the tape. Gently reposition the part or parts within the bag and ensure that the Through-Bag Connector is still correctly position above a patch of breather cloth is some free space within the bag and that the breather cloth from underneath the connector is directly connected to the breather cloth on your part(s).

Have a really loose-fit at positioning the vacuum bag over the mould surface to ensure the bag is big enough to allow for plenty of excess bag in any contoured areas of your moulds. If you are in any doubt at this stage as to whether the bag is big enough, now is the time to change the bag!



Tape-up the last open side of the bag and press and squeeze the seal firmly.

11. Vacuum Bag Pull-down

The single most important part of the prepreg manufacturing process, particularly when working out-of-autoclave, is the vacuum bagging process. How well you put down the vacuum bag will essentially determine whether your parts are perfect, rejects or somewhere in-between. The reason for this is because vacuum pressure alone is only just sufficient to make perfect prepreg parts. If any area of the vacuum bag 'bridges' it will significantly reduce the pressure the bag exerts on the laminate; without the full vacuum pressure in these areas the laminate will 'void' and appear pitted. For this reason, extreme care and lots of time should be spent on this part of the process to ensure the best possible results. As your experience builds, you will be able to achieve perfect results in much less time.



Connect the pump to the through bag connector using a length of silicone or PVC hose. Remember that silicone hose must be used on the part is in the oven.



After removing some of the air, start to position the bag particularly in difficult areas like the underside of this duct.

Start by connecting the Through-Bag Connector to your vacuum pump using a length of 8mm ID Silicone Vacuum Hose (or clear PVC hose just whilst you are outside of the oven).

Switch the vacuum pump on and begin to evacuate some of the air from the vacuum bag. Close the ¼ Turn Valve on the pump or the bag to isolate the vacuum once the bag has just started to take shape. Carefully but forcefully move and position the bag to ensure a surplus of bag is available over the whole mould

surface. Pay particular attention to awkward corners where you will want to 'collect' extra bag so ensure it's not possible for the bag to bridge.

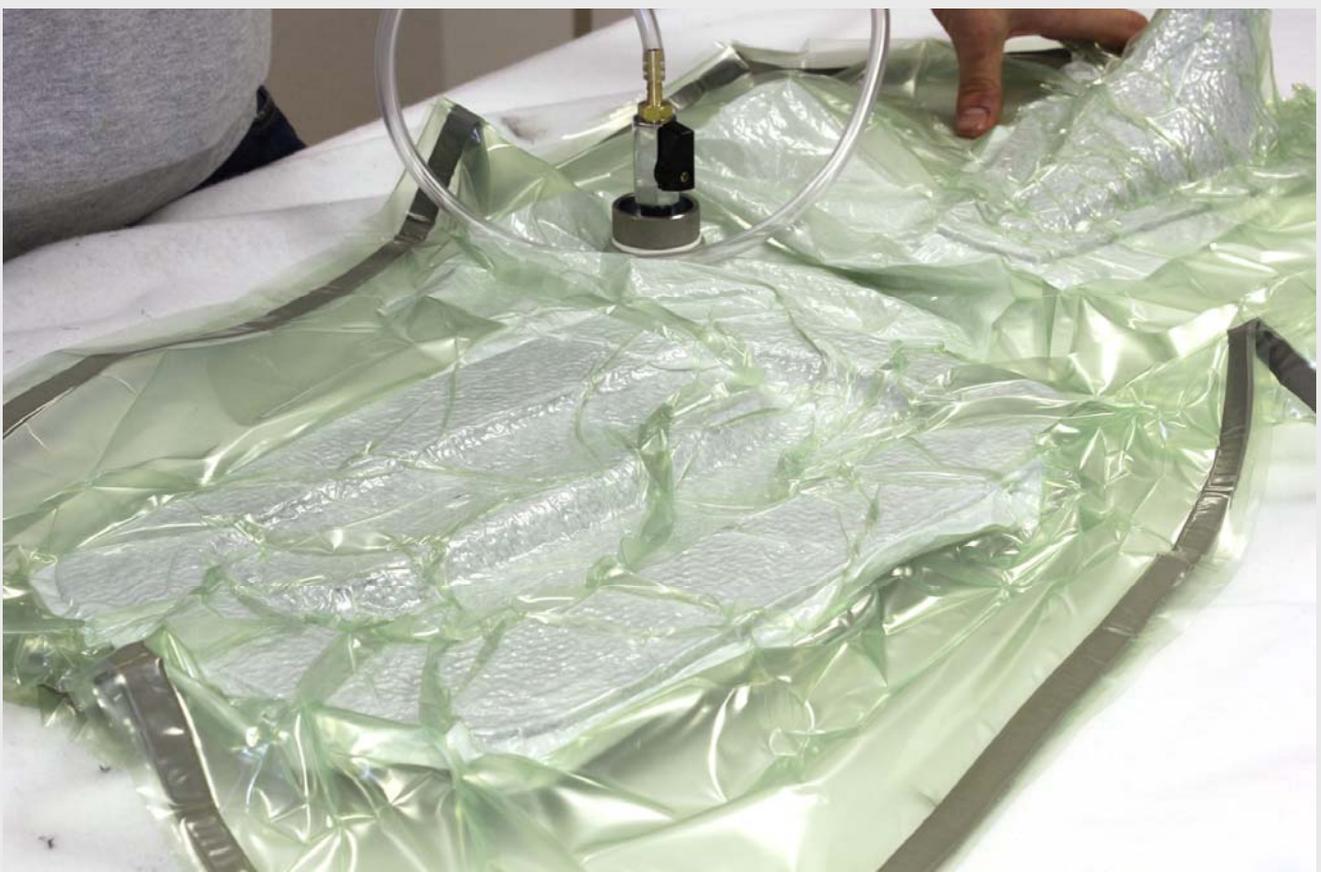


Push plenty of 'wrinkles' of bag into difficult shapes like the underside of this duct. The more wrinkles the better!



Push and pull the bag from side to side to free up more 'slack'. The whole surface should have an excess of bag.

Open the valve again to draw some more air out and repeat the process all over again. Keep doing this until you reach full vacuum in the bag. We would usually take about 4-5 steps of opening and closing the vacuum and positioning and pushing the bag before we reach full vacuum.



Correctly bagged parts under full vacuum. Plenty of wrinkles show there is an excess of bag on both parts.

During the bagging process, a range of blunt tools can be used to push and manipulate the bag and reinforcement underneath to ensure it is tightly and firmly positioned in all the corners of your mould. Be very careful when doing this to ensure that your tools have NO sharp edges that could puncture the bag but don't worry that stretching the bag will burst it because this is almost never the case (our bagging film has a 500% elongation before break).

Wrap tools such as ice scrapers, rulers or even screwdrivers in breather cloth to use as 'jamming' tools without the risk of them puncturing the bag.

When you're entirely satisfied that the bag is firmly down, pay close attention to the seal on the bag, listening for any leaks. Often it takes several minutes of going round and round the bagging tape to find every last little leak but it is essential to do this because this process requires a perfectly sealed vacuum bag in order to be successful.

Open and close the valve on the pump or the vacuum bag, listening carefully to the vacuum pump. If the bag is perfectly sealed there should be no change in note when you open and close the valve. If the sound of the pump changes in any way when you open and close the valve then that is a sure indication that there is a leak, however small, somewhere in the bag (usually the seal but sometimes the fittings and sometimes a puncture in the bag itself. If you simply cannot find the leak then as frustrating as it is, it is necessary to re-bag from the start. If you ignore a leaking bag then the end result is very unlikely to be as you would hope.

If the bag seems to be completely sealed and you cannot hear any change in the pump's tone when you open and close the vacuum valve then you are ready to perform a vacuum leak 'drop-test'.

WHY SILICONE HOSE?

The reason we use silicone hose is because the silicone hose will not soften and collapse at elevated temperatures and so can be used with prepregs inside the oven. If you use standard PVC hose (such as the hose we use with our resin infusion kits) you will find that the hose will soften and self-seal at 100°C closing the vacuum connection when the parts are loaded into the oven. As discussed earlier, it is possible to cure prepreg parts without an active vacuum connection into the oven but it is far from ideal. If you do intend to cure your parts without a vacuum connection into the oven then it doesn't matter what type of hose you use because the hose will never be exposed to elevated temperature but for all circumstances where a vacuum hose will be running into the oven it needs to be a silicone or other high temperature hose.

12. Vacuum Leak Drop-Test

As a final check that your vacuum bag is perfectly sealed, we perform a leak 'drop-test'. This test will identify any tiny leaks that can be beyond the scope of any other means of detection (including the pump 'pitch change' test, leak-flow indicators and ultrasonic detectors).

With the bag at full vacuum, close the vacuum valve on the Through-Bag Connector and switch off the vacuum pump. Wait 30 minutes and see how the bag feels; it should still feel perfectly tight. As a final check, switch the vacuum pump on at this stage with the vacuum pumps vacuum valve open, wait a few seconds to familiarise yourself with the tone of the vacuum pump and then open the valve on the Through-Bag Connector. When you do this, if you don't hear a change in the tone of the vacuum pump then you have a perfectly sealed bag.

CURING WITH AN ACTIVE VACUUM CONNECTION:

If, as recommend, you have a hole through the side of your oven through which you can pass a vacuum hose so that an active vacuum connection can be maintained to the parts throughout the curing process then in practice, a very tiny leak will sometimes not damage the finished parts. If the bag still felt tight after the drop test but a tiny change in the pumps not was detectable when opening the valve then this sort of micro-leak can probably be overcome. If, however, the bag actually feels slack after the drop-test then the leak needs to be found or the whole part re-bagged.

CURING WITHOUT AN ACTIVE VACUUM CONNECTION:

If you intend to cure you part in the oven without an active vacuum connection to it then this is the level of perfect seal that you must have. Any leak in the bag whatsoever without an active vacuum connection will guarantee a failed part.

13. Loading into the Oven for Curing

Having successfully performed the drop-test you are now ready to cure your parts. Both Easy Composites' Easy-Preg and Vari-Preg can be cured at a range of temperatures from about 85°C to 140°C. For the best results, we suggest a cure temperature of 100°C for a period of 8hrs. Higher temperatures will cure the prepreg much quicker but will require more specialist mould materials and may also reduce the surface finish quality of the cured parts.

Ensure that you have a shelf or platform within the oven on which you can position your parts. If you are using an oven that is equipped with wire rack shelves then you should wrap the wire shelves with breather or some other soft, high temperature tolerant material to prevent the wire shelves from puncturing the vacuum bag. Be sure that the parts can be positioned within the centre of the oven and that there will be sufficient space all around to allow for good airflow.

Pre-heat your oven to 100°C and ensure your vacuum bag is at full vacuum pressure before closing the vacuum valve on the pump and disconnecting the vacuum hose.



When bagging multiple parts at the same time it is possible to fold the bag over on itself...



...making it possible to cure multiple parts at the same time in a small oven.

CURING WITH AN ACTIVE VACUUM CONNECTION:

Position the vacuum pump near to the outside of the oven and connect a length of silicone hose to the vacuum pump with the other end of the silicone hose passed through a hole in the side of the oven. Load the parts into the oven and connect up the silicone vacuum hose that enters the oven from the outside to the hose-tail barb on the Through-Bag Connector.

Switch on the vacuum pump and open the vacuum valve on the pump. Open the vacuum valve on the Through-Bag Connector and then close the oven door. Keep an eye (and an ear) on the vacuum pump to ensure that the bag does not develop a leak as the bagging tape comes up to temperature and softens. In reality it is more likely that tiny leaks will seal as the tape softens but never *rely* on this happening.

TIP

A Vacuum Leak-Flow Indicator positioned in-line with the silicone hose on the outside of the oven is a very useful visual indication of any problems occurring inside the oven (such as a leak developing or a burst bag). The Vacuum Leak-Flow Indicator should never be spinning; if it starts spinning a problem has occurred that will need to be rectified (sometimes an emergency strip of bagging tape can seal a puncture).



CURING WITHOUT AN ACTIVE VACUUM CONNECTION:

If you will be curing the parts in an oven without a vacuum connection inside then all that remains is to load the parts into the oven and close the door.

Avoid opening the oven door throughout the full curing cycle of the prepreg (typically 8hrs). After 8hrs, open the door, disconnect the hose (if necessary) and remove the parts from the oven.

Allow the parts to cool for 1-2hrs until they have returned to room temperature before de-moulding. Do NOT de-mould hot parts as this is very likely to cause 'print-through' on the surface of the parts.

14. De-moulding



Release film virtually falls off the parts in seconds.



Releasing parts is simply a matter of sliding a fingernail or plastic card under an edge of the cured laminate.



This bonnet scoop has a high gloss finish straight out of the mould.



This NACA duct has a satin finish because the mould itself is satin finished.

Once the parts have cooled to room temperature the vacuum bag, film and breather can be removed from the parts and they can be de-moulded. You will find it very quick and easy to remove the bag, breather and release film; the bag and film should be discarded but the breather can be used again if required.

To release the parts from the mould simply start at an edge and using something non-marking like a plastic scraper, tease a corner of the part away from the mould. If you're using Easy Composites' prepreps and release agent on compatible moulds then the parts should practically self-release and will require almost no effort to release from the mould.

Cured parts can now be trimmed using a Dremel or similar and fettled using a range of abrasive papers.

15. Finishing

There are a variety of ways that cured parts can be finished before use. For many applications, no finishing whatsoever is required. Highly polished moulds should yield very glossy parts with a really professional finish straight out of the mould and these parts can be put into use exactly as they are. If using parts in this way, they can be lightly polished using a very fine polishing compound (such as Mirka's Nano Wax) and then protected and buffed off using a black pigmented car wax (such as Turtlewax Colormagic) to make them look their very best.

If you do use parts without any further finishing then keep in mind that epoxy resin (the resin system used in prepregs), although UV resistant is not 100% UV stable and if exposed to direct sunlight for long periods of time will eventually show signs of fading. For race parts this is never an issue and further finishing is rarely required but for daily use parts a 2k automotive lacquer/clear coat is recommended to provide extra gloss, UV stability and general protection from the elements.

To lacquer/clearcoat parts, rub the surface down using a scotch-pad or similar fine abrasive to remove any traces of release agent and ensure a good key for the paint. You will find that lacquer/clear coat on composite parts generally requires spraying, flatting, spraying and flatting again to achieve the best results.

For further advice on clear coating bare carbon fibre, see the Easy Composites website or the Talk Composites forum.



TIP

On any less than perfect parts the black hard wax 'chipstick' that comes free with Turtlewax Colormagic is an excellent way of filling and disguising tiny pits or pin holes.

Do not use wax to fill pin holes on parts that will be painted or lacquered.

The Prepreg Carbon Fibre Starter Kit™ and this guide were created by Easy Composites Ltd.

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About Easy Composites Ltd

Easy Composites Ltd was launched in 2010 and has quickly grown to become one of the UK and Europe's leading suppliers of advanced composite materials and equipment. What distinguishes Easy Composites and has led to our phenomenal growth is a total commitment to providing unrivalled technical support on all of our products and processes which we deliver through our online video training courses, technical guides, support forum and expert telephone support.

Operating from large, modern premises in Stoke-on-Trent, Easy Composites benefits from both extensive warehousing, a well equipped development and manufacturing facility and a purpose-built composites training centre.



The Easy Composites Centre includes our extensive warehouse, trade counter and composites training facility.

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