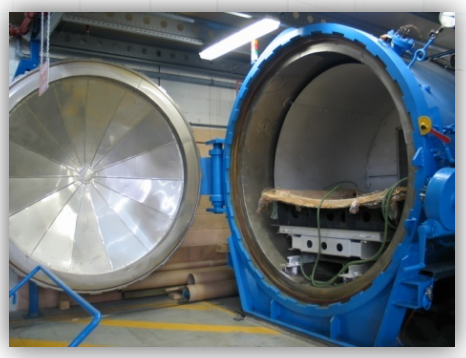
AIRTECH Global

User Guide

More than a manufacturer...
a technical partner !



Prepreg

Vacuum bagging

AIRTECH

AIRTECH EUROPE Sarl
www.airtech.lu

AIRTECH INTERNATIONAL INC.
www.airtechonline.com

TYGAVAC ADVANCED MATERIALS LTD
www.tygavac.co.uk

AIRTECH ASIA LTD
www.airtech.asia

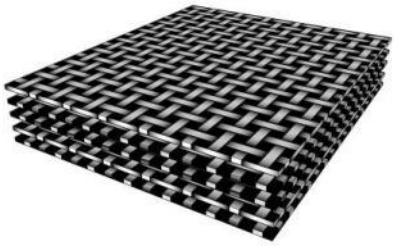
More than a manufacturer... A technical partner !

Contents

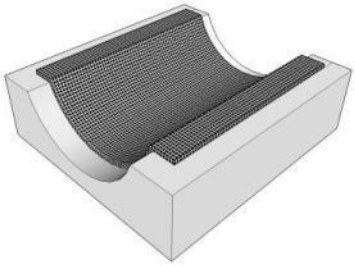
1. Introduction

The vacuum bag has the ability to evenly apply pressure by conforming to complex shapes. The flexible diaphragm bags most nearly match the shape of the tool and part. With the incorporation of a vacuum pump or venturi block, pressures of 14.7 lbs. per square inch, 2,000 lbs. per square foot can be attained.

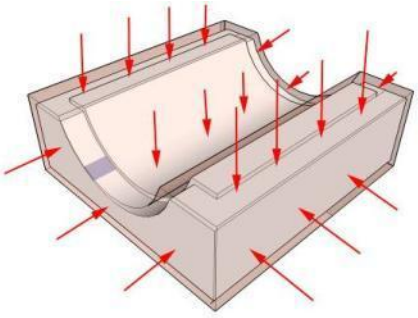
This allows for predictable and consistent pressure application. The constant vacuum pressure in turn provides control of part thickness and assistance in core placement and bonding. Laminate strength directly relates to the ratio of fibre content to resin.



Layers of pre-preg (woven fabrics impregnated with resin)

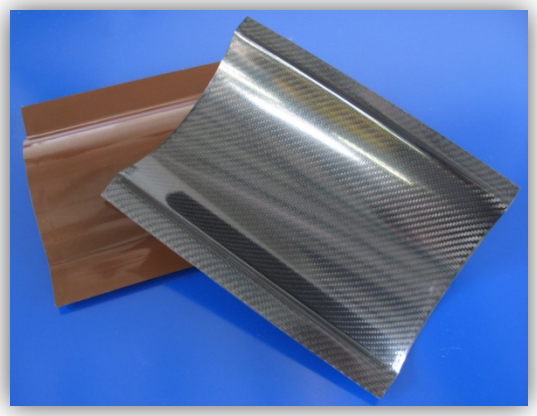


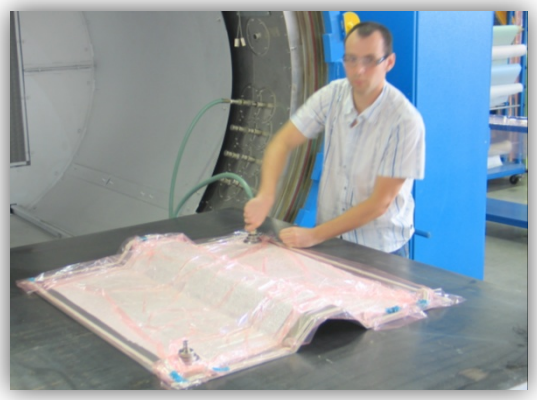
Layers of pre-preg fabrics on mould tool



Vacuum Bag applies pressure consolidating layers of pre-preg evenly onto mould tool

2. Benefits of Vacuum Bagging





The even distribution of vacuum pressure aids in a more precise control of the fibre/resin ratio. The working environment is also greatly improved as resin films are trapped under tile vacuum bag and ventilated through the exhaust system.

Utilisation of the basic techniques and materials will vary with specific applications. Hopefully, reviewing this information along with process demonstrations will inspire adaptations to your specific manufacturing needs. All the materials mentioned this paper could be found in the Airtech catalogue.

3. Requirements for Vacuum Bagging

The basic requirements necessary to perform any type of vacuum bagging procedure, to attain all benefits, are as follows. First you must have

- **Mould Tool**, providing the shape of the desired part and remaining stable during application of pressure for consolidation of pre-preg and elevated temperatures for resin curing.

- **Laminate or Part,** layers of pre-preg, core materials and inserts positioned on the mould tool in the desired configuration

- **Peel Ply,** a fabric layer placed over the laminate which is removed after curing to leave a textured surface on the laminate. Desirable when parts are subsequently bonded or painted.

- **Release film**, a non-stick plastic film which is placed over the laminate or part to contain resin during the consolidation and curing process and allow removal of air and volatile gases.

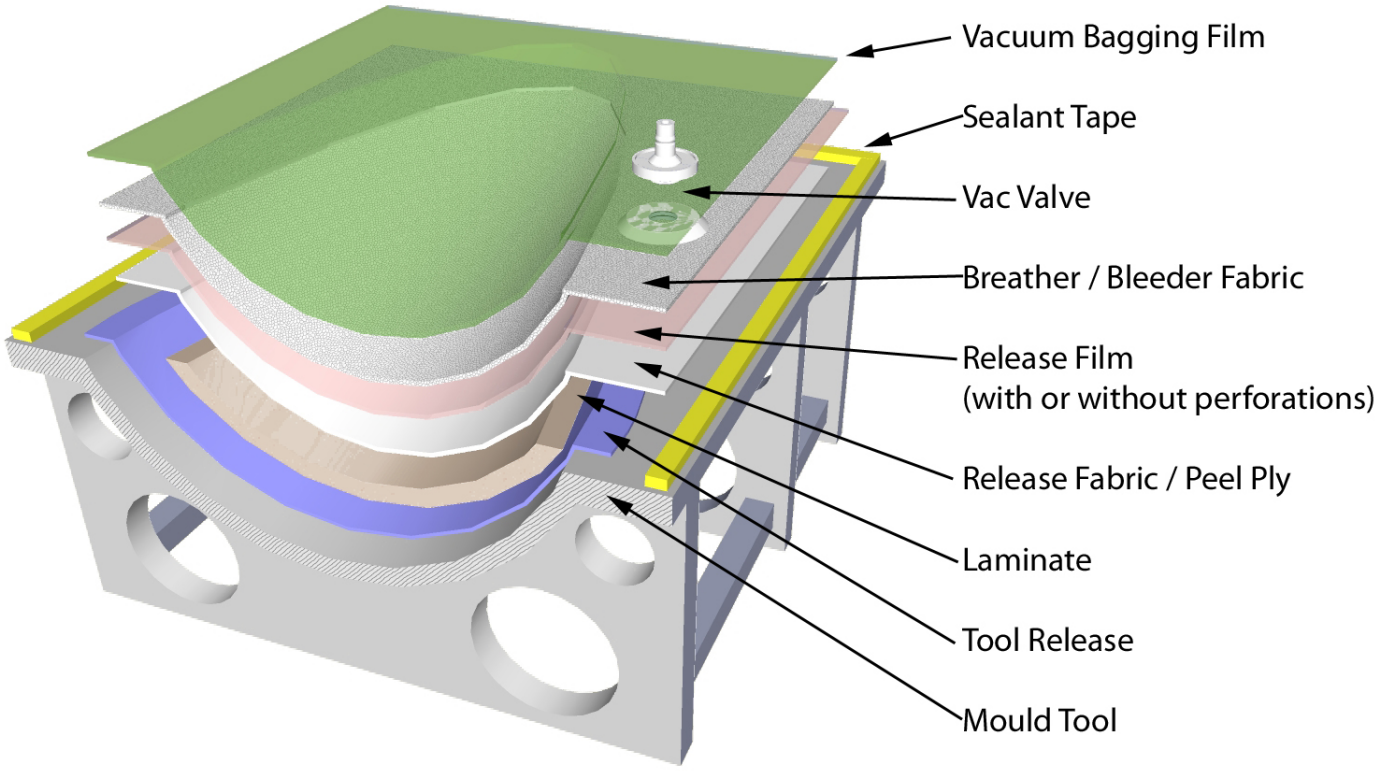
- **Breather & Bleeder Fabrics**, a non woven fabric positioned over the release film which provides an air path over the entire laminate surface to ensure complete removal of air and application of vacuum & autoclave pressures.

- **Sealant Tapes**, airtight vacuum sealing tapes which allow bagging films to be sealed together or to a tool flange area. These maintain a vacuum seal through the curing process to ensure efficient vacuum & autoclave pressure application.

- **Bagging Film**, a flexible and airtight plastic film. The bagging film applies pressure over the part making it conform to the shape of the part and consolidating the pre-preg layers, core materials and inserts together.

- **Vacuum Valve & Quick Disconnect Hose**, a means of connecting a vacuum source to the vacuum bag.

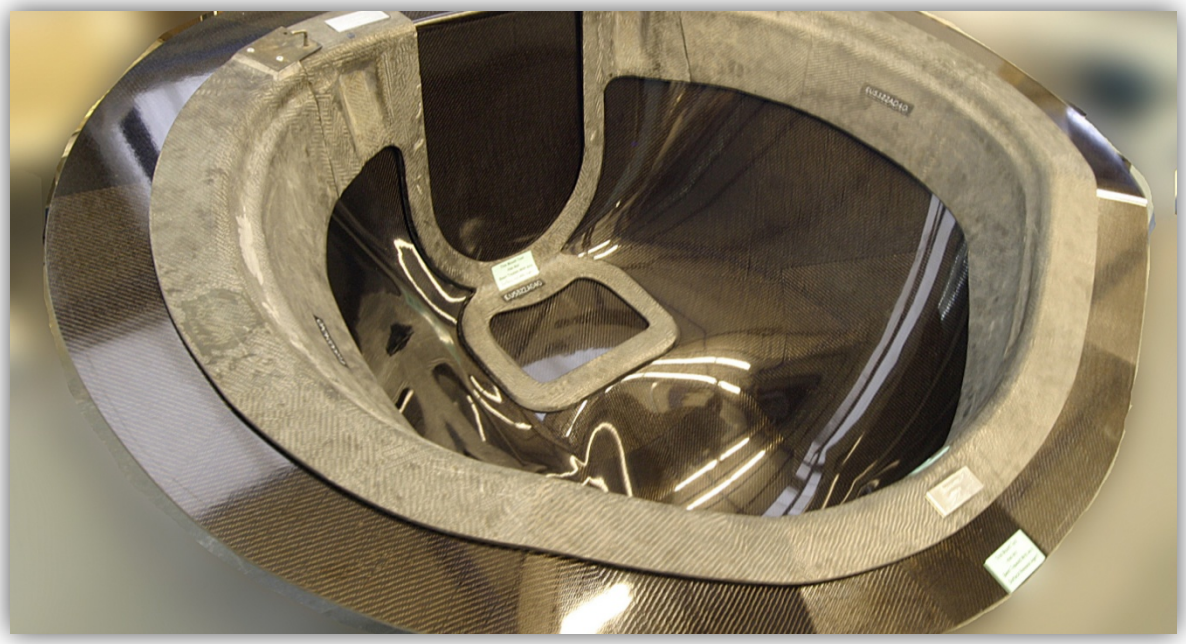
- **Vacuum Source**, either a vacuum pump or venturi block.



4. Mould Tool Requirement

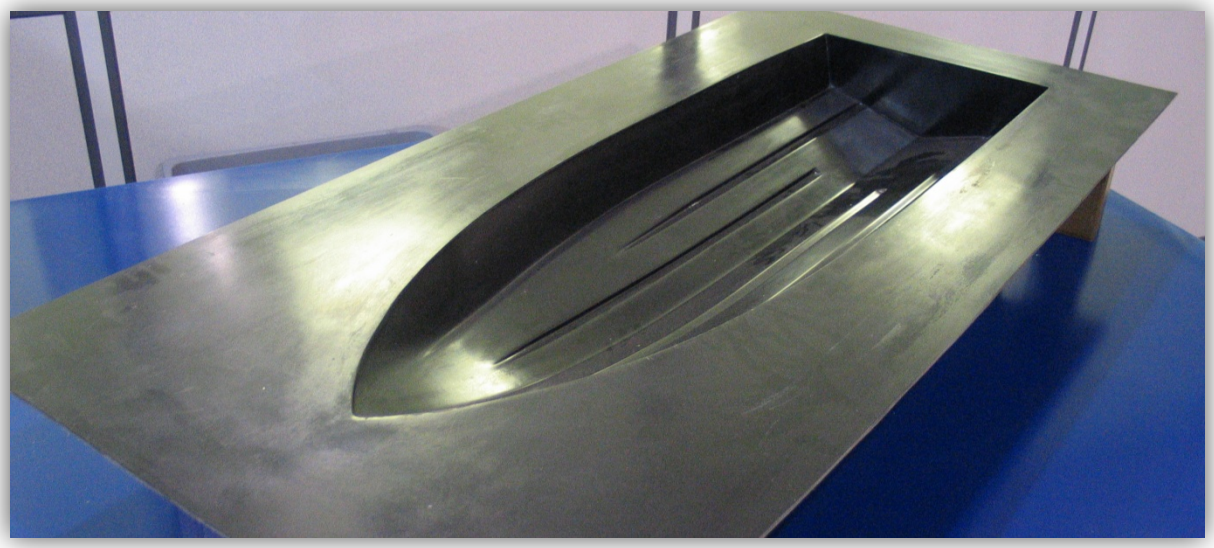
4.1. **Vacuum Integrity**, vacuum integrity is vital, any air drawn through the mould can create air voids in the cured composite laminate, reducing strength of the part. Where mould tools are not vacuum tight the options of envelope vacuum bagging and vacuum bagging onto a base plate are available to ensure good vacuum.

4.2. **Compressive Strength,** the mould tool must capable of withstanding the application of vacuum pressure over the surface to be moulded. This force can collapse any hollow sections or low density materials such as foams, care must be taken to ensure tool shape will be retained under vacuum application.



4.3. **Chemically Inert,** some tooling materials and surface finishes contain reactive ingredients which can inhibit the curing of resins. We recommend avoiding the use of such materials or conducting tests to assess their suitability for this application.

4.4. Surface Porosity, in addition to potential vacuum loss this can create poor surface finish which may require time consuming refinishing after moulding of the laminate.

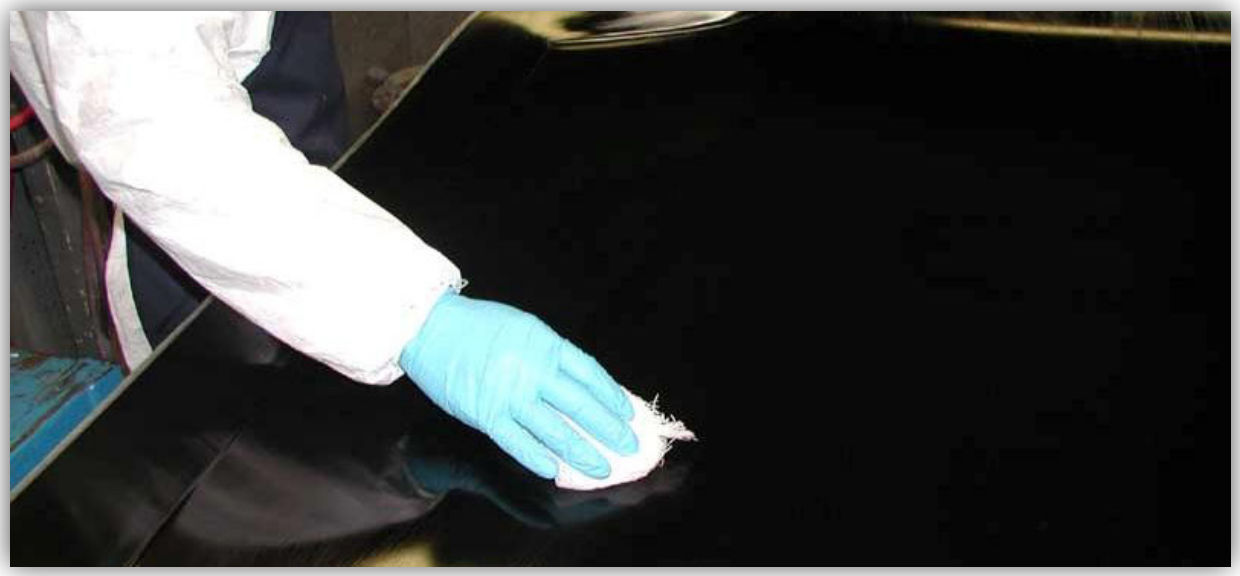


4.5. Flange Area, it is desirable to have a flange area of approximately 100mm around the perimeter of the proposed part, this provides enough space for vacuum bag sealant tape placement. If insufficient flange area exists envelope bagging can be employed.

4.6. Airtech Toolmaster Materials, this range provides a wide variety of tooling material options designed specifically for the manufacture of composite mould tools ideal for the vacuum bagging application.

5. Tool Release

Release can be accomplished by a liquid release or by a release film. For a double contour tool, a liquid release is required in order to cover all the shape.



5.1. Release Liquids, Choosing a liquid release agent is very important. You must take into consideration the following points:

- Does it release from the resins being used?
- Is it safe for people and the environment?
- Does it transfer contaminants like silicone?
- Does it perform at the use temperature?

Product	Description	Maximum Use Temperature
Release All® 19	All purpose water based release agent	177°C
Release All® 45	Semi-permanent release agent Aliphatic hydrocarbon solvent	475°C
Release All® Safelease 30	Water based PTFE release agent	177°C
Release Off 826	Water based release agent removal system	

5.2. Self Adhesive Release Films can be applied to flat and simply curved tool surface to provide a permanent release surface. Airtech Tooltec® CS5 is a formable P.T.F.E. film with a high temperature pressure sensitive adhesive on one side.

Tooltec® can be applied wrinkle free to the tool surface with care, with pieces joined with little or no mark-off by using overlap carpet-cut techniques.

Once Tooltec® has been applied to the surface application of a vacuum bag and exposure to intended cure cycle will expand and highlight any trapped air under the PTFE film. These air pockets can be eliminated by making pin holes in the film and rubbing out trapped air.

Tooltec® should give 50 or more releases before a new piece is needed. For a harder wearing tool surface Self Adhesive PTFE Coated Fibreglass such as Tooltec A005 can be used. This cannot be formed in the same way as Tooltec CS5 but does provide a surface more resistance to mechanical abrasion.

6. Laminate construction

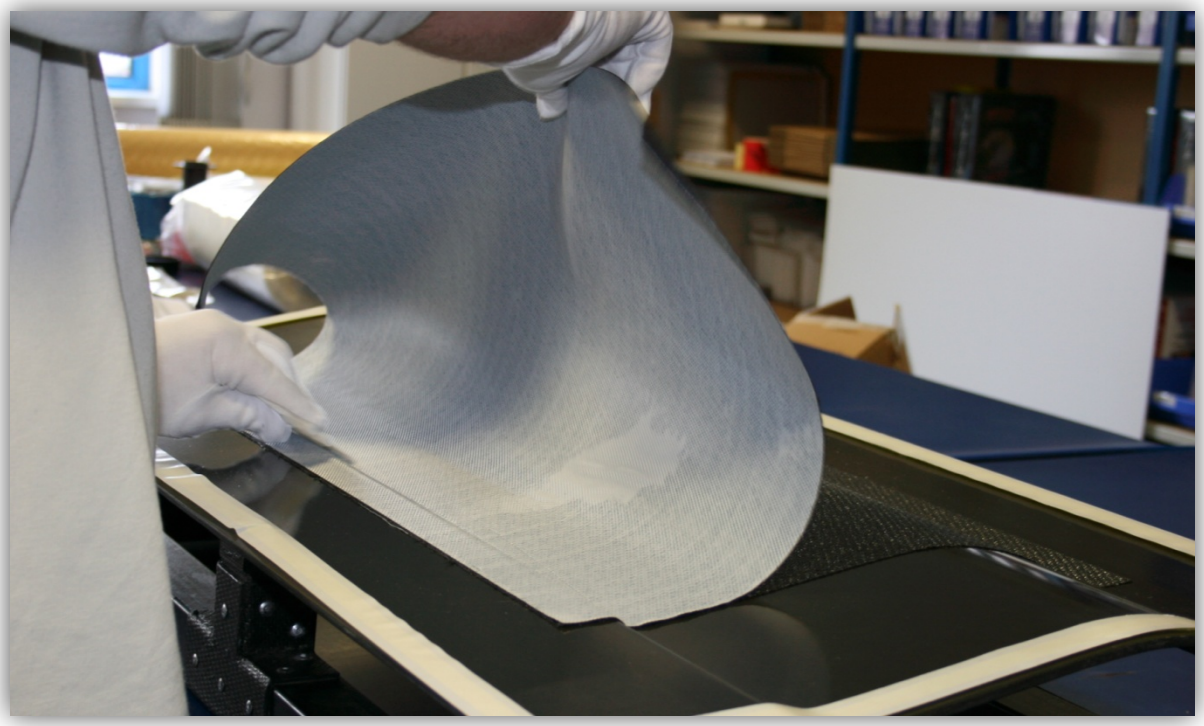
layers of pre-preg, core materials and inserts positioned on the mould tool in the desired configuration.

6.1. Pre-preg materials are fabrics coated with a pre-catalysed resin system. Fabrics can be woven or unidirectional and can be obtained in a variety of weights and weave styles. Common Fibre types available include Glass, Carbon & Aramid, other more exotic fibre types *such as Quartz, Boron, Dynema are also available for more specialised applications. Common resin systems applied to pre-preg materials include Epoxy, Phenolic, Polyester, BMI, Cynate Ester.*

6.2. Core materials are used to create a sandwich construction which adds thickness and therefore stiffness to parts. These can be honeycomb and foam type materials cur to shape from sheet stock and layed up between layers of pre-preg.

6.3. Multiple layers of oriented fabric are used to achieve the desired part shape, thickness and strength. These are laid on the mould tool taking care to ensure complete contact of the materials over the mould face.

6.4. Positioning the layers of pre-preg is assisted by the tack of the resin coating on the fabric. This tack enables the first layer of pre-preg to be adhered to the mould face and for subsequent layers to be positioned and held in position. Any non-contact areas or BRIDGED areas can result in poor part definition, poor fibre volume fraction. A bridged area means there is low pressure in this area. Resin will rush to the areas of low pressure causing resin starvation in the areas the resin exits.



6.5. Tools such as the Airtech Airsweep can be used to work the pre-preg fabrics into sharp corners and fine detailed areas. The Airtech Airsweep is an HDPE paddle tool which will not contaminate the pre-preg fabrics like similar PTFE paddles.

6.6. Additional laminating tools such as high performance cutting shears and rollers aid in production of accurate laminated components.

Shop Shears

Techshears

AirRoller

AirSweep

7. Peel Ply Fabric

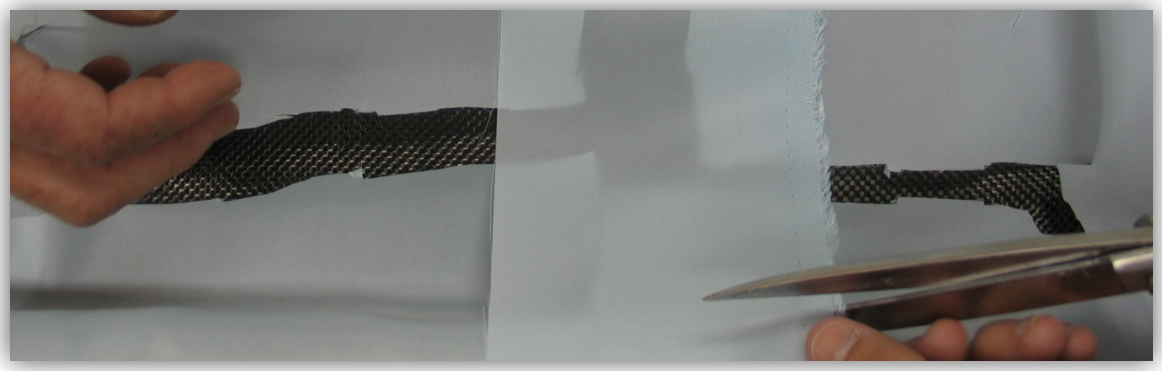
A fabric layer placed over the laminate which is removed after curing to leave a textured surface on the laminate, this is desirable when parts are subsequently bonded or painted.

7.1. Selection of Peel Ply, there is a wide range of Peel Ply fabrics available, each developed to provide specific features and benefits.

- **Non-Coated Peel Ply**, Scoured and Heat set fabrics to ensure clean, shrink free contact with part. Once removed textured surface aids preparation for painting or bonding
- **Release Coated Peel Ply,** Release coating aids removal in demanding applications, complex geometries, aggressive resin systems, thin laminate structures
- **Nylon**, good temperature resistance, can be attacked by oxidisers (e.g. Phenolics)
- **Polyester**, good temperature resistance and chemical resistance
- **Fibre Glass**, High temperature performance for use with thermoplastics
- **Weave Style**, Important consideration affecting drape and tear strength. Drape being an important factor in achieving wrinkle free application over compound curves. Tear strength being an important factor in being able to remove the fabric from the cured laminate
- **Fabric Weight**, Important consideration affecting tear strength and resin absorption – approx equal weight of resin will be absorbed.
- **Tracers & Colour** for visibility, these have been included in some products to ensure visibility after cure.

7.2. Peel Ply Application, ensure full contact of the Peel Ply to prepreg. Wrinkling should be avoided as this with transfer onto part surface.

- Peel Ply can be applied to the whole part surface to give an even surface finish over the whole part once removed, or can be applied only in the areas where secondary bonding is going to take place
- Tailor pieces to allow slippage over multiple corners, joining of pieces with small overlaps. This will help to avoid bridging in corners, which can cause resin richness.
- Extending the peel ply past the edge of part will aid visibility and removal from the laminate after cure.



7.3. Airtech Release Fabric

Airtech Non-Coated Peel Plies				
Product	Color	Yarn Type	Weight oz./yd² (g/m²)	Maximum Recommended Use temperature °F.(°C.)
Release Ply A	Off-White	Nylon	2.34 (79)	450 (232)
Release Ply Super A	White	Nylon	4.10 (139)	450 (232)
Stitch Ply A	White w/ Red Tracer	Nylon	2.54 (86)	450 (232)
Release Ply B	White	Nylon	1.83 (62)	450 (232)
Release Ply C	White	Polyester	1.90 (64)	400 (204)
Release Ply F	White	Polyester	2.81 (95)	400 (204)
Release Ply Super F	White	Polyester	3.35 (114)	400 (204)
Release Ply G	White	Polyester	2.50 (85)	400 (204)
Stitch Ply G	White w/Black Tracer	Polyester	2.50 (85)	400 (204)
Release Ply Super G	White	Polyester	3.40 (115)	400 (204)
Ultra Ply 22T	White	Polyester	2.80 (95)	400 (204)

Airtech Release Coated Peel Plies					
Product	Color	Yarn Type	Coating Type	Weight oz./yd² (g/m²)	Maximum Recommended Use Temperature °F. (°C.)
Bleederlease® A	Green	Nylon	Silicone	2.34 (80)	450 (232)
Bleederlease® B	Green	Nylon	Silicone	1.83 (62)	450 (232)
Bleederlease® C	Green	Fiberglass	Silicone	8.8 (299)	800 (427)
Bleederlease® E	Green	Fiberglass	Silicone	3.70 (126)	800 (427)
Bleederlease® G	Green	Polyester	Silicone	2.45 (83)	400 (204)

Airtech Econo Peel Plies				
Product	Color	Yarn Type	Weight g/m2	Maximum Recommended Use Temperature °C
Econoply E	White	Polyester	95 g/m²	149°C
Econoply J	White	Polyester	54 g/m²	121°C
Econostitch	White w/Red Tracers	Polyester	88 g/m²	190°C
Econolease	Lt. Blue	Silicone Coated Nylon	61 g/m²	204°C

8. Release Films

A film placed over the laminate or part to contain resin during the consolidation and curing process and allow removal of air and volatile gases.

8.1. Release Film Selection, a wide range of release films are available offering a range of performance and pricing level. In order to make a technically suitable and coat effective selection the following factors should be considered.

- **Temperature resistance,** to ensure stable performance during elevated temperature cure cycles.
- **Chemical resistance,** to withstand chemical degradation during full surface contact with curing resin systems.
- **Elongation & tear strength,** elongation of films into sharp corners and surface details will prevent bridging conditions. Good tear resistance is essential where films are expected to conform to shape without failure.
- **Level of release & surface finish,** different release films offer a range of surface finish and ease of release. Higher performance films release more easily and leave a smoother, glossier finish on the part.
- **Thickness and Width,** thicker films can provide more robust performance and smoother finish. Wider films can reduce touch labour during application onto larger parts.
- **Perforations,** Airtech provides the largest choice of perforation styles. Perforations allow air, steam and volatiles to be conducted away from the laminate preventing laminate voids. Perforations can also be used to bleed out excess resin from laminate when required.

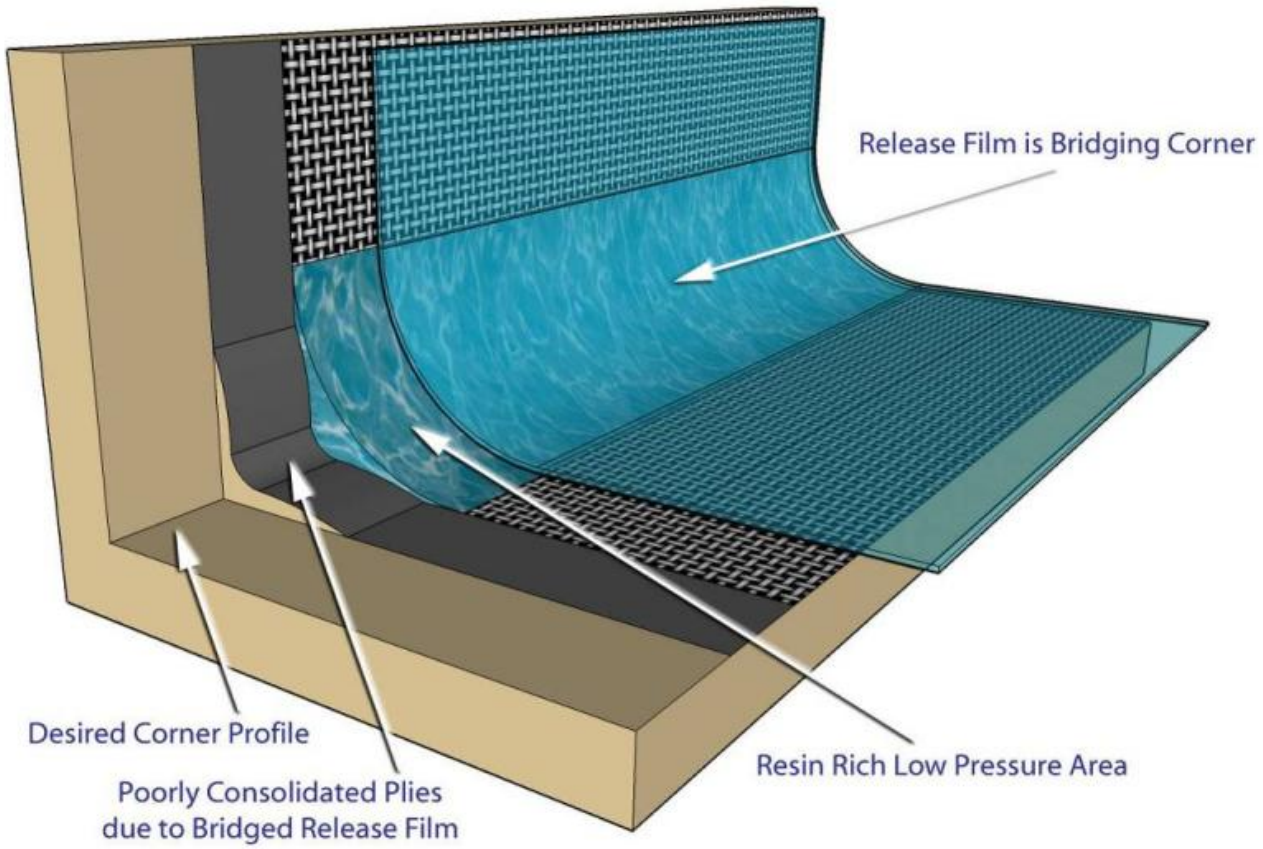
8.2. Release Film Application, release films are either applied over the top of the Peel Ply Fabric or directly onto the part. Where a textured surface is not required and the Peel Ply has been omitted the Release Film is applied directly onto the Pre-preg fabric and will leave a smooth resin rich surface. This surface can be matt or glossy depending on the selection of release film. The Release film should;-

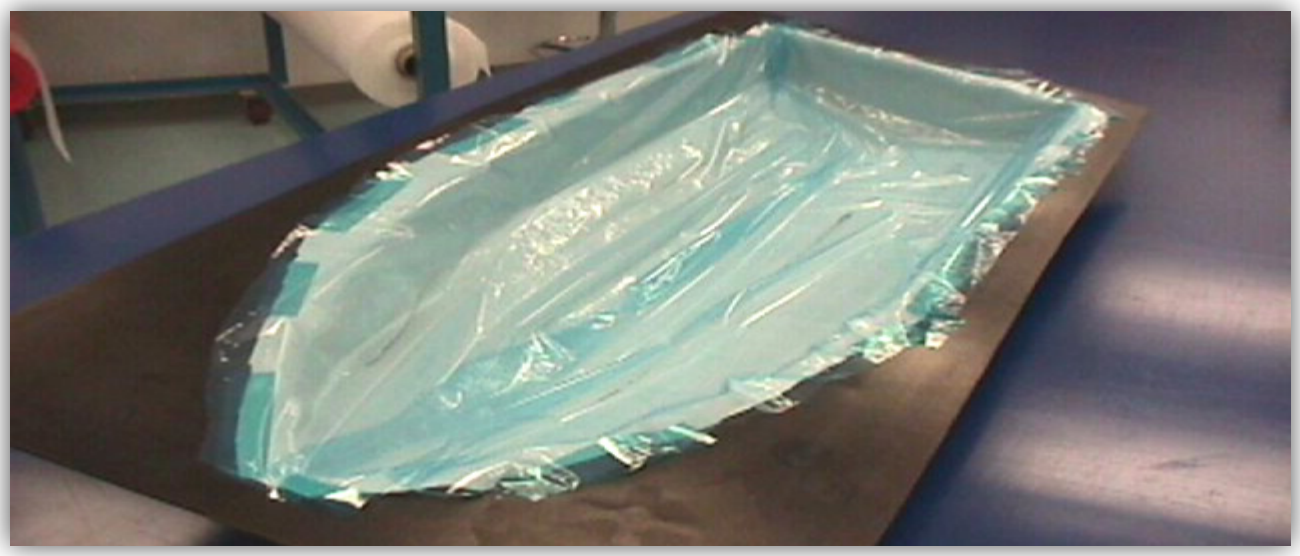
- Completely cover the part.
- Extend past the edge of the part by at least 25mm.
- Conform closely to the shape of the part to avoid bridging.
- Be held in position with Flashbreaker tapes.
- Be overlapped by 25mm to 50mm when joining.

During the curing process the release film must contain the resin inside the woven fabrics and allow the vacuum bag to apply its compaction force over the laminate. If any area of the laminate is not covered by release film there is a danger of resin escaping and the cured part suffering from resin starvation.

If the release film is not positioned to closely follow the shape of the part and holds off over a detail feature or sharp corner, when the vacuum bag applies pressure this bridging of the release film will cause ;-

- A low pressure area creating resin richness, poor consolidation and resin starvation in surrounding areas.
- Excessive elongation of release film, possible tearing and then excessive resin bleed out causing resin starvation.





8.3. Airtech Release Films

- **Polyolefin Release films,** Inexpensive range. Most of these films are for use under 135°C. Perfect for low temperature range, compaction or debulking.

Polyolefins Release films				
Product	Colour	Maximum Use Temperature °C	Thickness	Elongation
WL3900R	Red	150°C	50µm	300%
Release Bag 125	Green	140°C	25µm	400%

- **Fluorocarbon Release films,** Use up to 260°C. High elongation. Inert to most resins systems. Excellent release and glossy finish when used directly on the laminate.

Flurocarbons Release films				
Product	Colour	Maximum Use Temperature °C	Thickness	Elongation
WL5200	Blue / Red	232°C	15, 20 & 25µm	350%
A4000	Clear / Red	260°C	20, 25 & 50µm	350%
MR1 & MR2	Red	315°C	25 & 50µm	500%

- **Ultra High Temperature Release films,** use up to 343°C for thermoplastic processing applications.

8.4. Release Films Perforations, The choice of the perforation is dependent on the desired open area for air & volatile evacuation considered along with the acceptable level of resin bleed out from the laminate. Removal of Air, Water Vapour and volatile gases during the curing process is desirable to avoid trapped gases creating voids in the cured composite laminate.

E.g. Phenolic resin systems create steam as a by-product of their curing process and this needs to be removed to prevent voids.

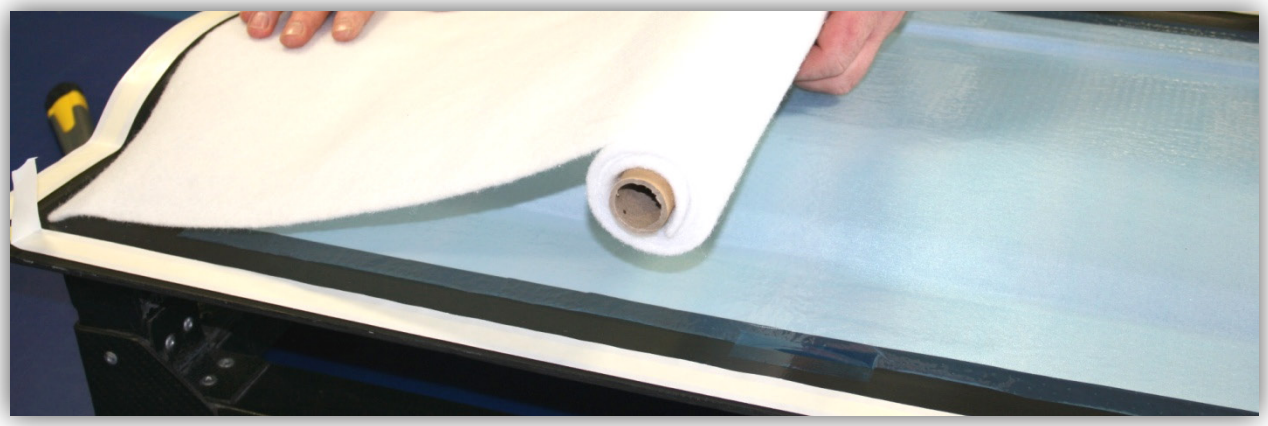
Perforation styles P, P3 and P6 are common choices for pre-preg processing.

- P perforation for good air removal and medium resin bleed
- P3 perforation for good air removal and lower resin bleed
- P6 allow air flow but low resin bleed net resin part moulding.
- MP25 Micro-perforation is an ideal selection for vacuum debulking cycles, providing a large open area and very high hole density to ensure excellent removal of air from the lay-up. The Micro-perforation also prevents breather fibres adhering to the uncured pre-preg, avoiding contamination of the lay-up.

Style	Nominal Hole Diameter	Hole Pattern Description	Open Area	Hole Density
MP22	0.016 inch, 0.4mm	Staggered, 1.5mm Centres	2.79%	222,222/m²
P	0.045 inch, 1.143mm	Staggered , ¼" Centres	1.27%	12,246/m²
P2	Pierced	Staggered, ½" Centres	0.71%	
P1	0.045 inch, 1.143mm	Staggered, ½ Centre	0.63%	6,200/m²
P34	0.045 inch, 1.143mm	Staggered, ½" Centres	0.318%	3,100/m²
MP25	0.005 inch, 0.125mm	Staggered, 1mm Centres	0.307%	250,000/m²
P11	0.015 inch, 0.381mm	Staggered, 1/8" Centres	0.28%	24,800/m²
P3	0.015 inch, 0.381mm	Staggered, ¼" Centres	0.14%	12,400/m²
P4	0.045 inch, 1.143mm	2" Centres	0.04%	388/m²
P31	0.015 inch, 0.381mm	1" Centres	0.018%	1,550/m²
P5	0.045 inch, 1.143mm	3.5" Centres	0.013%	126/m²
P6	0.015 inch, 0.381mm	2" Centres	0.0044%	388/m²
P7	0.015 inch, 0.381mm	3" Centres	0.0019%	172/m²
P10	0.045 inch, 1.143mm	10" Centres	0.0016%	16/m²
P8	0.015 inch, 0.381mm	8" Centres	0.0004%	24/m²

9. Breather & Bleeder Fabrics

A non woven fabric positioned over the release film which provides an air path over the entire laminate surface to ensure complete removal of air and application of vacuum & autoclave pressures.



9.1. Breather & Bleeder Fabric Selection, wide ranges are available offering a range of performance and pricing level. In order to make a technically suitable and cost effective selection the following factors should be considered.

- **Temperature Performance,** dependant on the cure temperature and length of cure cycle. Selection should be made to ensure air flow is maintained throughout the curing cycle.
- **Pressure Performance,** for high pressure cure cycles selection of a high air flow breather version can be considered.
- **Fibre Type, Denier and Weight,** fabrics of differing construction are available to provide differing temperature and pressure performance.
- **Fire retardant properties,** at elevated temperatures in high pressure autoclaves this is a desirable feature to prevent ignition occurring and to avoid the potential damage of an autoclave fire.
- **Stretch, Drape and elongation,** when vacuum bagging complex shapes it is desirable to have fabrics with stretch and drape. This allows wrinkle free application over the part surface and helps avoid bridging conditions in sharp corners.

9.2. Breather & Bleeder Fabric Application, the function of breathers is to provide an always open air path across the entire surface of the part. When being used as a bleeder material the fabric absorbs excess resin squeezed out of the laminate by the application of pressure by the vacuum bag. The Breather & Bleeder should;

- Be positioned over the top of a release film. The breather should never make direct contact with the pre-preg fabrics as this could result in excess resin bleed out and resin starvation of the part.
- Breather should completely cover the surface of the part and extend past the edge of the part by at least 25mm.
- The fabric should be tailored to closely follow the shape of the part surface without bridging.
- When joining pieces of breather it should be overlapped to maintain airflow continuity over the part.
- Breather should be held in position with Flashbreaker tape to prevent movement during subsequent vacuum bag application.

9.3. Airtech Breather & Bleeder Fabrics

- **Polyester Breathers** in various deniers and weights to channel air under a vacuum bag in an oven or autoclave. These products have good elongation and protect vacuum bags in sharp radius areas. Slitting master rolls to various widths is available. Most can be made in a fire retardant version.

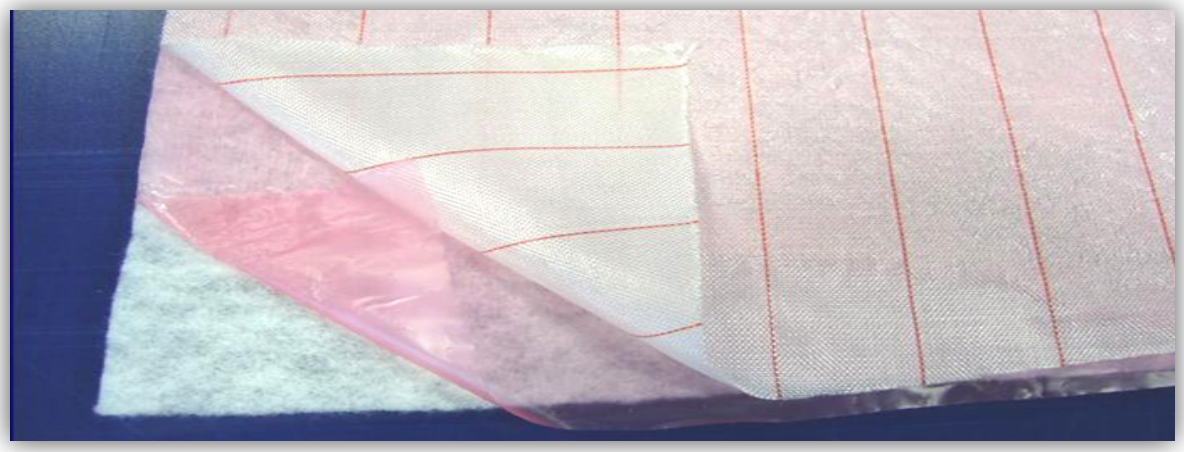
- **Nylon Breathers** for maximum airflow under a vacuum bag in the autoclave. Nylon breathers do not soften, like polyester, which starts to restrict airflow at 250°F (120°C). Various deniers and weights are available, and may be slit to any width.

Product	Nominal Weight oz./yd.2 (g/m2)	Maximum Recommended Use Temperature °F. (°C.)
Airweave® A	1.6 (54.3)	400 (204)
Airweave® S	3 (102)	400 (204)
Airweave® SSFR	4 (135)	400 (204)
Airweave® N-4	4 (135)	400 (204)
Airweave® N-4 FR	4 (135)	400 (204)
Airweave® N-7	7 (237)	400 (204)
Airweave® N-7 FR	7 (237)	400 (204)
Airweave® N-10	10 (339)	400 (204)
Airweave® N-10 FR	10 (339)	400 (204)
Airweave® Super 10	10 (339)	400 (204)
Airweave® Super 10 FR	10 (339)	400 (204)
Airweave® Super 18	18 (610)	400 (204)
Airweave® Super 18 FR	18 (610)	400 (204)
Ultraweave® 406	4 (135)	450 (232)
Ultraweave® 606	6 (204)	450 (232)
Ultraweave® 1032	10 (339)	450 (232)
Ultraweave® 1332	13 (441)	450 (232)

- **Econoweave**®, Inexpensive, recycled polyester breather for room temperature and elevated temperature cures. These breathers are not made to advanced composites standards, but are designed to be cost effective for use in the marine, automotive and general composites industries.

Product	Nominal Weight oz./yd.2 (g/m2)	Maximum Recommended Use Temperature °F. (°C.)
Econoweave 22	68 g/m²	190°C
Econoweave 44	135 g/m²	190°C
Econoweave 1010	339 g/m²	190°C

- **Airweave**® UHT, This "ultra high temperature" non-woven fibreglass breather that works well with high temperature resin systems and thermoplastics to 427°C.
- **Stretchlease, Flashpac,** laminated consumables can be used to reduce the touch labour required to apply the individual layers of material.
- Laminated materials simplify the vacuum bagging operation and work best with large flat or simply curved parts.
- Standard combinations of Peel Ply / Release Film / Breather Fabrics are available and custom combinations specifically for individual applications can be supplied by Airtech.



10. Flashbreaker & PS Tapes

Airtech offers a range of high temperature general purpose self adhesives tapes for masking, holding and releasing applications

10.1. Pressure Sensitive Tape Selection, wide ranges are available offering a range of performance and pricing level. In order to make a technically suitable and cost effective selection the following factors should be considered.

- **Temperature Performance,** dependant on the cure temperature and length of cure cycle.

- **Carrier Type,** depending on the applications a variety of tape carriers is available. Polyester for general purpose applications, Nylon for high temperature applications and PTFE for applications where release from cured resins is required. In addition PTFE coated Fibreglass are also available for more heavy duty release applications.

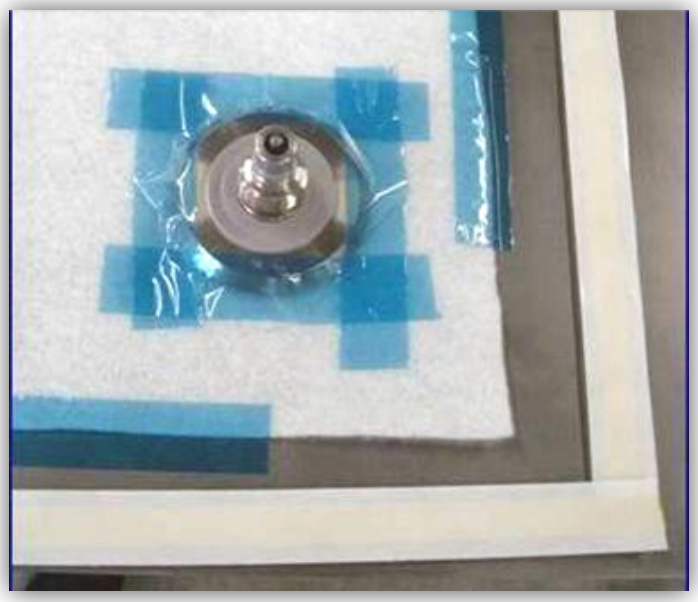
- **Carrier Thickness,** the thickness of the film carrier can be modified for light duty and heavy duty applications.

- **Adhesive Type,** a selection of adhesive types including Silicone, Rubber and acrylic are available, providing a range of adhesion and potential transfer options.

10.2. Pressure Sensitive Application, the range of potential uses for pressure sensitive tapes is large, these include;-

- **Flashbreaking,** when tapes are applied adjacent to a metal bond line or around the periphery of a composite lay-up, the excess resin spew will form on the tape. Once cured the resin flash can be easily removed with the tape leaving either a clean component or tooling surface.

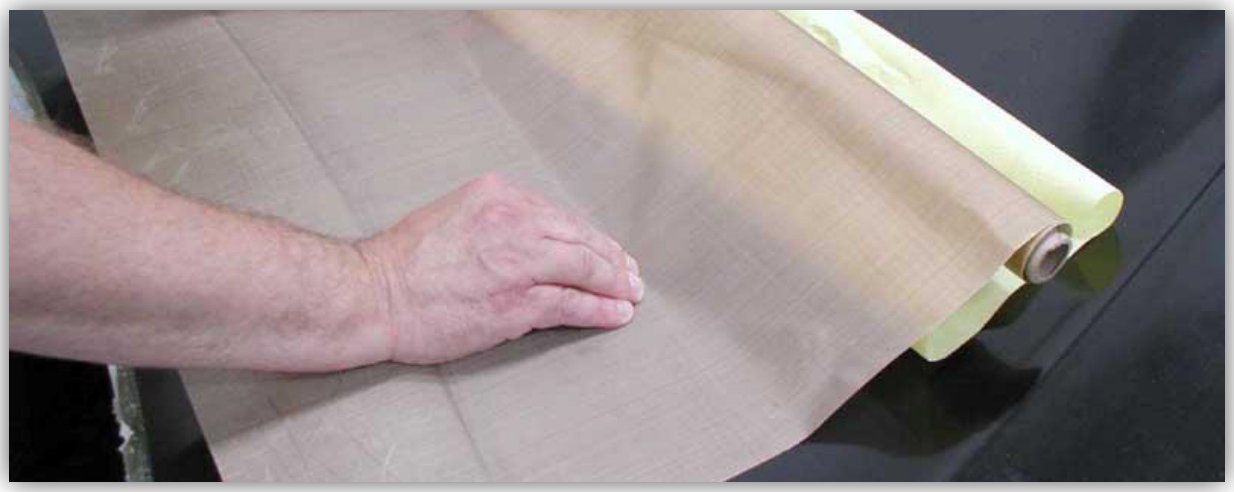
- **Holding & Protection,** tapes can be used to hold materials such as peel plies, release films and breather fabrics in place during elevated temperature cure cycles. They can also be used to hold vacuum valves and thermocouples in place during the vacuum bagging process. Holding down pleats in vacuum bagging films to prevent winds in the autoclave or oven applying stress on the bagging films and sealant tapes, can prevent vacuum loss.



- **Masking,** Polyester and PTFE tapes can be used for masking components during bonding, Chemi Milling, Etching and painting processes.

- **Release & Low Friction Performance,** PTFE tapes can be employed to provide either permanent all over tool release or localised temporary release. Thicker PTFE adhesive films and PTFE coated Fibreglass adhesive fabrics provide hard wearing surfaces capable of multiple releases.

  These PTFE materials also provide very low friction surfaces which helps to promote the flow of resins during the curing process, providing superior high gloss surface finish.



10.3. Airtech Pressure Sensitive Tapes

Product	Carrier	Adhesive	Maximum Use Temperature
Flashbreaker 1	Polyester 25µm	Silicone	204°C
Flashbreaker 1R	Polyester 25µm	Rubber	204°C
Flashbreaker 1 HT	Polyester 25µm	Ultra High Tack Silicone	204°C
Flashbreaker 2R HT	Polyester 50µm	High Tack Rubber	204°C
WC 8500 PS	Nylon 25µm	Rubber	204°C
Teflease MG2	PTFE 25µm	Silicone / Rubber	260°C
Airkap	Polyimide	25µm	400°C

11. Vacuum Bag Films

Airtech Vacuum bagging films are flexible and airtight plastic film. The bagging film applies pressure over the part making it conform to the shape of the part and consolidating the pre-preg layers, core materials and inserts together

11.1. Vacuum Bag Film Selection, a wide range of Vacuum Bag Films are available offering a range of performance and pricing level. In order to make a technically suitable and coat effective selection the following factors should be considered.

- **Temperature resistance,** to ensure stable performance during elevated temperature cure cycles.
- **Chemical resistance,** to withstand chemical degradation due to resin contact.
- **Elongation & tear strength,** elongation of films into sharp corners and surface details will prevent bridging conditions. Good tear resistance is essential where films are expected to conform to shape without failure.
- **Thickness and Width,** thicker films can provide more robust performance and wider films can reduce touch labour during application onto larger parts.
- **Format,** vacuum bag films are available in Sheet, Tubular, Centre-folded or Gusseted Tube and should be selected depending on the size and method of bagging.

11.2. Vacuum Bag Application, Vacuum bagging film is used as the final layer , a vacuum is applied, the bag is pulled down and conforms appropriately to the tool and part. There are three basic methods of vacuum bagging,

- ***Surface Bagging –*** where the film is sealed onto the mould tool surface using vacuum bag sealant tape. For this technique the mould tool must be completely vacuum tight to ensure no leakage and loss of vacuum.
- ***Envelope Bagging*** – where the mould tool is placed inside a tubular vacuum bag and the ends of the tube are sealed using sealant tape. For this technique the mould does not need to be vacuum tight but must be able to withstand crushing. This technique can only be used when the tool is small and light enough to be lifted inside a vacuum film tube.
- ***Internal Bagging*** – this is an advanced technique for the manufacture of hollow structures. The bagging film is drawn through the hollow structure and seals to either the outside of the mould tool or an external vacuum bag.

  In general, the same basic guidelines and techniques apply in both situations. The condition and configuration of the tool to be used will guide your decision to either surface bag or envelope bag.

11.3. Surface Bagging Method, surface bagging method involves the vacuum bagging material being secured to the face of the tool using sealant tape. The tool should not contain any penetrations that would cause leaks, thereby ensuring vacuum integrity.

- Apply sealant tape around the periphery of the mould tool leaving the backing paper in place and position bagging film over the tool in approximately the correct position. For best results, it is highly recommended that the surfaces are thoroughly cleaned in the area where the sealant tape is used in order to remove any release agent residue prior to using any Airtech vacuum bag sealant tape.

- Typically the bagging film is 30-40% larger than the mould and excess bag film will be taken up with pleats in the sealant tape. Pleats should be placed evenly around the periphery of the tool; if there are severe changes in shape of the tool in any area additional pleats may be required in these areas.

- Apply the bagging film to the corners of the tool by removing the backing paper and pressing the bag film to the sealant tape.

- Moving around the tool form pleats in the bagging film as shown, continue around the tool until the bag is completely sealed onto the tool surface. Utilising pleats in corners, inside and outside radii, and any area where a sudden change in part shape occurs will avoid vacuum bag bridging. This practice equalises pressure application and alleviates additional stress on material. Pleating allows the bag to best conform to part shape, which will determine part thickness and resin placement.

11.4. Envelope Bagging Method, envelope bagging is accomplished by encompassing the entire tool with the nylon bagging material. In this instance the bag itself and not the tool ensures vacuum integrity.

- Tubular vacuum bags are available for the envelope bagging technique, which means sealant tape seals are only required for the two open ends.

- Breather fabric should be applied over the part surface and the reverse side of the tool. This will protect the bag film from potential puncture by sharp areas of the tool backside. It will also ensure complete vacuum distribution over and under the tool.

- Apply the sealant tape onto the inside lower face of the tubular film, leaving the backing paper in place. Ensure that the sealant tape runs across the full width of the tube. Start to remove the backing paper in small sections applying the top layer of film onto the sealant tape without any wrinkles. Continue until the open end is completely sealed.

11.5. Internal Bagging Method, small bore tubular bagging film is drawn through the hollow section of the part. The small bore tubular film should be carefully chosen to ensure enough internal bagging is present to fill the hollow section without relying on elongation of the bagging film. The internal tubular bag needs to be sealed to either the outer mould tool or the external vacuum bag. This should be done with vacuum sealant tape. Atmospheric or autoclave pressure will then be able to inflate the internal bag and apply internal pressure into the hollow section, consolidating pre-preg plies to achieve a high quality laminate.

11.6. Airtech Vacuum Bagging Films

- **Securlon®**, the safest film available, made from advanced multi-layer extrusion technology. These films are soft yet strong and have incredible elongation even at high temperatures. With Securlon®, the most expensive lay-up, regardless of size, will be bagged with the safest nylon film made.

- **Stretchlon®** the highest elongation films available, some over 500%. When parts with multiple contours are vacuum bagged, Stretchlon® is the most practical choice and allows even inexperienced employees to be able to make a good vacuum bag since the extra elongation will stretch into most areas. These films stay soft even in very low humidity. Stretchlon 700 is recommended for phenolic and epoxy resins, Stretchlon 200 is not recommended for BMI, Polyester, or Vinyl ester resins. Stretchlon 800 and 850 are recommended for epoxies and BMI resins. Stretchlon 800 and 850 are not recommended for phenolic resins.

- **Ipplon®** a softer and stronger version of the original nylon films. These films have been the industry "workhorse" for over 20 years and are on worldwide specifications.

- **Wrightlon®**, The original nylon films used for over 30 years worldwide. These products are called out on many specifications for use temperatures to 450°F (232°C).

- **Econolon**, Inexpensive nylon film for low temperature cures, compaction or debulking.

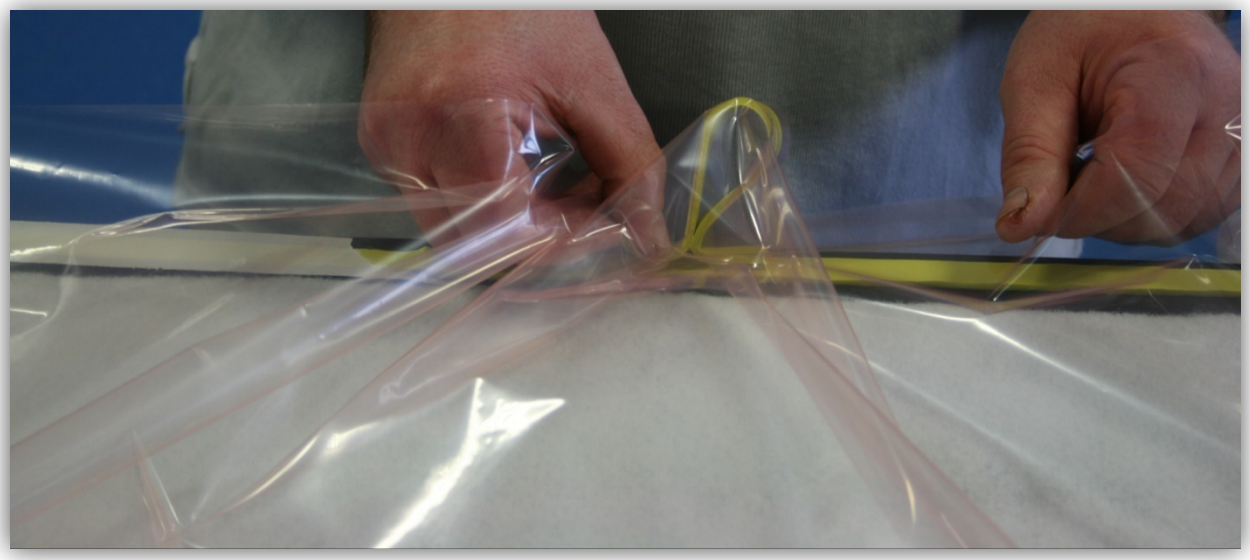
- **Ultra High Temperature Films** most of these films can take temperatures up to 750°F (395°C) and still have good elongation.

12. Vacuum Bag Sealant Tape

Airtight vacuum sealing tapes allow bagging films to be sealed together or to a tool flange area. These maintain a vacuum seal through the curing process to ensure efficient vacuum & autoclave pressure application.

12.1. Vacuum Sealant Tape Selection, a wide range of Vacuum Sealant Tapes are available offering a range of performance and pricing level. In order to make a technically suitable and cost effective selection the following factors should be considered.

- **Temperature resistance,** to ensure stable performance during elevated temperature cure cycles.
- **Chemical resistance,** to withstand chemical degradation due to resin contact.
- **Tack and adhesion,** tapes with high tack and low tack are available. Higher tack tapes are provide better adhesion onto rougher surfaces. Lower tack tapes work well with smooth metal and composite surfaces and allow easy repositioning of vacuum bag films. The ability to remove bag films from the tape and reposition is called SNAP BACK, high quality tapes offer good tack and snap back performance.
- **Clean up after cure,** tapes with good clean up prevent time consuming cleaning of mould tools when the tape is removed after cure of the component.



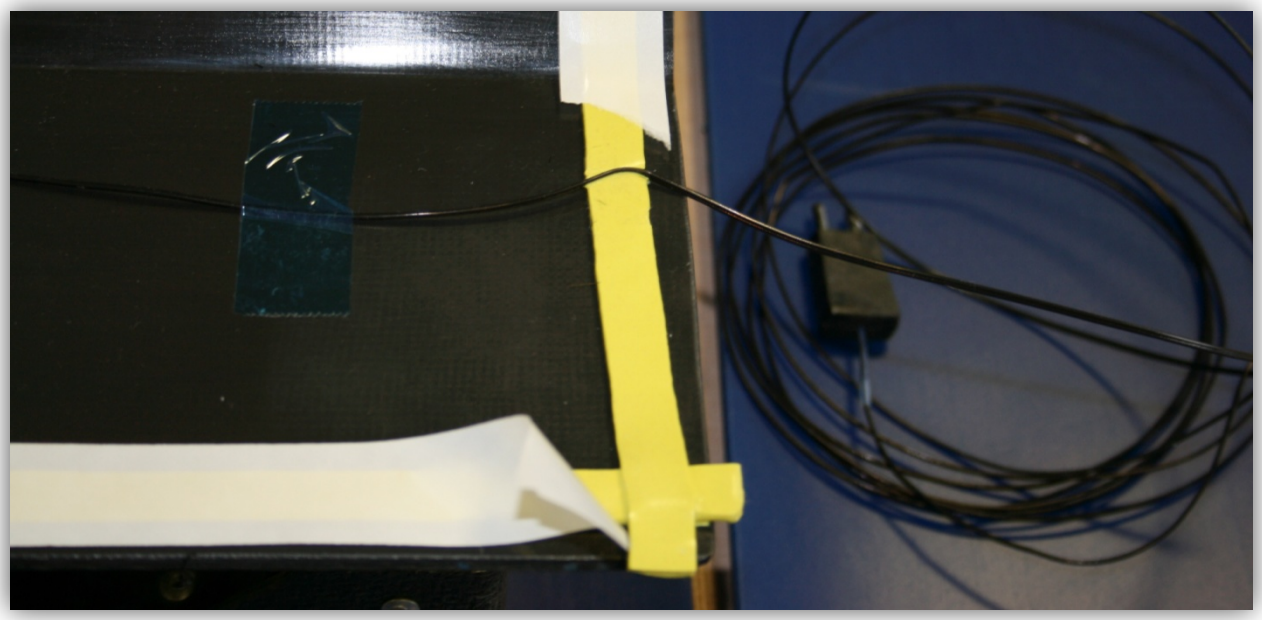
12.2. Vacuum Sealant Tape Application; apply sealant tape around the periphery of the mould tool. Position bagging film as described in the previous section allowing excess bag film to create pleat positions. For best results, it is highly recommended that the surfaces are thoroughly cleaned in the area where the sealant tape is used in order to remove any release agent residue prior to using any Airtech vacuum bag sealant tape. To make a pleat;

- Lay the formed pleat flat across the tool surface, then cut or tear a piece of sealant tape at least as long as the length of the pleat.
- Insert the tape into the pleat, push approximately 10mm onto the tape on the tool. Run the remaining tape along the inside of the bagging film pleat.
- Remove the bagging paper from the sealant tape and close the pleat from bottom to top, taking care to avoid wrinkles. Wrinkles with no sealant tape on the bagging film will be leak paths.

12.3. Placing Thermocouples through Sealing Tape, In additional to providing an airtight seal between bagging films and mould tools, Airtech vacuum sealant tapes also provide an efficient and reliable means of inserting thermocouples inside the vacuum bag for accurate temperature measurement during the curing process.

Airtech Autocouples™ are co-extruded wires and jacket for vacuum integrity. Thermocouple wires with separate outer jackets may need to have this jacket removed before being placed across the vacuum sealant tape to avoid vacuum leakage from the back.

Place the Autocouple across the sealant tape and apply another layer of sealant over the Autocouple. Then proceed with vacuum bagging as normal.



12.4. Airtech Vacuum Sealant Tapes, We offer sealant tapes for use from room temperature debulking to 800°F (427°C) cures. These sealant tapes are designed to stick to the vacuum bag, yet remove cleanly from metal or composite tools.

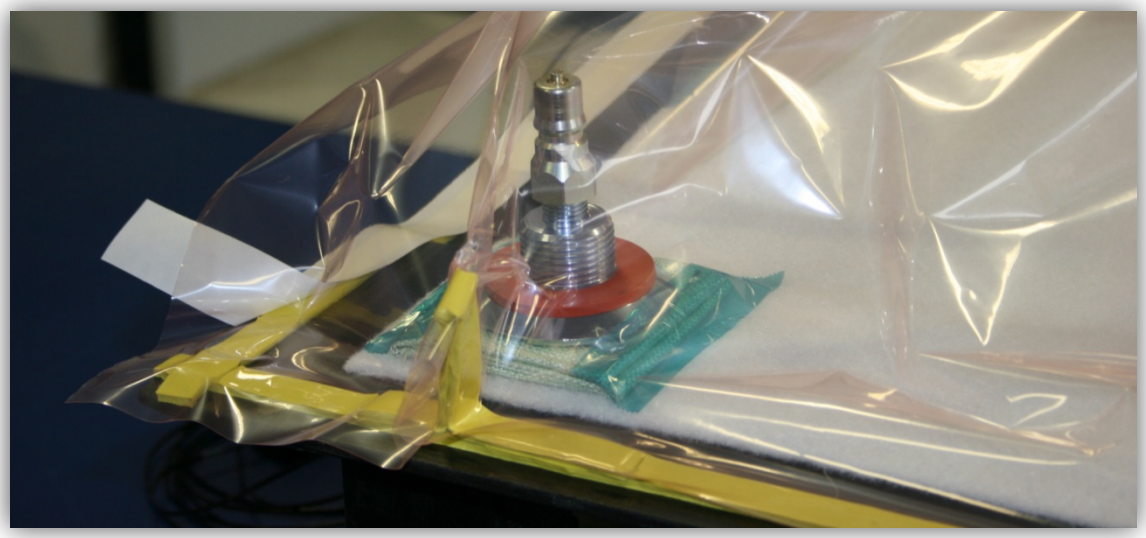
- **GS-95**, This tape is designed for compaction and debulking applications 225°F (107°C).
- **AT-199**, Low profile, economic sealant tape to 300°F (149 °C)
- **GS-100**, Lower temperature multi-purpose sealant tape that works well with composite or metal tools 375°F (191°C)
- **AT-200Y**, Economical multi-purpose sealant tape with high tack and removes easily from metal or composite tools 400°F (204°C)
- **GS-213**, Recognized worldwide, it has excellent tack and clean-up 400°F (204°C).
- **GS-300BE**, Designed for use in extended cure cycles, will adhere to the vacuum bag and tool surface under extreme conditions.
- **GS-333**, Designed for the composite industry to take longer cures and remove cleanly 400°F (204°C).
- **GS-213-3**, A higher temperature version of GS-213. It has lower tack and excellent clean-up on any surface 450°F (232°C).
- **GS-43MR**, The most reliable sealant tape with excellent tack and clean-up to 450°F (232°C). Long cure cycles in an autoclave.
- **GS-580B**, High temperature service good for use up to 600°F (316°C).
- **AVBS 750**, High temperature sealant tape with excellent tack at room temperature.
- **A-800-3G**, The highest temperature sealant tape available with good tack, works to 800°F (427°C).

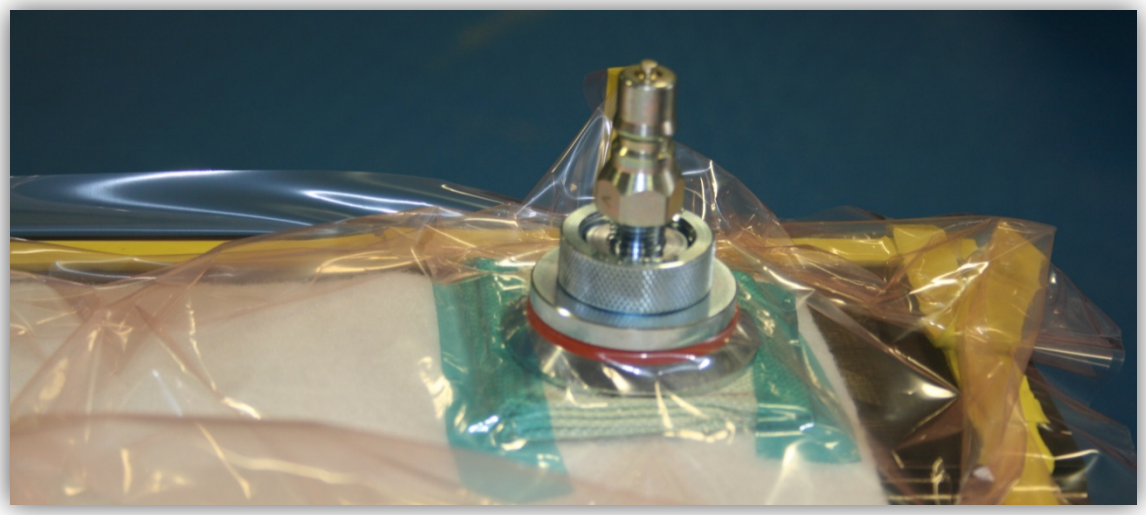
13. Vacuum Valves, Connections & Hoses

Vacuum valves provide a convenient and reliable means of connecting a vacuum source to the vacuum bag. Vacuum Valves clamp the bag film between pressure plates with either a cam-lock mechanism or with a threaded clamp arrangement. Selection can be made based on ;-

- **Temperature,** depending on the usage temperature valve with low temperature or high temperature materials construction can be selected.
- **Clamping Style,** the method of inserting the valve into the bagging film membrane can be cam-lock or threaded clamping.
- **Size and materials,** a variety of size and materials types are available to best suit the tooling configurations used.

13.1. Vacuum Valve Installation, A guide for determining the recommended number of valves needed per square foot of tool area is Up to 30 Square Feet = 2 valves, 20 - 100 Square Feet =4 valves, 100-200 Square Feet = 6 valves





13.2. Vacuum Valve Installation in Pleat, placing the vacuum valve in a pleat in the backing film prevents mark-off on the part when there is insufficient tool surface for valve placement. This technique also helps to prevent resin flow through vac valves into the vac hoses.

14. Vacuum Checking

14.1. Vacuum Lock-off Check

- Connect the Gauge to a VacValve in an opposite diagonal corner to the vacuum hose attachment port.
- After pulling full vacuum, disconnect the vacuum source from the quick disconnect.
- Allow a little air to re-enter through the vacuum connector by depressing the quick disconnect valve button. The gauge should register a drop in vacuum pressure.
- If this is not the case you may have vacuum 'trap off' around the vacuum port area and breather paths should be checked.

14.2. Vacuum Drop / Vacuum Leak Check

- Attach gauge to through bag connector and attach vacuum source.
- Allow vacuum source to draw out air and apply increasing vacuum force, this will be indicated on the Gauge.
- Check and fix potential leakage areas until a stable and satisfactory reading is shown on the gauge.
- Disconnect vacuum source and monitor vacuum reading over period of time.
- Any drop in Vacuum reading highlights a leakage

14.3. Ultrasonic leak detectors, such as the VacLeak LEQ-70 and Sontector WRD-33 can assist in locating minor leaks by detect high pitch frequencies emitted from any vacuum leak paths.

- Scan the vacuum bag with the Ultrasonic detector
- The detector will register stronger signal the closer it is to a leak path
- The Audible tone and LED signal will rise and then fall as the detector passes over a leak.
- Pin point the leakage and repair with vacuum sealant tape.

15. Troubleshooting

15.1. Common causes of Vacuum Leakage or Loss

- ***Bag Film Wrinkle on the Sealant Tape*** - whether using edge bagging or envelope bagging technique, if the bagging film is wrinkled on the sealant tape there will be a leak path. If the wrinkle is small simply massage the wrinkle into the sealant tape to achieve a seal. If the wrinkle is too large, carefully separate the film from the sealant tape and add extra sealant tape.
- ***Bagging Film Wrinkle under Vac Valve Seal –*** Remove the pressure plate from the vac valve connection and check for wrinkling of the bagging film, any wrinkles under the silicone gasket could be a potential leak patch. Smooth out the wrinkles found and re-clamp the vac valve pressure plate firmly shut.
- ***Sharp objects on bagging table –*** When envelope bagging, make sure the table used is free from sharp objects which could puncture the vacuum bag. This can be avoided by covering the table with breather fabric to avoid bag puncturing. If you suspect the bag has been punctured, use a leak detector to find the puncture and reseal with vacuum sealant tape.
- ***Breather or Peel Ply fibres on Sealing area –*** Take care when cutting and trimming breathers or Peel Plies not to leave any fibres over the sealing area. These stray fibres if trapped under the sealing tape can create a potential leak path. Stray fibres can be picked up off the seal area using a piece of pressure sensitive adhesive tape. This a difficult situation to fix without making a new vacuum bag.
- ***Vacuum Bag pleats flapping in autoclave wind cause sealant tape failure –*** Inside autoclaves and recirculation ovens there is a strong wind which can create flapping of large vacuum bag pleats. This can weaken the sealant tape seal under the pleat and lift the bagging film off the tool face. Secure pleats in the vacuum bag down to the tool with PS Tape. This will avoid putting stress on the sealing area.
- ***Bag Bust in corner –*** Bridged bagging materials can stretch past their limit and burst when placed in the autoclave. Ensure all the materials, peel ply, release film, breather and bag film are well tailored and seated in position to avoid bag bursts.

- ***Release agent excess on sealing area -*** Application of release agents over the bag sealing area of the mould tool can prevent secure adhesion of sealing tapes and increase danger of the sealant tape lifting off the mould tool during vacuum bag cures. Masking the sealing areas during application of release agents will avoid poor sealant tape adhesion.
- ***Sealant Tape Slippage –*** Side slipping of the sealant tape is a result of tension in the bagging film, this is usually due to the film being too small for the mould tool and bridging some of the tool shape.
- ***Single layer of breather under vacuum valve –*** A single breather layer under the vacuum valve will not be enough to withstand the crushing effect of the hard vacuum valve base. To ensure adequate breather path under the valve use a vac-pad, a piece of PTFE coated glass fabric or 4 layers of N10 75mm x 75mm.
- ***Vacuum valves or Hoses are blocked –*** resin can sometimes find its way into the vacuum valves and hoses during cure cycles. This will block the vacuum line and prevent flow of air. Hoses can be checked easily, with one end connected to the vacuum source depress the button in the centre of the socket on the free end to check air is flowing. With Vacuum Valves, check their base for signs of resin and depress the button on the quick disconnect plug to check valve can open.