SAE INTERNATIONAL

AEROSPACE RECOMMENDED PRACTICE

ARP5143™ REV. A

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Superseding ARP5143

(R) Vacuum Bagging of Thermosetting Composite and Metalbond Repairs

RATIONALE

Introduction of bagging for metalbond repair.

ARP5143A has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE

This Aerospace Recommended Practice (ARP) describes methods of vacuum bagging, a process used to apply pressure in adhesive bonding and heat curing of thermosetting composite materials and metalbond for commercial aircraft parts. If this document is used for the vacuum bagging of other than thermosetting composite materials and metalbond, the fitness for this purpose must be determined by the user.

The methods shall only be used when specified in an approved Repair Document or with the agreement of the Original Equipment Manufacturer (OEM).

1.1 Purpose

The purpose of this ARP is to provide a set of standard methods for the bagging of thermosetting composite and metalbond materials that may be referenced in Repair Documents produced by airlines or airframe and engine manufacturers. It is intended that this ARP be one of a number of ARPs that will cover other aspects of the techniques required to perform composite and metalbond repairs.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of the other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR4844 Composites and Metal Bonding Glossary

AIR5431 Repair Tooling

ARP4916 Masking and Cleaning of Epoxy and Polyester Matrix Thermosetting Composite Materials

ARP4977 Drying of Thermosetting Composite Materials

ARP4991 Core Restoration of Thermosetting Composite Repairs

ARP5144 Heat Application of Thermosetting Composite Repairs

ARP5319 Impregnation of Dry Fabric and Ply Lay Up

2.1.2 Other References

Original Equipment Manufacturers (OEM) Manuals

2.2 Definitions

All terms used in this ARP are defined in AIR4844.

3. GENERAL

The vacuum bagging procedure is an integral part of fabricating adhesive bonded composite and metalbond repairs. Bagging refers to the sealing of the repaired area by enclosing it in an impervious plastic film. Air can then be evacuated from within the bag to create pressure upon the repair materials.

For the vacuum bag cure, heating may be applied with heat blankets, heat lamps, hot air, or by placing the assembly in an oven or autoclave.

4. MATERIALS AND INSTALLATION PROCEDURES FOR BAGGING OPERATIONS

This section describes the materials needed to carry out the different types of bagging operations. The intention of this section is to describe materials generically in sufficient detail to allow a suitable commercial product to be purchased, and to describe the proper installation techniques, function and potential problems of each of the vacuum bag materials. It is not intended that the information provided be biased to any particular manufacturer and no commercial product is recommended in preference to any other. All materials used should be capable of withstanding temperatures at which cure is required.

It is assumed that the repair materials have already been applied. It is recommended that this section be referred to when following the instructions for proper installation using the methods of vacuum bagging in 8.1 through 8.8 and Figures 9 through 15.

When handling all repair materials suitable gloves must be worn for the operator's safety and to prevent contamination of the repair.

All vacuum bagging fabrics, films, and tapes need to be kept dry to prevent adding moisture to the repair. The storage environment needs to be non-contaminating, dust and oil-free. Protect materials from exhaust fumes, soot, oils, sprayed silicone, mist, rain, or other obvious particulate contaminates. If there is a risk of contamination, envelope bag the materials in a sealed bag or store in a covered container.

4.1 Fabrics

Note that some vacuum bagging fabrics are capable of more than one use inside and outside of the vacuum bag. Check with the material manufacturer or OEM to verify the uses and limitations of various fabrics.

4.1.1 Peel Ply

A layer of open-weave material, usually polyester or heat-set nylon, applied directly to the surface of an uncured lay-up. It protects the surface from contamination during subsequent operations. It is preferable to leave the peel ply on until it is removed from the cured laminate immediately before further surface preparation, bonding or painting of the repair.

NOTE: In some applications it is possible to bond directly to the surface after the peel ply has been removed, however further surface preparation usually is required prior to subsequent bonding or painting operations. Make sure that any materials placed in contact the repair materials are an approved contact material for the cure temperature

Dry peel ply may also be used as a light weight breather between release film, heat blankets and caul plates if applicable.

Peel ply is available pre-impregnated or dry. Refer to ARP5319 for information on the use of peel ply with wet lay up repairs. Refer to OEM recommendations or the Repair Document for suitable peel ply.

CAUTION: Do not use release fabrics (peel ply with an added release agent), on a surface where a subsequent bonding operation will occur. We know that release agents in all circumstances result in weaker bonds.

4.1.1.1 Installation and Removal of Peel Ply

When applying peel ply on complex contours, remove all wrinkles. If necessary, cut and overlap the plies to prevent wrinkles. The peel ply will release easily from the repaired area after cure. To remove peel ply, carefully lift one corner and pull the peel ply back over itself. A sharp knife or a single edged razor blade may be used to start or lift the peel ply to begin removal. Use caution to avoid damaging the composite plies below the peel ply.

4.1.2 Bleeder Cloth

Bleeder cloth consists of a woven fabric or non-woven mat. It is used in single or multiple layers that are placed over the perforated release film to allow the passage of air or gases and to absorb any excess resin. It can also be placed around the edge of the laminate or repair to provide an edge bleed. Some lay-ups, especially those using net resin prepreg materials, do not require bleeding, and do not require bleeder plies.

It is important to note that the number of bleeder plies, in combination with the selected bleeder cloth, peel ply and/or perforated release film, will have a direct effect on the resin content of the cured component. Too few plies of bleeder cloth may result in a resin rich repair, too many plies of bleeder cloth may result in a resin starved repair.

There are two ways to bleed excess resin from a laminate, vertical and horizontal. Vertical bleed can be accomplished with the assembly bleeding through the top surface. Horizontal bleed is known as the Squeeze Out Method. If performing the Squeeze Out Method, edge bleeder is used to absorb excess resin. Refer to ARP5319 for more information.

4.1.2.1 Installation of Bleeder Cloth for Edge Bleed

Place several narrow strips of bleeder cloth around the periphery of the lay-up. Overlap the strips of bleeder material approximately 1.5 inch (38 mm) to create a continuous border or window frame around the repair area. In an edge bleed repair this bleeder material also acts in conjunction with a ventilation channel as an edge breather.

4.1.2.2 Installation of Bleeder Cloth for Vertical Bleed

Bleeder cloth should be placed smoothly over the assembly with as few wrinkles as possible and laid flat against the contour of the component. If bridging is a possibility (see Figure 1), it may be necessary to splice bleeder cloth to maintain full contact with the component. Cut the cloth into two pieces and overlap approximately 0.5 inch (13 mm). If the overlap is too small, a gap may be created due to movement when the vacuum is applied. This can interrupt the vacuum path. Use small pieces of high temperature tape or flashbreaker tape to hold the overlapped edges together. Tape can also be used, if needed, to hold bleeder cloth in place. In no case should the tape be allowed to pass under or over the vacuum bag sealant tape. Do not allow the bleeder cloth to touch the vacuum bag sealant tape. Bleeder cloth fibers across the sealant tape can cause leaks.

4.1.3 Breather Cloth

Breather cloth consists of a woven fabric or non-woven mat. It is used in single or multiple layers that are placed inside the vacuum bag to provide a continuous vacuum path to remove the air initially inside the bag. Breather cloth is also used to prevent excess resin from clogging vacuum ports, lines, valves, etc.

In unheated areas of the repair, sisal or polyamide nylon rope can be placed around the periphery of the vacuum bag to provide a low air resistance ventilation channel to minimize vacuum drop across the vacuum bag. A ventilation channel is necessary in edge bleed vacuum bags to improve the resin bleed from the edge of the repair.

4.1.3.1 Installation of Breather Cloth

Breather cloth should cover the entire area under the vacuum bag to ensure a good vacuum path. It should be placed smoothly over the assembly with as few wrinkles as possible and laid flat against the contour of the component. Additional breather cloth should be placed on all sharp areas where the vacuum bag could be punctured. An additional technique of ensuring a good vacuum path is to place an open weave material or edge breather around the periphery of the repair area.

If bridging is a possibility (Figure 1), it may be necessary to splice breather cloth to maintain full contact with the component. Cut the cloth into two pieces and overlap a minimum of 1 inch (25 mm). If the overlap is too small, a gap may be created due to movement when vacuum is applied. This will interrupt the vacuum path. Use small pieces of high temperature tape or flashbreaker tape to hold the overlapped edges together. Tape can be used if needed to hold breather cloth in place. In no case should the tape or breather cloth be allowed to pass under or over the vacuum bag sealant tape. Do not allow the breather cloth to touch the vacuum bag sealant tape.

Additional layers of breather cloth may be used as insulation plies. They can be placed under or over the vacuum bag film. The number of insulation plies will vary depending on the ambient temperature, and the required cure temperature. It

is important to note that the number of layers of breather cloth under the vacuum bag, can have a direct effect on the compaction of the repair. Too many layers of breather cloth may result in reduced compaction.

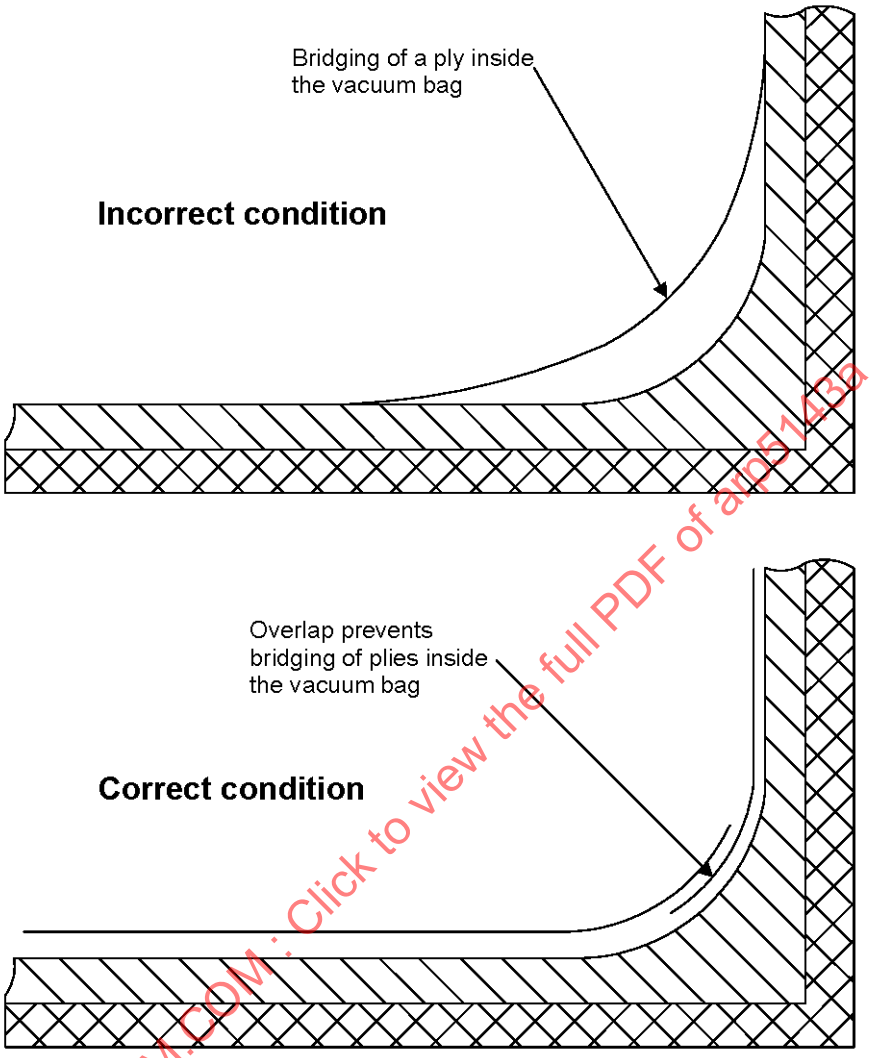


Figure 1 - Comparison of bridged plies (incorrect condition) versus unbridged plies (correct condition)

4.2 Films

Note that some films are capable of more than one use inside the vacuum bag. Check with the material manufacturer or OEM to ensure that the film to be used is suitable for the application.

4.2.1 Release Film

Release film is a permeable or impermeable layer of film that does not bond to the resin being cured. The most common films available are modified halohydrocarbons, PVF, PTFE coated fiberglass cloth (porous and non-porous), polyester, and Fluorinated Ethylene Propylene (FEP). FEP films are used as release films for all types of epoxy resins and are light weight and easily conformable although the ability of the thinner films to stretch can make them difficult to apply to flat surfaces without wrinkles.

4.2.1.1 Perforated Release Film

Perforated release film, also known as porous parting film, or separator, is placed between the repair plies (or peel ply, if used) and the bleeder cloth. This allows for gas flow and resin bleed out through the film, and prevents the bleeder plies from bonding to the repair plies during the cure cycle It is important to note that the kind of film selected (hole size and type of perforations, as well as perforation spacing) in combination with the choice of bleeder cloth has a direct effect on the resin content of the cured component (see 4.1.2).

4.2.1.2 Non-Perforated Release Film

Non-perforated release film, also known as non-porous or solid parting film or separator, is placed over the bleeder plies and is intended to stop resin flow from bleeder plies into the breather cloth layers. It is to be spliced or otherwise overlapped wide enough to prevent bleed-through of the resin or adhesive into the breather plies. Non-perforated release film is also used as a barrier to stop excess resin from bleeding onto heat blankets and caul plates when they are used.

4.2.2 Installation of Release Film

The films should be placed smoothly over the whole surface. Use cuts and overlaps as necessary to avoid wrinkles, gaps or bridging at transitional changes in the assembly (Figure 1). If the release film has not been placed completely against the contour of the assembly, all successive plies (bleeder, breather, etc.) will have the same bridging condition causing a questionable result. Keep overlaps small and use small, narrow pieces of tape on the splices to minimize covering of the holes in the perforated release film.

Release films should be applied to maintain full contact with the configuration of the repair during the cure cycle and cover any uncured resin or adhesive.

4.3 Bagging Film

An impervious plastic film such as nylon or PVF that covers the repaired area or completely envelopes the entire part (and the tool if used) and is sealed at the edges so that vacuum can be applied. The bagging film most typically used is 0.002 to 0.004 inches (0.05 to 0.1 mm) in thickness. Using a thicker gauge of film allows less opportunity for punctures on complex shapes. Use caution when handling the bagging film, avoid wrinkling when possible. Use caution when using sharp-edged tools to avoid cutting the bagging film.

Nylon bagging film is hygroscopic, allowing moisture from the air to be absorbed into the film. When the film is exposed to a humid environment it is more pliable and less likely to crack during bag fabrication. If brittle material is used the bagging film may rip or tear. Ideal conditions are 50 to 70 °F (10 to 21 °C) and 40 to 60% relative humidity.

Be aware of the temperature limitations of vacuum bagging film. Check with the manufacturers recommendations for use.

4.3.1 Installation of Vacuum Bagging Film

(Figures 2, 3 and 4) There are several approaches that may be taken to bag the repaired area. If the area being repaired is small compared to the size of the part, it may be possible to seal only the area around the repair to the part surface. This is known as a surface bag. For large repairs or high temperature cures especially on honeycomb sandwich parts or when using an oven or an autoclave, an envelope bag enclosing the entire part (Figure 2) or the bagging of the whole part to a tool, is recommended.

Envelope bagging of hollow parts is not recommended due to the potential for crushing and highly curved or flexible parts will need a support tool in order to maintain the part contour. Contact the OEM for further information.

Vacuum bagging film should be cut large enough to allow for movement under pressure and to allow for making tucks or pleats (Figure 3). For large or highly contoured parts, an adequate amount of vacuum bagging film will be approximately 1.5 times the length and width of the area to be covered by the vacuum, with 1.0 to 2.0 inches (25 to 50 mm) of vacuum bag film extending over the vacuum bag sealant tape. After removing the paper backing from the vacuum bag sealant tape, care must be taken to position the film evenly around the periphery of the repaired area.

Seal the vacuum bag film at a minimum of four places equally spaced around the repair area. Work from one side to the next making tucks (or pleats) and sealing the film to the surface. Tucks are necessary to prevent bridging and distortion of the part and must be used at all contour changes of the part and/or tool (figure 4)Tucks are used at all abrupt contour changes and on highly contoured parts to avoid bridging (Figure 4). To seal a tuck, the film should be pulled away from the repair and a piece of vacuum bag sealant tape placed in the fold. The vacuum bag film material should be pressed firmly onto the vacuum bag sealant tape to obtain an air-tight seal. If the vacuum bag film pulls on the sealant tape or bridges, the bag may be too small, or the tucks incorrectly positioned.

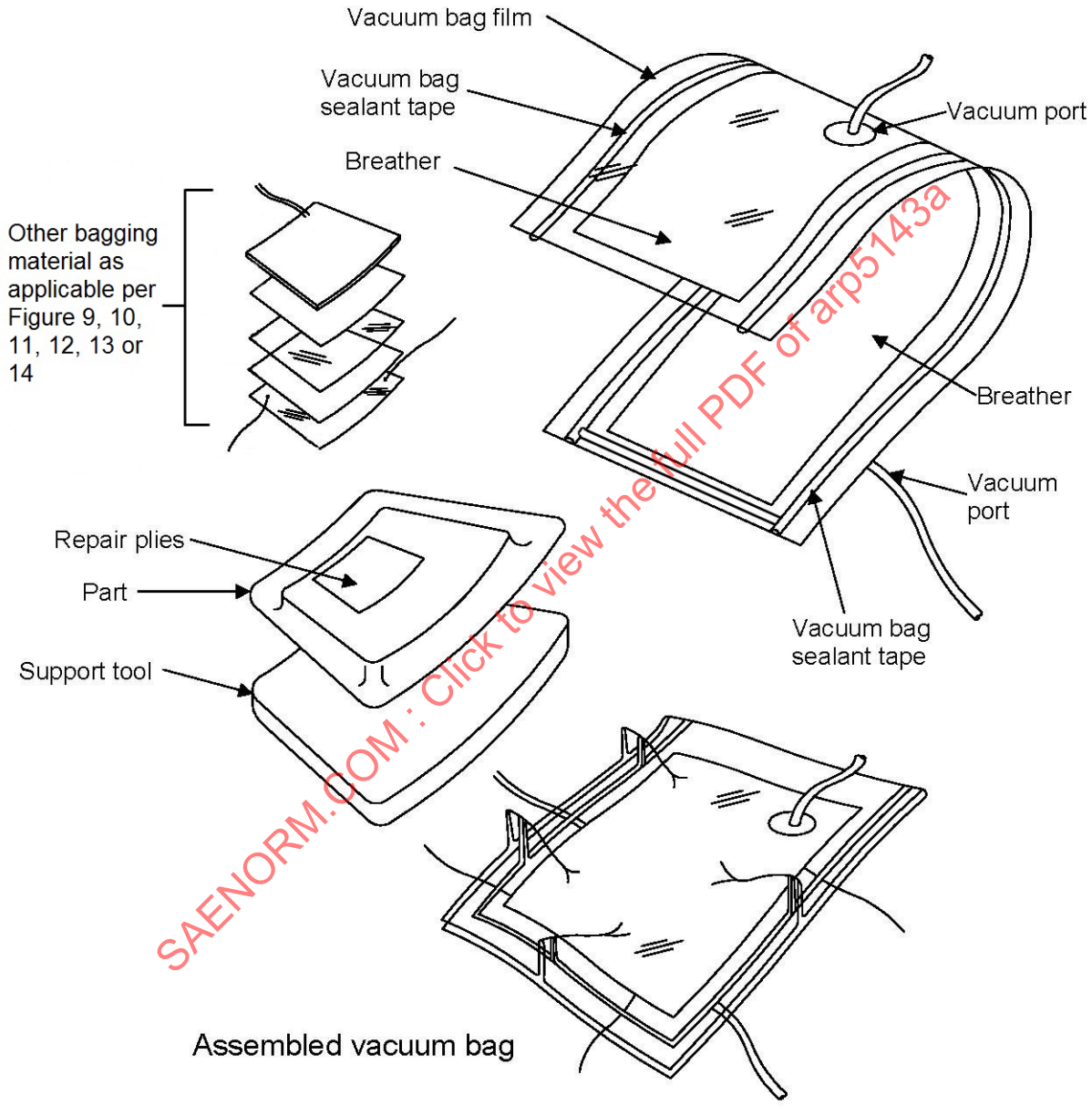
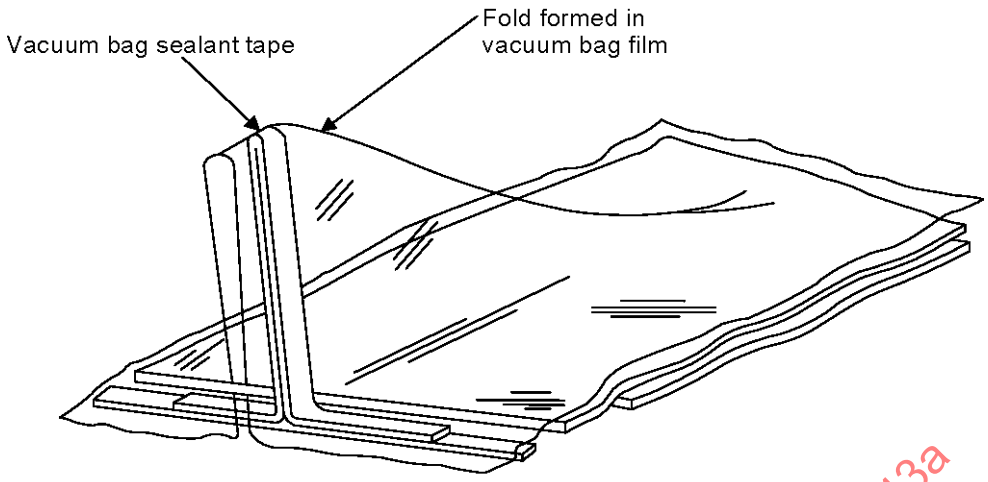
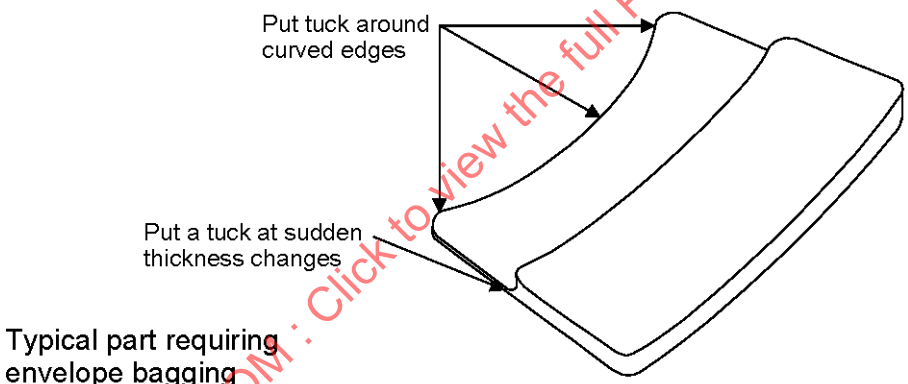


Figure 2 – Envelope bag



NOTE:
It is optional to enclose the breather into the fold of the vacuum bag film when you make the tuck.

Figure 3 - Typical vacuum bagging film tuck or pleat



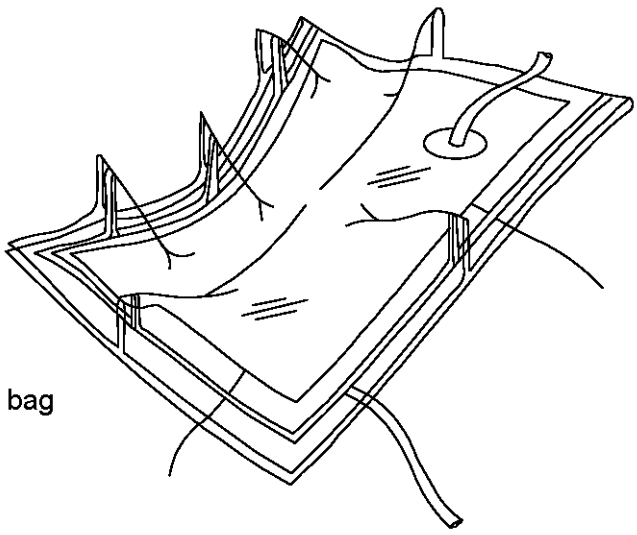


Figure 4 - Typical tuck locations

4.4 Tapes

Note that some tapes are capable of many uses both inside and outside of the vacuum bag. Check with the material manufacturer or OEM to ensure that the tape to be used is suitable for the application.

4.4.1 Vacuum Bag Sealant Tape.

NOTE: Do not use silicone based pressure sensitive adhesive tapes above room temperature within the vacuum bag.

A semi-cured plastic material having the tackiness to hold and seal the bagging film during the cure cycle. It comes on rolls with one side covered with backing paper. Sealant tape is the sealing medium between the vacuum bag film and either the tool surface or the periphery of the repair area. Use the vacuum bag sealant tape designed for the temperature and pressure required or as called out by the Repair Document. Be aware of temperature limitations of some tapes.

4.4.1.1 Installation of Vacuum Bag Sealant Tape for a Surface Bag

Prior to applying vacuum bag sealant tape to the periphery of the repair area or the tool surface, the surfaces should be cleaned per ARP4916, Composite Cleaning method 3, 4, or 5.

NOTE: Do not touch the sealant tape, you will contaminate the tape, this will make it difficult to meet the leak check requirements.

Place the vacuum bag sealant tape, approximately 6 inches (150 mm) beyond the largest repair ply unless otherwise specified in the Repair Document. The best technique is to apply the sealant tape in one continuous strip; turning it at each corner pressing firmly with your thumb or palm of your hand. When applying sealant tape, be careful not to stretch the tape, as this may cause the bagging film to gather and bunch up when tension is released. Keep the paper backing on to prevent the sealant tape from stretching during application, and to keep it clean from contaminants to avoid a leaky bag. The paper backing should not be removed from the sealant tape until you are ready to apply the vacuum bag film.

Where sealant tape ends meet, the two strips should overlap (Figure 5). Do this by peeling the paper back from the sealant to be crossed and lay the second strip over the bared sealant.

4.4.1.2 Installation of Vacuum Bag Sealant Tape for an Envelope Bag

To make an envelope bag, apply the vacuum bag sealant tape around the periphery of the vacuum bag film approximately 2.0 inches (50 mm) from the edge of the film using the same method as described in 4.4.1.1 above.

When the bag is ready to be sealed the bagging film is folded around the part (and the tool, if used) to completely enclose the part. The vacuum bag sealant tape is pressed together (see Figure 2).

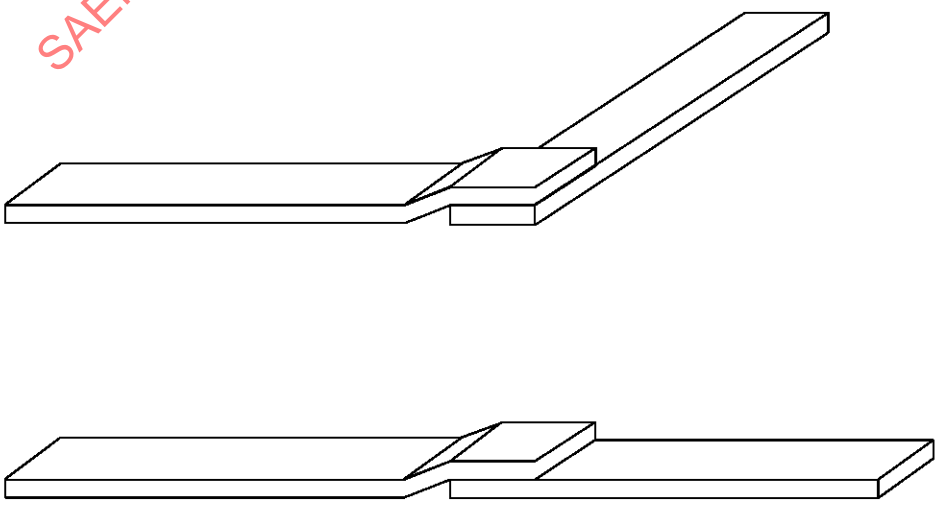


Figure 5 - Vacuum bag sealant tape overlap

4.4.2 High Temperature, Pressure Sensitive Tapes

Tape is used for a variety of applications in the composite fabrication process. It will stick to another material when applied under finger tip pressure and it is capable of withstanding the high temperatures encountered during a high temperature cure. The tape is removed after the cure cycle is complete and is not part of the final composite assembly. Tape is used for various composite fabrication purposes, such as securing thermocouple wires and holding the various fabrics and films in position during assembly of the vacuum bag.

4.4.2.1 Flashbreaker Tape

Nylon or polyester one sided non-contaminating adhesive coated film tape. This is a tape used around the edge of a bonded joint or repair patch so that any adhesive that flows out during cure can be easily removed. Refer to ARP4916 Composite Masking Method 5.

Flashbreaker tape is also used for other applications in the composite repair process, such as securing thermocouple wires around the repair area and covering a caul plate to protect it from adhesive bleed out.

4.4.2.2 Double Backed Tape

A polyester film coated on both sides with a non-contaminating adhesive. Used primarily to hold items in place in vacuum bag lay-ups, such as holding peel plies and breather cloths.

5. EQUIPMENT AND INSTALLATION PROCEDURES FOR BAGGING OPERATIONS

This section describes the equipment needed to carry out the different types of bagging operations. The intention of this section is to describe equipment generically, in sufficient detail, to allow a suitable commercial product to be purchased. It is not intended that the information provided be biased to any particular manufacturer and no commercial product is recommended in preference to any other. All equipment used should be capable of the temperatures at which cure is required.

This section also describes proper installation techniques, function and potential problems of vacuum bag equipment. It is assumed that the repair materials have already been applied. It is recommended that this section be referred to when following the instructions for proper installation described in the methods of vacuum bagging in 8.1 to 8.7 and Figures 9 through 14.

5.1 Thermocouples

Thermocouples (also known as T/C's) are used to monitor the cure temperature during the cure cycle. Several types of thermocouples can be found, but they always use the same principle: a device which uses a circuit of two wires of dissimilar metals or alloys, with dissimilar thermo-electric characteristics, joined at one end. Refer to ARP5144 for more detailed information.

5.1.1 Installation of Thermocouples

(Figure 6) Perform a functional test of the thermocouples before installation to prevent unnecessary rebagging if a thermocouple is not working correctly, refer to ARP5144. Pass the wires through a convenient seam in the vacuum bag sealant tape. Tape the wires to the base structure inside the bag with a pressure sensitive tape. Place the wires over the sealant tape that is on the tool or part surface. Cover the wires with a second piece of sealant tape. Keep the wires separated so that air cannot leak between the wires. Thermocouple wires should be sealed to prevent vacuum leaks. If a thermocouple with a braided exterior is being used, remove the braiding to prevent air leakage through the braid. For other types of insulation, try to obtain the desired vacuum, if leaks occur, remove the exterior insulation locally. Do not allow the bared section of wire to contact conductive surfaces of tools, conductive caul plates or as this will cause the thermocouple to give inaccurate readings. Place a layer of flashbreaker tape under the TC junction when in contact with any conductive surface, for example a carbon part or conductive caul plate.

Avoid laying wire across any sharp transitions between overlays and/or pressure pads that might damage the wires. Do not allow thermocouple wires to cross when under the vacuum bag. This has been known to cause erratic readings.

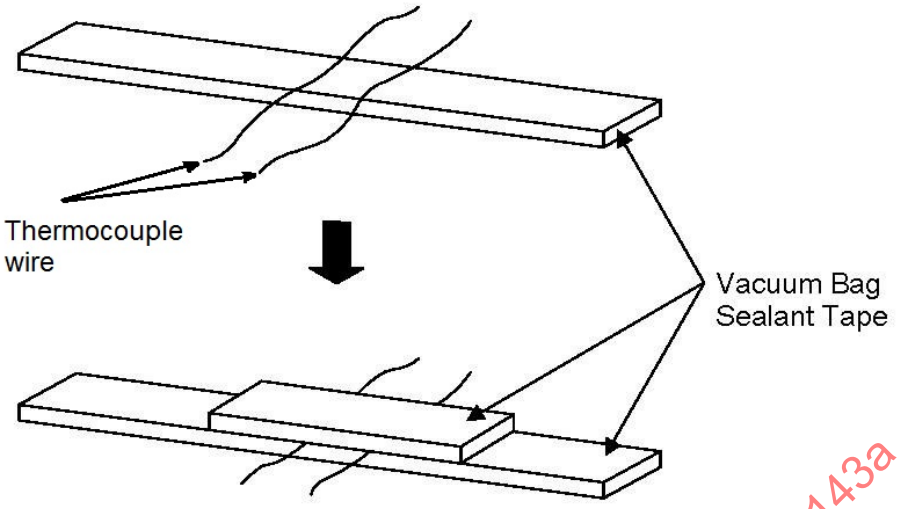


Figure 6 - Installation of thermocouples or heat blanket wires

For the number of thermocouples required and their location, especially with regard to heat sinks and their effects, refer to the Repair Document and ARP5144.

5.2 Caul Plate

Smooth support plate, usually metal, cured composite or silicone sheet. Caul plates are used in the following ways:

a. To enhance the aesthetic appearance by providing a smooth surface on the finished laminate.

b. To act as a local tool to maintain contour possibly with the assembly tool to fix the part details in place. Pressure on the repair will be uneven, or non-existent, if the caul plate does not conform to the required contour.

c. To support the bag over an area where the vacuum bag pressure may cause local crushing at vulnerable edges.

   For example, at core splices or at repair edges when performing a drying operation on honeycomb parts. Refer to ARP5144.

   In complex parts a caul plate may also be used during cure to support the bag over pockets or holes.

d. To provide more uniform temperature distribution when using a heat blanket, heat lamps or heat guns. A thin, flexible, metal sheet (the same size as the heat blanket, if one is used) can be used to aid in even heat distribution to the repair area during cure. For more information on the use of caul plates for temperature distribution, refer to ARP5144.

5.3 Pressure Pad

Pressure pads, also somewhat inaccurately known as pressure intensifiers, are used to assure ply compaction in a specific location. They are generally made from felt or rubber. A pad may be used around square edges of honeycomb panels or to control the bondline thickness in a doubler area where a critical dimension is to be met. Pads may also be used on sharp edges or radii to prevent rupture of the bagging material.

NOTE: In some applications like open core along the edges it is best practises to use edge protectors also called fairing bars to keep the core from crushing.

5.3.1 Installation of Pressure Pads

Pads shall be separated from the part with release films (Figure 7) to prevent direct contact with uncured materials. Always cover the pad with breather material prior to installing the bagging film.

5.4 Heat Blankets

Heat blankets are commonly made of a silicone rubber sheet with an electrical resistance heating circuit. They must be flexible to match the repair contour and have a good temperature uniformity to minimize hot and cold areas. Use caution when bending or forming heat blankets to prevent breaking the fragile wires within the blanket. Check the heat blanket manufacturer for recommendations and/ or limitations.

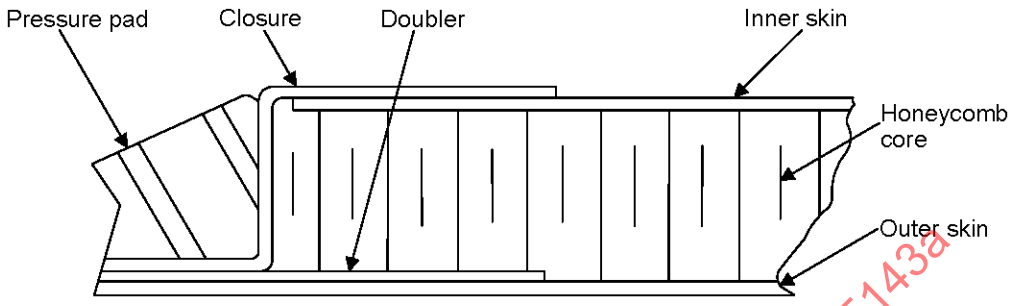


Figure 7 - Typical installation of pressure pad

5.4.1 Installation of Heat Blankets

Heat blankets have a cooler area around the perimeter of the blanket. Place the heat blanket so that it extends past the repair on all sides by a minimum of 2.0 inches (50 mm). Refer to ARP5144, Heat Application, for more information. Pass the heat blanket wires through a convenient seam in the vacuum bag sealant tape and away from any thermocouple wires passing through the sealant tape. Tape the wires to the base structure inside the bag with a pressure sensitive tape. Place the wires over the sealant tape that is on the tool or part surface. Cover the wires with a second piece of sealant tape (Figure 6).

5.5 Vacuum Ports

Vacuum ports provide air passage through the bagging film and a hose connection for the vacuum line. A number of port designs exist and are commercially available such as two piece ports or tube type ports. The two piece ports provide greater efficiency as there are fewer points of contact where a leak could occur. Tube type ports can be used when no space on the tool or repair periphery is available.

The vacuum port and the vacuum gauge port (see 5.6) should be placed at opposite corners of the bag. At least one vacuum port and one vacuum gauge port is required.

CAUTION: Do not place vacuum ports over the heatblanket and thermocouples.

5.5.1 Installation of Vacuum Ports (see Figures 8A, 8B, and 8C)

5.5.1.1 Installation of a Two-Piece Port

a. Determine where the port will be placed. Try to put the vacuum port and the vacuum gauge port near opposite corners of the bag.

b. Put the port away from the repair area. If no space is available around the repair, place the port on a tuck. This will prevent the port from contacting the repair area and permanently deforming the surface. Additionally, if the repair uses local heat application, put the port on an unheated area of the part and not on or near the edge of the heat blanket, if one is used. The concentration of heat in the metallic parts of the port can cause deformation or damage to the blanket.

c. Prepare the vacuum bag film to install a vacuum fitting by cutting a hole in the bagging film. Cut a hole in the bagging film with a circular hole punch or fold the film and cut a half circle, 1 inch (25 mm) diameter. An "x" shape may also be cut. Cutting an “x” shape may cause the bagging film to tear when subjected to vacuum so care should be used with this method. After the opening is made in the bagging film, the bag is placed over the vacuum connection and pressed firmly onto the gasket. If the is no gasket, make a gasket from vacuum bag sealant tape.

d. Attach the outer ring of the fitting onto the stem of the port to clamp the vacuum bag.

e. Use a breather cloth pad inside the vacuum bag under the vacuum ports to prevent edges of the port from obstructing vacuum flow and to absorb any resin flow before it gets into the vacuum line.

f. If the vacuum bag is large, more ports may be necessary. One port for every square meter is recommended.

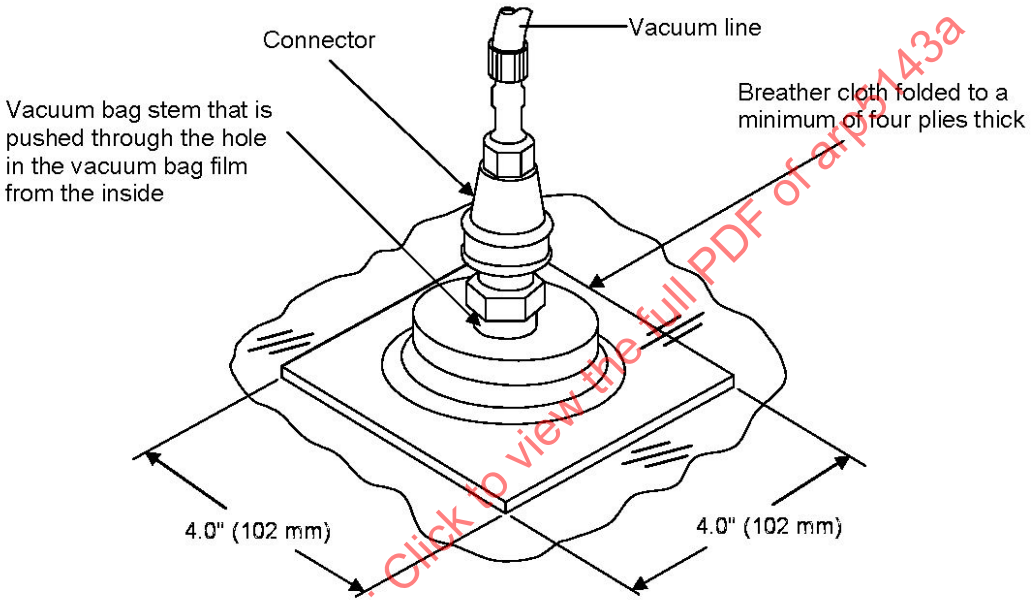


Figure 8A - Typical two-piece vacuum port

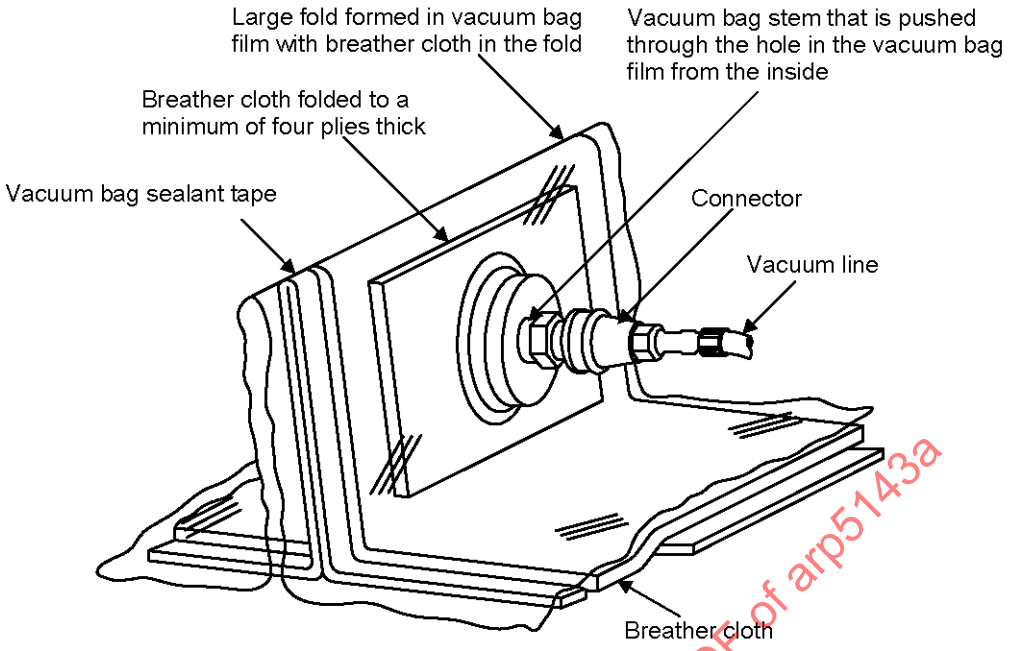


Figure 8B - Vacuum port located on a tuck

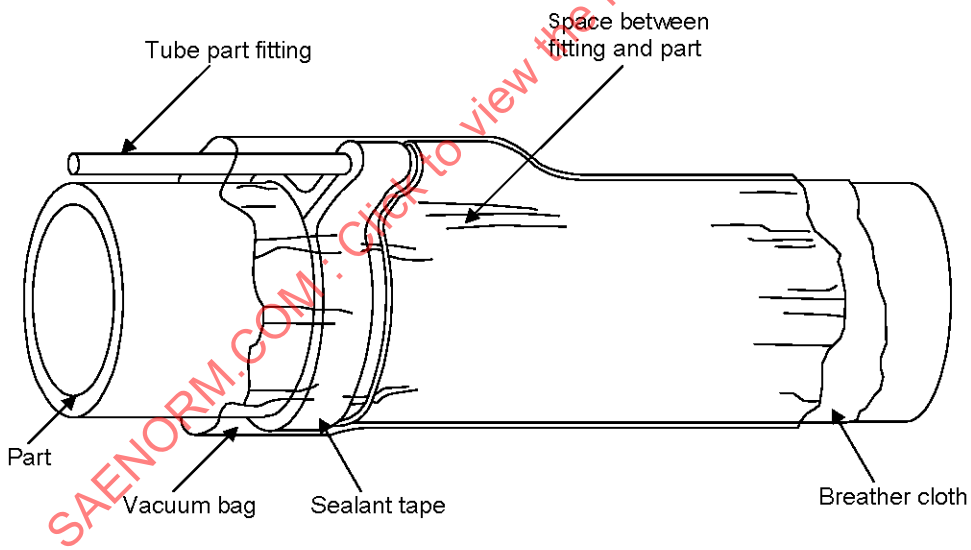


Figure 8C - Installation of a tube type port

Figure 8

5.5.1.2 Installation of a Tube Port (Figure 8C)

This type of vacuum port consists of a length of tube with a vacuum line connection at one end and a series of perforations at the other. The perforated end is covered with a glass fabric. To prevent the tube fitting from sealing off, the fabric should extend beyond the tube about 10 inches (254 mm) and contact the top of the breather system inside the bag. This will provide a good vacuum path between the vacuum source and the breather system.

a. Determine where the port will be placed. Try to put the vacuum port and the vacuum gauge port near opposite corners of the bag.

b. Put the port through a seam with the vacuum bag sealant tape around it. Leave a space between the fitting and the part. The tube, when properly installed, is placed in a tuck, not against the part, see Figure 8C.

5.6 Vacuum Gauge Ports

A vacuum gauge port is identical to a vacuum port, but is used to attach a vacuum gauge or a vacuum monitor line to measure the vacuum. At least one vacuum gauge port connection is required. The connection should be placed at the opposite corner of the bag to the vacuum port (see 5.5).

A vacuum gauge is a device attached directly to the vacuum gauge port capable of indicating vacuum pressure. A negative vacuum pressure range of 0 to 30 inch Hg (0 to 100 kPa) is required.

A vacuum monitor line is a vacuum hose connected to the vacuum gauge port and to a remote vacuum monitoring device via permanent vacuum piping. This is usually used when curing parts in an oven or autoclave where it is not possible to read a vacuum bag mounted gauge.

5.6.1 Installation of Vacuum Gauge Ports: A vacuum gauge port is installed as described in 5.5.1.

6. APPLICATION OF VACUUM PRESSURE AND LEAK CHECK

The vacuum integrity check (leak test) is performed as the last step in the bagging process. It is important to ensure the bag is sealed properly and is leak free before starting the cure. If the bag fails during the cure cycle, the vacuum bag will not be able to transfer uniform pressure to the assembly. A failed bag can cause discrepancies within the repair, often resulting in having to remove and repeat the repair.

When the bag is completely sealed, a light vacuum is drawn, approximately 5 inch Hg (17 kPa) and the bag is drawn into all contour changes, hollows and areas of overlays. At this point, check that no bridging occurs and adjust tucks as necessary.

Check the bag for leaks. Attach a gauge to the vacuum gauge port. Apply the minimum obtainable vacuum pressure available in the vacuum system, the vacuum must be sufficient that the test is accomplished at a minimum of 22 inch Hg (75 kPa) unless otherwise specified in the Repair Document. Wait for several minutes until the readings have stabilized. Disconnect the vacuum source at the probe and check the rate of vacuum loss. The leak rate should be less than 5 inch Hg (17 kPa) pressure drop timed over a 5 minute period. If the leak exceeds this rate, adjust the sealing until it is acceptable. The bag can be checked for leaks with the use of an Ultrasonic Leak Detector that gives an audible indication of leaks as the detector is passed along the possible leak paths.

If the vacuum bag is leaking, the seal may be improved by pressing the film more firmly into the sealant tape with a radius edged tool or finger pressure. Should there be a pinhole or tear in the vacuum bag film, cut a patch made from vacuum bag film larger than the hole or tear to be repaired by at least 2 inches (50 mm) in all directions. Apply vacuum bag sealant tape to the patch and attach the patch over the leak. A proper patch will draw down as the air is removed from the patch. Do not stick vacuum bag sealant tape over the hole or tear. Curing pressure along with the curing heat will force the sealant through the pinhole or tear causing the leak to reappear.

If the leak can not be fixed, remove and replace vacuum bag and sealant with new materials. Reclean the part seal surface prior to installing the new bag. With some parts it is not posible to use a surface bag and an envelop bag is required.

Areas where leaks are likely to be detected:

a. Places where the vacuum bag sealant tape has been doubled, e.g., thermocouple locations, heat blanket wire locations, tucks, overlap splice joints, etc., and the seam.

b. Vacuum ports, fittings, gauges (check seals, o-rings and threaded joints) and port locations (at locations where a hole is cut in the bag to accommodate the vacuum port fitting including vacuum line connections and fittings).

c. From contaminated sealant tape, as a result touching the sealant tape during application

d. Where bleeder or breather material fibers are stuck to the vacuum bag sealant tape.

e. If the release film is over the sealant tape.

f. Pin holes in the vacuum bag film.

g. Vacuum bag sealant tape not secured to the part or surface especially if the surface is not properly cleaned or not fully cured from a previous stage of the repair.

h. Leaks between heat blanket wires, or thermocouple wires and insulation.

i. Leaks at part fastener locations that are under a surface bag.

j. Tool leaks associated with porosity and tool attachment points, refer to AIR5431, Repair Tooling, for tool integrity checks and potential repairs.

k. Leaks at corners and turns of the sealant tape.

7. REPAIR INTEGRITY AND EVALUATION GUIDELINES

After the cure cycle has begun and a drop in vacuum is found, there are several factors to consider in order to determine whether and how the repair quality will be affected:

a. Where the leak occurred.

b. The amount of vacuum and how long it was lost.

c. The stage of the cure when the leak occurred.

If the loss of vacuum is on the edge seal of the bag and a channel breather or edge breather is being used, a leak is less likely to be detrimental. If the leak is coming through the backside of the repair or through the honeycomb and there is a possibility of the air going through the repair area, a problem is more likely in the repair. If the vacuum drops during a heat blanket cure, it will be easier to reseal the bag than if it is an oven cure where access is limited.

If the leak occurred before the resin was cured for up to 75% of the total required cure soak (dwell) time, the quality of the repair may be degraded. Use caution, since this may not apply to all resins. Once the resin has become gelled, it may be acceptable only if the heat source, such as a heat blanket, has not lifted away from the surface of the repair, resulting in uneven heat transfer. As a general rule, a loss of 5 inch Hg (17kPa) may be acceptable for the rest of the cure, if more than that is lost, the quality of the repair may be compromised. However, the location and magnitude of the leak can still compromise the quality of the repair even when the loss is less than 5 inch Hg (17kPa). Ask the OEM for the limitations on restarting a cure after a vacuum bag failure. The OEM will have the rheology data of the repair material.

When bagging for oven or autoclave cure, a maximum leak rate is 1 inch Hg in five minutes is recommended. The air or gas will have a lower viscosity at elevated temperature. A small leak at room temperature can become a large leak at high temperature.

For repair integrity and evaluation guidelines for a power source or heat failure, refer to ARP5144.

These are guidelines only. The Engineering and Inspection Authority shall evaluate these situations and determine further action.

8. METHODS OF BAGGING

The methods provided are standard methods for the bagging of thermosetting composite repairs and metalbond repairs that may be referenced in Repair Documents. The methods shall only be used when specified in an approved Repair Document or with the agreement of the Original Equipment Manufacturer (OEM).

In the methods provided, all instructions are essential unless they are specifically stated as optional. Optional steps are added to address specific repair needs. Optional steps should only be used if specified in the Repair Document. The methods should be read carefully before performing. All optional procedures should be reviewed for applicability.

8.1 Method 1 - Vertical Bleed Cure with or without the use of a heat blanket (Figure 9)

Refer to the Installation Procedures in Sections 4 to 7 for more detailed information on each step.

8.1.1 Application

a. Apply flashbreaker tape around the periphery of the repair area. Refer to ARP4916 Composite Masking Method 5.

b. If peel ply is specified (Optional), place a layer of peel ply over the repair plies, extending approximately 0.5 inch (13 mm) beyond the edge of the repair. Refer to ARP5319.

c. If edge breather is specified (Optional), place several strips of narrow breather material approximately 4 inches (100 mm) from the edge of the largest repair ply around the repair. Keep 0.5 inch (13 mm) away from the peel ply.

d. Apply vacuum bag sealant tape to the periphery of the repair area, approximately 6 inches (150 mm) beyond the largest repair ply. Use Figure 9 as a guide to determine the location of the vacuum bag sealant tape with respect to the materials inside the vacuum bag (heat blankets, edge breather, etc., if used) for each repair. Do not place the vacuum bag sealant tape on the flashbreaker tape, as this can cause leaks. Do not remove the protective paper at this time.

e. Install the thermocouples. Refer to ARP5144.

f. Place a layer of perforated release film over the repair area extending approximately 2 inches (50 mm) beyond the edge of the repair. Smooth to remove wrinkles.

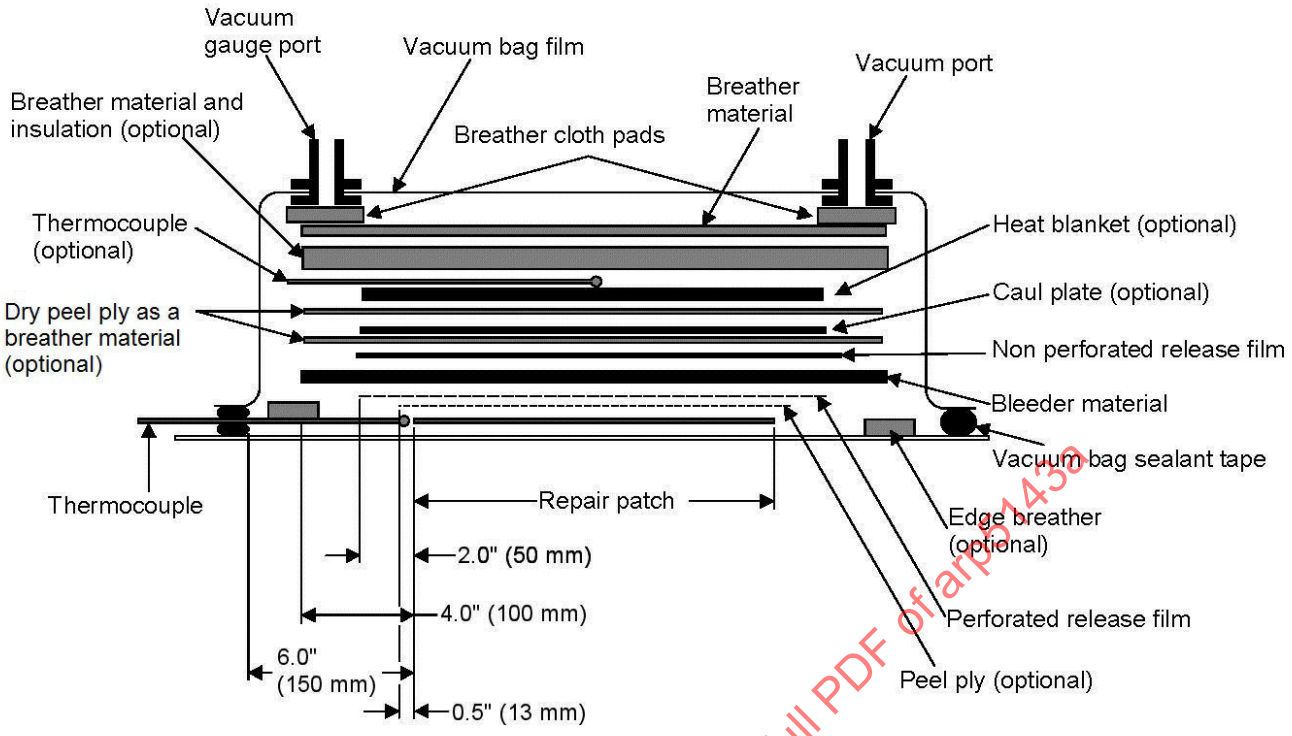


Figure 9 - Method 1 - vertical bleed cure

g. Place the bleeder material over the perforated release film extending approximately 2 inches (50 mm) beyond the edge of the perforated release film. If using a heat blanket, extend the bleeder material approximately 2 inches (50 mm) beyond the heat blanket. (Refer to the Repair Document for the number of bleeder plies needed.)

h. Place a layer of non-perforated release film over the bleeder plies, but allow the bleeder plies to extend 2.0 inches (50 mm) beyond the edges of the non-perforated release film. Cut the non-perforated release film so that the edges extend past the perforated release film, and the heat blanket.

i. If a caul plate is specified: (Optional)

1. Use annealed copper or AL 1100-0 aluminum 0.016 in (0.4 mm) inches thick. Place one layer of peel ply over the non-perforated release film as a breather cloth layer under the caul plate Optional). If used, make sure that the peel ply makes contact with the bleeder plies along the edges.2.Place the caul plate over the peel ply (optional).

j. If a heat blanket is specified as the heat source: (Optional)

1. Place one layer of peel ply (optional) over the non-perforated release film (or the caul plate if one is used) as a breather cloth layer under the heat blanket. Make sure that the peel ply makes contact with the bleeder plies along the edges.

   NOTE: The peel ply is used here because it has better heat transfer than woven cloth or non-woven mat breather material.

2. Place the heat blanket on the peel ply.

3 If it is necessary to monitor the heat blanket to prevent over-temperature of the heat blanket place a thermocouple over the center of the heat blanket.

4. Place four to five layers of breather cloth over the heat blanket. This will also insulate the heat blanket and prevent damage to the vacuum bagging film. Make sure that the breather cloth makes contact with the bleeder plies along the edges.

k. If a heat blanket is not specified, place one to two layers of breather cloth over the non-perforated release film or the caul plate if specified. Make sure that the breather cloth makes contact with the bleeder plies along the edges.

l. Install the vacuum ports and cover the repair area with vacuum bagging film as follows:

1. Cut the vacuum bag film 1.5 times the size of the area to be covered.

2. Make a minimum of two cut openings in opposite corners of the vacuum bag film. One will be used for the vacuum port and one will be connected to the vacuum gauge port.
When using an envelope bag the base of the vacuum ports have to be installed prior to the sealing of the bag.
It is best practice to place the vacuum port on top of the breather but not over a heat blanket or thermocouple.

3. Seal the vacuum ports to the vacuum bag film.

4. Place the vacuum ports on a breather cloth pad (4 ply thick minimum) and place them on the edge of the breather cloth layers. Do not place the vacuum ports on or near the repair area.

5. Seal the vacuum bag. At the side of the vacuum port, remove the paper from the vacuum bag sealant tape. Lightly apply the film to the sealant tape. Make sure that the vacuum bag film is not stretched and is in the correct position, adjust if necessary. Press the vacuum bag film firmly onto the vacuum bag sealant tape to obtain an air-tight seal.

6. Continue to remove the backing paper from the sealant tape and seal the edge of the vacuum bag to the sealant tape. Place tucks in vacuum bag film at intervals to allow for material stretching and contour changes.

m. Evacuate the bag as follows:

1. Connect the vacuum source and smooth the bag by hand pressure as the air is removed.

2. Stop and make adjustments to the vacuum bag film to prevent local stretching of the film

3. Continue to evacuate the vacuum bag.

4. Check for leaks and reseal if necessary. If available, use an Ultrasonic Leak Detector to detect air leaks in vacuum bag. A minimum vacuum pressure reading of 22 inch Hg (75 kPa) is required, unless otherwise specified by the Repair Document.

5. Wait for several minutes after the readings have stabilized.

6. Disconnect the vacuum source at the probe and check the rate of vacuum loss. The leak rate should be less than 5 inch Hg (17 kPa) pressure drop timed over a 5 minute period.

7. If the leak exceeds this rate, adjust the sealing until it is acceptable.

n. If a heat blanket is specified (Optional), insulating material can be placed over the vacuum bag to reduce heat loss.

8.2 Method 2 - No Bleed Cure (With or Without the Use of a Heat Blanket)

Refer to the Installation Procedures in Sections 4 through 7 for more detailed information (Figure 10).

8.2.1 Application

a. Apply flashbreaker tape around the periphery of the repair area. Refer to ARP4916 Composite Masking Method 5.

b. If peel ply is specified (Optional), place a layer of peel ply over the repair plies, extending approximately 0.5 inch (13 mm) beyond the edge of the repair. Refer to ARP5319.

c. If edge breather is specified (Optional), place several strips of narrow breather material approximately 4 inches (100 mm) from the edge of the largest repair ply around the repair. Keep 0.5 inch (13 mm) away from the peel ply.

d. Apply vacuum bag sealant tape to the periphery of the repair area, approximately 6 inches (150 mm) beyond the largest repair ply. Use Figure 9 as a guide to determine the location of the vacuum bag sealant tape with respect to the materials inside the vacuum bag (heat blankets, edge breather, etc., if used) for each repair. Do not place the vacuum bag sealant tape on the flashbreaker tape, as this can cause leaks. Do not remove the protective paper at this time.

e. Install the thermocouples. Refer to ARP5144.

f. Place a layer of non-perforated or perforated release film over the repair plies or peel ply if specified.

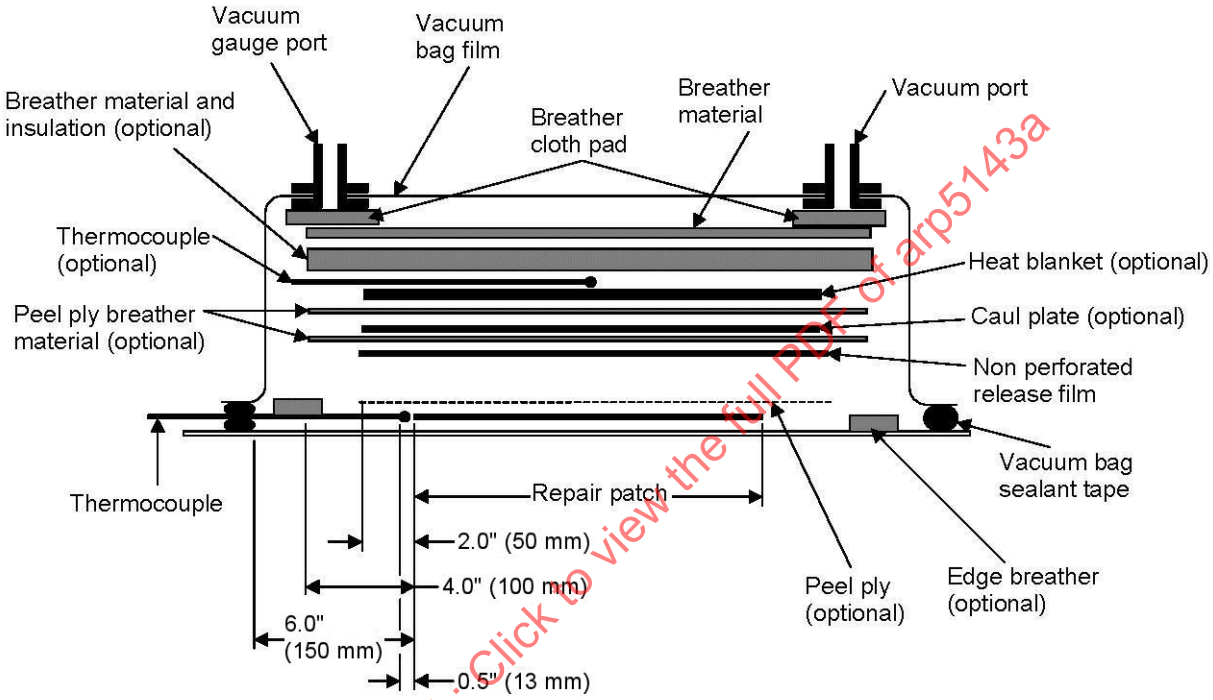


Figure 10 - Method 2 - no bleed cure

g. If a caul plate is specified: (Optional)

1. Place one layer of peel ply over the non-perforated release film as a breather cloth layer under the caul plate. Make sure that the peel ply extends 2.0 inches (50 mm) past the unperforated release film.

2. Place the caul plate over the peel ply.

h. If a heat blanket is specified as the heat source: (Optional)

1. Place one layer of peel ply over the non-perforated release film (or the caul plate if one is used) as a breather cloth layer under the heat blanket. Make sure that the peel ply extends 2.0 inches (50 mm) past the unperforated release film.

   NOTE: The peel ply is used here because it has better heat transfer than woven cloth or non-woven mat breather material.

2. Place the heat blanket on the peel ply.

3. If it is necessary to monitor the heat blanket to prevent over-temperature of the heat blanket, place a thermocouple over the center of the heat blanket.

4. Place four to five layers of breather cloth over the heat blanket. This will also insulate the heat blanket and prevent damage to the vacuum bagging film. Make sure that the breather cloth extends 2.0 inches (50 mm) past the unperforated release film.

i. If a heat blanket is not specified, place one to two layers of breather cloth over the non-perforated release film or the caul plate if specified. Make sure that the breather cloth extends 2.0 inches (50 mm) past the unperforated release film.

j. Install the vacuum ports and cover the repair area with vacuum bagging film as follows:

1. Cut the vacuum bag film 1.5 times the size of the area to be covered.

2. Make a minimum of two cut openings in opposite corners of the vacuum bag film. One will be used for the vacuum port and one will be connected to the vacuum gauge port.
When using an envelope bag the base of the vacuum ports have to be installed prior to the sealing of the bag.
It is best practice to place the vacuum port on top of the breather but not over a heatblanket or thermocouple.

3. Seal the vacuum ports to the vacuum bag film.

4. Place the vacuum ports on a breather cloth pad (4 ply thick minimum) and place them on the edge of the breather cloth layers. Do not place the vacuum ports on or near the repair area.

5. Seal the vacuum bag. At the side of the vacuum port, remove the paper from the vacuum bag sealant tape. Lightly apply the film to the sealant tape. Make sure that the vacuum bag film is not stretched and is in the correct position; adjust if necessary. Press the vacuum bag film firmly onto the vacuum bag sealant tape to obtain an air-tight seal.

6. Continue to remove the backing paper from the sealant tape and seal the edge of the vacuum bag to the sealant tape. Place tucks in vacuum bag film at intervals to allow for material stretching and contour changes.

k. Evacuate the bag as follows:

1. Connect the vacuum source and smooth the bag by hand pressure as the air is removed.

2. Stop and make adjustments to the vacuum bag film to prevent local stretching of the film

3. Continue to evacuate the vacuum bag.

4. Check for leaks and reseal if necessary. If available, use an Ultrasonic Leak Detector to detect air leaks in vacuum bag. A minimum vacuum pressure reading of 22 inch Hg (75kPa) is required, unless otherwise specified by the Repair Document.

5. Wait for several minutes after the readings have stabilized.

6. Disconnect the vacuum source at the probe and check the rate of vacuum loss. The leak rate should be less than 5 inch Hg (17 kPa) pressure drop timed over a 5 minute period.

7. If the leak exceeds this rate, adjust the sealing until it is acceptable.

l. If a heat blanket is specified (Optional), insulating material can be placed over the vacuum bag to reduce heat loss.

8.3 Method 3 - Squeeze Out Bleed Method

Refer to the Installation Procedures in Sections 4 through 7 for more detailed information (Figure 11).

8.3.1 Application

a. Place impregnated peel ply over outer laminate. Extend over the edge by 0.4 in (10 mm). Refer to ARP5319.

b. Apply flashbreaker tape around the periphery of the repair area. Refer to ARP4916 Composite Masking Method 5.

c. Apply a length of sisal or polyamide nylon rope around the repair area approximately 4 inches (100 mm) from the edge of the largest repair ply.

d. Place several strips of narrow breather material over the rope approximately 4 inches (100 mm) from the edge of the largest repair ply around the repair. Keep 0.5 inch (13 mm) away from the peel ply. Refer to Figure 11.

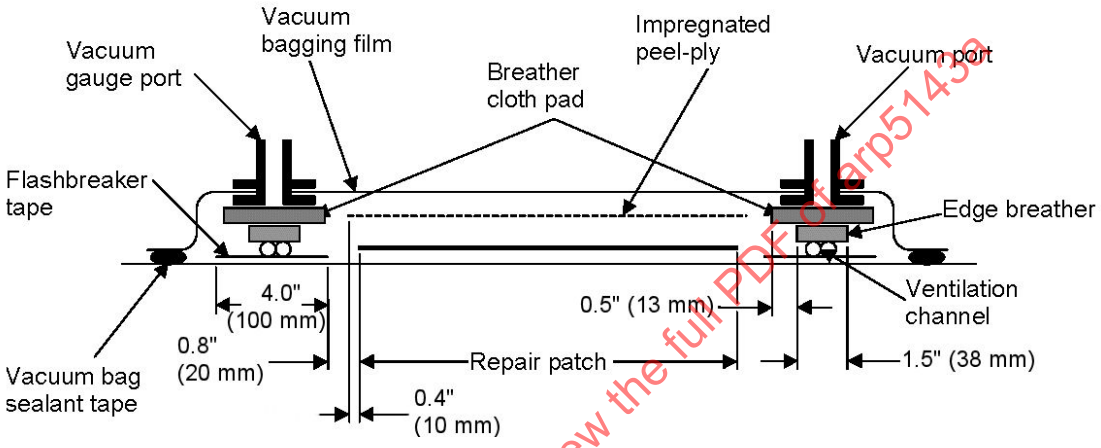


Figure 11 - Method 3 - squeeze out method vacuum bag

e. Apply vacuum bag sealant tape outside the masked area. Do not place the vacuum bag sealant tape on the flashbreaker tape, as this can cause leaks. Do not remove the protective paper at this time.

f. Install the thermocouples. Refer to ARP5144.

g. Install the vacuum ports and cover the repair area with vacuum bagging film as follows:

1. Cut the vacuum bag film 1.5 times the size of the area to be covered.

2. Make a minimum of two cut openings in opposite corners of the vacuum bag film. One will be used for the vacuum port and one will be connected to the vacuum gauge port.
When using an envelope bag the base of the vacuum ports have to be installed prior to the sealing of the bag.
It is best practice to place the vacuum port on top of the breather but not over a heatblanket or thermocouple.

3. Seal the vacuum ports to the vacuum bag film.

4. Place the vacuum ports on a breather cloth pad (4 ply thick minimum) and place them on the edge breather layers. Do not place the vacuum ports on or near the repair area.

5. Seal the vacuum bag. At the side of the vacuum port, remove the paper from the vacuum bag sealant tape. Lightly apply the film to the sealant tape. Make sure that the vacuum bag film is not stretched and is in the correct position, adjust if necessary. Press the vacuum bag film firmly onto the vacuum bag sealant tape to obtain an air-tight seal.

6. Continue to remove the backing paper from the sealant tape and seal the edge of the vacuum bag to the sealant tape. Place tucks in vacuum bag film at intervals to allow for material stretching and contour changes. Avoid positioning the tucks so that pleats are formed over the repair area. Try to make the vacuum bag smooth over the surface of the repair.

h. Evacuate the bag as follows:

1. Connect the vacuum source and smooth the bag by hand pressure as the air is removed. Make the vacuum bag smooth over the surface of the repair.

2. Stop and make adjustments to the vacuum bag film to prevent local stretching of the film.

3. Continue to evacuate the vacuum bag.

4. Check for leaks and reseal if necessary. If available, use an Ultrasonic Leak Detector to detect air leaks in vacuum bag. A minimum vacuum pressure reading of 22 inch Hg (75 kPa) is required, unless otherwise specified by the Repair Document.

5. Wait for several minutes after the readings have stabilized.

6. Disconnect the vacuum source at the probe and check the rate of vacuum loss. The leak rate should be less than 5 inch Hg (17 kPa) pressure drop timed over a 5 minute period.

7. If the leak exceeds this rate, adjust the sealing until it is acceptable.

i. Proceed with the instructions of ARP5319, Impregnation of Dry Fabric and Ply Lay Up. After completion continue with ARP5143.

8.4 Method 4 - Core Restoration (see Figure 12).

Refer to the General Installation Procedures in Sections 4 to 7 for more detailed information. Follow ARP4991 Core Restoration for directions on how to prepare the core. For single sided heat application, refer to the SRM or Repair Document and ARP5144 for core plug restrictions.

8.4.1 Application

a. Apply flashbreaker tape around the periphery of the core replacement area. Refer to ARP4916 Composite Masking Method 5.

b. If edge breather is specified (Optional), Place several strips of narrow breather material at approximately 4 inch (100 mm) away from the edge of the core cavity.

c. Apply vacuum bag sealant tape to the periphery of the core replacement area, approximately 6 inches (152 mm) beyond the repair area. Do not place the vacuum bag sealant tape on the flashbreaker tape, as this can cause leaks. Do not remove the protective paper at this time.

d. Place the thermocouples around the core replacement area and in the core. Refer to ARP4991 and ARP5144 for more information.

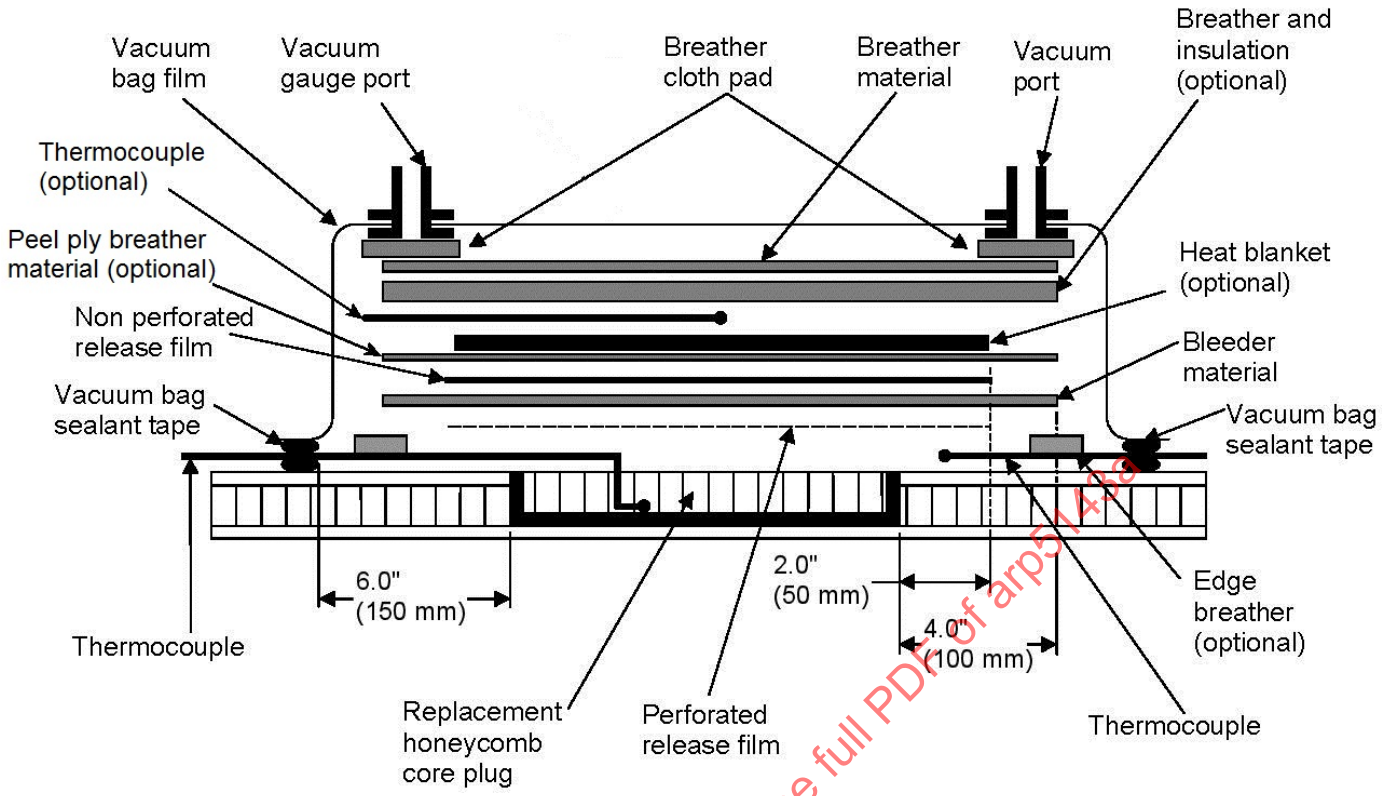


Figure 12 - Method 4 -core restoration method vacuum bag for access on one side only

e. Place a layer of perforated release film over the core replacement area. Extend the perforated release film approximately 2.0 inches (50 mm) beyond the core replacement area.

f. Place the bleeder material over the perforated release film extending approximately 2 inches (50 mm) beyond the edge of the perforated release film. If using a heat blanket, extend the bleeder material approximately 2 inches (50 mm) beyond the heat blanket. (Refer to the Repair Document for the number of bleeder plies needed.)

g. Place a layer of non-perforated release film over the bleeder plies, but allow the bleeder plies to extend 2.0 inches (50 mm) beyond the edges of the non-perforated release film. Cut the non-perforated release film so that the edges extend over the perforated release film, and the heat blanket.

h. If a heat blanket is specified as the heat source: (Optional)

   1. Place one layer of peel ply over the non-perforated release film as a breather cloth layer under the heat blanket. Make sure that the peel ply makes contact with the bleeder plies along the edges.

      NOTE: The peel ply is used here because it has better heat transfer than woven cloth or non-woven mat breather material.

   2. Place the heat blanket on the peel ply.

   3. If it is necessary to monitor the heat blanket to prevent over-temperature of the heat blanket place thermocouples over the center of the heat blanket.

   4. Place one layer of 10 ounce breather cloth or equivalent over the heat blanket. This will also insulate the heat blanket and prevent damage to the vacuum bagging film. Do not place excessive breather material in the vacuum bag, it will prevent the effectiveness of added insulation over colder areas.