DE HAVILLAND AIRCRAFT OF CANADA LIMITED

PPS 10.40

PRODUCTION PROCESS STANDARD

PROPRIETARY INFORMATION

REPAIRS TO LAMINATES & SANDWICH PANELS

Issue 15
- This standard supersedes PPS 10.40, Issue 14.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS related questions to PPS.Group@dehavilland.com or (416) 375-7641.
- This PPS is effective as of the distribution date.

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	Quality	

Signed original on file. Validation of paper prints is the responsibility of the user.

Issue 15 - Summary of Changes (over the previous issue)

The following summaries are not detailed and are intended only to assist in alerting PPS users to changes which may affect them; refer to the applicable sections of this PPS for detailed procedure and requirements.

- Clarified that this process is categorized as a controlled critical process.according to PPS 13.39.
- Replaced MIL-C-9084 with superseding AMS-C-9084.
- Added a new section detailing the procedure for the repair of surface scratches and resin starved areas using epoxy resin-gelcoat.
- Clarified that repairs using pre-impregnated plies shall only be used when specifically authorized by an approved dispositioned RNC.
- Specified to always use the oldest stock first (i.e., first in/first out (FIFO) basis).
- Added new Disposal of Chemical Wastes section. Added reference to EHS-OP-005 (Hazardous Materials Management).

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1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for the repair of cured laminates or sandwich panels if authorized by a fabrication PPS or De Havilland Canada Material Review Board (MRB) or De Havilland Canada delegated MRB as specified by a Report of Non Conformance (RNC).

1.1.1 This PPS complements the engineering drawings that specify its use as an authorized instruction. The procedure specified in this PPS shall be followed to ensure compliance with all applicable specifications. In general, if this PPS conflicts with the engineering drawing, follow the engineering drawing. The requirements specified in this PPS are necessary to fulfil the engineering design and reliability objectives.

1.1.2 Refer to PPS 13.26 for the subcontractor provisions applicable to this PPS.

2 HAZARDOUS MATERIALS

2.1 Before receipt at De Havilland Canada, all materials shall be approved and assigned Material Safety Data Sheet (MSDS) numbers by the De Havilland Canada Environment, Health and Safety Department. Refer to the manufacturer's MSDS for specific safety data on any of the materials specified in this PPS. If the MSDS is not available, contact the De Havilland Canada Environment, Health and Safety Department.

3 REFERENCES

3.1 EHS-OP-005 - Hazardous Materials Management, *De Havilland Canada internal operating procedure*.

3.2 PPS 10.21 - Certification of Autoclaves.

3.3 PPS 10.22 - Preparation of Moulds.

3.4 PPS 10.23 - Storage, Handling and Preparation of Pre-Impregnated Materials.

3.5 PPS 10.24 - Preparation of Honeycomb Cores for Lay-Up In Sandwich Panel Assemblies.

3.6 PPS 10.28 - Assembly of Wire Thermocouples.

3.7 PPS 10.39 - Machining of Fibre Reinforced Composite Parts.

3.8 PPS 10.51 - Certification of Ovens.

3.9 PPS 13.13 - Personal Protective Respiratory Equipment.

3.10 PPS 13.23 - Preparation & Use of DHMS P1.30 Resin.

3.11 PPS 13.26 - General Subcontractor Provisions.

3.12 PPS 13.28 - Storage Life of Adhesives, Sealants, Paints and Composite Products.

3.13 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.14 PPS 15.04 - Use of Felt Tip Markers For Marking Aircraft Parts and Assemblies.

3.15 PPS 31.14 - Cleaning Aluminum Screen for Lay-Up in Composite Parts.

3.16 PPS 31.17 - Solvent Usage.

3.17 PPS 34.34 - Surface Finishing Compounds (F33).

3.18 QAPI 3.8.7.20 - Control of Inspection, Measuring and Test Equipment - *De Havilland Canada internal Quality procedure*.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Abrasive paper, aluminum oxide, 180 - 220 grit size.

4.1.2 Disposable wax-free paperboard containers (e.g., MELO take-out containers).

4.1.3 Vacuum bagging materials, see Table I.

TABLE I - VACUUM BAGGING MATERIALS TO DSC 234

MATERIAL DSC 234	MATERIAL TYPE
-1	Nylon Vacuum Bagging Film, 250°F Cure Cycle
-3	2 Mil Nylon Tubular Vacuum Bagging Film, 250°F Cure Cycle
-5	1 Mil Perforated (pin prick) Release Film
-7	1 Mil Non-Porous Release Fabric, Max Temperature 450°F
-9	Breather/Bleeder Cloth, Non-Woven Polyester, Max Pressure 50 psi. For autoclaves which do not have an inert atmosphere, use -11 breather/bleeder cloth in place of -9 breather/bleeder cloth.
-11	Breather/Bleeder Cloth, Non-Woven Polyester, Fire Retardant, Max Pressure 50 psi
-15	High Temperature Pressure Sensitive Tape
-17	Vacuum Bag Sealant

4.1.4 Epoxy resin as specified in Table II.

4.1.5 Epoxy resin filler, Cab-O-Sil.

4.1.6 Glass fabric to AMS-C-9084, style 181, 181-50, 181-77, 1581 or 7781.

4.1.7 Lint-free cotton wiping cloths (e.g., DSC 378-2).

4.1.8 Protective wrapping, neutral Kraft paper or polyethylene storage bags.

4.1.9 Non-perforated vacuum bagging film (e.g., DSC 234-7 non-porous release fabric) for covering epoxy resin repairs.

4.2 Equipment

4.2.1 Autoclave, certified according to PPS 10.21.

4.2.2 Brush, camel hair.

4.2.3 Curing oven, certified according to PPS 10.51.

4.2.4 Countersink, rosette type (e.g., TS.561.35.10 hole deburring tool).

4.2.5 Heat blanket (e.g., Heatcon Composite Systems HCS9200). Heat blankets shall be calibrated (e.g., to meet the requirements of QAPI 3.8.7.20).

4.2.6 Hypodermic needle.

4.2.7 Knife (e.g., X-Acto).

4.2.8 Leather gloves (e.g., DSC 422-3).

4.2.9 Protective gloves, neoprene (e.g., DSC 422-5) or rubber (e.g., DSC 422-2).

4.2.10 Cotton gloves, lint-free (e.g., DSC 422-1).

4.2.11 Sanding blocks.

4.2.12 Shop vacuum source, capable of maintaining and monitoring a minimum vacuum of 24" Hg.

4.2.13 Spatula, squeegee.

4.2.14 Temperature and humidity control equipment capable of maintaining the requirements specified herein.

4.2.15 Temperature and relative humidity continuous chart recording equipment.

4.2.16 Thermocouples to PPS 10.28.

4.2.17 Weighing scale (e.g., triple beam balance type) capable of weighing to ± 0.5 grams.

4.3 Facilities

4.3.1 This PPS has been categorized as a Controlled Critical Process according to PPS 13.39 and as such only facilities specifically approved according to PPS 13.39 are authorized to perform the repair of cured laminates or sandwich panels if authorized by a fabrication PPS or De Havilland Canada Material Review Board (MRB) or De Havilland Canada delegated MRB as specified by a Report of Non-Conformance (RNC) according to this PPS.

4.3.2 Subcontractors shall direct requests for approval to De Havilland Canada Supplier Quality Management.

4.3.3 Facility approval shall be based on a facility report, a facility survey and completion of a qualification test program, if required. The facility report shall detail the materials and equipment to be used, the process sequence to be followed and the laboratory facilities used to show compliance with the requirements of this PPS. Any deviation from the procedure or requirements of this PPS shall be detailed in the facility report. Based upon the facility report, De Havilland Canada M&P Engineering may identify additional qualification and/or process control test requirements. During the facility survey, the facility requesting qualification shall be prepared to demonstrate their capability. Once approved, no changes to subcontractor facilities may be made without prior written approval from De Havilland Canada M&P Engineering.

4.3.3.1 For approval of subcontractor facilities to perform the repair of cured laminates or sandwich panels if authorized by a fabrication PPS or De Havilland Canada Material Review Board (MRB) or De Havilland Canada delegated MRB as specified by a Report of Non Conformance (RNC) according to this PPS according to this PPS, completion of a test program and submission of suitable test samples representative of production parts is required. Test samples shall meet the requirements specified in section 6.

5 PROCEDURE

5.1 General

5.1.1 All repairs utilizing pre-impregnated fabric lay-up require MRB authorization and shall be carried out as specified by the RNC and according to section 5.3.

5.1.2 For the purposes of this standard, consider laminates to consist of a single or multi-ply layer of pre-impregnated fabric.

5.1.3 For the purposes of this standard, consider sandwich panel assemblies to consist of a honeycomb core sandwiched between single or multi-ply layers of pre-impregnated fabric.

5.1.4 Perform receipt inspection and shelf life extension according to PPS 13.28 for all raw materials.

5.1.5 Protect all materials to be incorporated into a lay-up against contamination by carefully wrapping them in neutral Kraft paper or polyethylene storage bags and storing them in areas free of dust, solvents, release agents, etc.

5.1.6 Perform all repair operations in a clean area according to section 6.2.

5.1.7 Lay-up area condition shall be according to section 6.3.

5.1.8 If machining of fibre reinforced composite parts is required, machine according to PPS 10.39.

5.1.9 For parts which may be subject to contamination with fuel or hydraulic fluid and were fabricated according to PPS 10.43, use Loctite EA 9390 Aero epoxy resin system for repair (i.e., do not use Loctite EA 9396 Aero epoxy resin system).

5.1.10 Do not use Loctite EA 9396 Aero epoxy resin system for repair on parts that will be installed in areas exceeding 212°F (100°C) in service (e.g., lower cowl and light pot).

5.2 Epoxy Resin and Resin-Gelcoat Repairs

5.2.1 Preparation and Curing of Epoxy Resin and Resin-Gelcoat

5.2.1.1 Prepare epoxy resin and resin-gelcoat as follows:

Step 1. Thoroughly stir the resin and hardener in their separate containers.

Step 2. Weigh out the resin in a disposable mixing container in even 100 gram increments or fraction thereof as required for the work on hand.

Step 3. Weigh the correct proportion of hardener according to Table II directly into the resin container on the scale. Do not weigh the hardener into a separate container.

Step 4. If preparing epoxy resin-gelcoat, thoroughly mix 2 to 4 parts (by weight) of epoxy resin filler (see paragraph 4.1.5) to the resin component to produce a thixotropic paste.

Step 5. Stir the resin and hardener to obtain a homogeneous air-free mixture.

5.2.1.2 Prepare a cure chart and a cure plot, if available, for each autoclave, oven and heat blanket cure showing each of the following readings recorded every 5 minutes or less.

- Temperature reading of each thermocouple.
- Vessel temperature and pressure (if applicable).
- Vacuum/pressure monitor system readings or vacuum/pressure check readings (if applicable). For curing equipment not equipped with a vacuum/pressure monitor system, ensure that the cure chart shows the vacuum/pressure under the bag recorded at the start of the cure period, in the middle of the cure period and at the end of the cure period. Close the vacuum lines for 30 seconds before the vacuum/pressure check and re-open them after the check.

TABLE II - MIXING AND CURING OF DHMS P1.49 EPOXY RESIN

DHMS P1.49 EPOXY RESIN		MIXING RATIO RESIN/HARDENER (Parts by Weight)	GEL TIME/ POT LIFE (Note 2)	CURE TO HANDLE (@ 75 ± 5°F)	FULL CURE	
CLASS (Note 1)	COMPONENTS				ROOM TEMP (@ 75 ± 5°F)	HEAT ACCELERATED (Note 3)
Class 1	L-363-A FR Resin/ L-363-B FR Hardener	100/16	30 - 80 minutes	4 hours minimum	7 days	3 hours at 120°F - 125°F
Class 2 (Notes 4 & 5)	Loctite EA 9396 Aero Resin/ Loctite EA 9396 Aero Hardener	100/30	75 - 90 minutes	48 hours minimum	5 days	180 minutes at 100°F - 120°F
Class 3 (Notes 4 & 5)	Loctite EA 9390 Aero Resin/ Loctite EA 9390 Aero Hardener	100/56	120 minutes	N/A (fully cure before handling)	N/A (heat accelerated cure only)	220 minutes at 180°F - 200°F
	Loctite EA 9396 Aero Resin/ Loctite EA 9396 Aero Hardener	100/30	75 - 90 minutes	48 hours minimum	5 days	180 minutes at 100°F - 120°F

Note 1. Unless the RNC, if any, specifies the use of a particular epoxy resin, it is recommended that Class 1 epoxy resin be used for interior parts; Class 2 epoxy resin be used for parts fabricated according to PPS 10.35 or PPS 10.48; and Class 3 epoxy resin be used for parts fabricated according to PPS 10.43. For parts wet laid-up according to PPS 10.04 or PPS 10.15, any class epoxy resin may be used. Also, for repairs to parts fabricated according to PPS 10.04 only, it is acceptable to use polyester resin prepared and cured according to PPS 10.04 in placed of epoxy resin as specified herein.

Note 2. Pot life (or gel time) is the time during which a 100 gram mix of epoxy resin remains suitable for application at 75 ± 5°F. The pot life specified for Loctite EA 9396 Aero epoxy resin system is for a 450 gram mix. Discard excess material upon expiration of the pot life.

Note 3. Do not begin heat accelerated curing until gelation is complete.

Note 4. Loctite EA 9396 Aero resin/Loctite EA 9396 Aero hardener is qualified to both DHMS P1.49 Class 2 and Class 3 epoxy resin. Do not use this Loctite EA 9396 Aero epoxy resin system for repair on parts that will be installed in areas exceeding 212°F (100°C) in service (e.g., lower cowl and light pot).

Note 5. For parts which may be subject to contamination with fuel or hydraulic fluid and were fabricated according to PPS 10.43, use Loctite EA 9390 Aero epoxy resin system for repair (i.e., do not use Loctite EA 9396 Aero epoxy resin system).

5.2.2 Epoxy Resin-Gelcoat Repair of Surface Scratches and Resin Starved Areas

5.2.2.1 Repair surface scratches and resin starved areas as follows:

Step 1. Lightly sand the damaged area with 180 - 220 grit abrasive paper to remove all loose pieces of resin and fibre. Do not sand through the outer ply of cloth (localized abrasion of the cloth is acceptable).

Step 2. Solvent clean the area to be repaired according to PPS 31.17 just before beginning the repair. Protect the cleaned surface from contamination. Wear clean lint-free cotton gloves when handling cleaned parts.

Step 3. Using a spatula or brush, apply a small amount of epoxy resin-gelcoat to the repair area and work the resin-gelcoat into the imperfection.

Step 4. After filling the repair area, remove all excess resin-gelcoat from the surface. Take care to ensure no more epoxy resin-gelcoat is used than the minimum required to fill the repair. Ensure the reworked areas conform to the part contours.

Step 5. Allow the epoxy resin-gelcoat repair to cure at room temperature according to Table II.

Step 6. Sand the reworked area to the correct contour using 180 - 220 grit abrasive paper and appropriately shaped sanding blocks.

Step 7. Check to ensure the repaired surface is smooth and continuous with no evidence of ridges, unevenness, pinholes or voids. Ensure the final repaired part conforms to the engineering drawing dimensions.

5.2.3 Epoxy Resin-Gelcoat Repair of Deep Scratches and Partial Fractures

5.2.3.1 Repair deep scratches and partial fractures as follows (see Figure 1):

Step 1. Solvent clean the area to be repaired according to PPS 31.17 just before beginning the repair.

Step 2. Bevel the edges of the defect using a sharp knife (see paragraph 4.2.7) to approximately 45°. Avoid cutting into the next deeper layer of cloth in the laminate.

Step 3. Lightly sand the damaged area with 180 - 220 grit abrasive paper to remove all loose pieces of resin and fibre. Ensure that the sanded edges are smooth and well bonded with no evidence of interlaminate separation.

Step 4. Fill the prepared cut with epoxy resin-gelcoat so as to be just slightly above flush with the laminate surface.

Step 5. Cover the repair with a piece of non-perforated vacuum bagging film (e.g., DSC 234-7) cut approximately 2" larger than the repair and tape the film to the laminate along one longitudinal edge.

Step 6. Smooth the vacuum bagging film down onto the laminate so that it is smooth and tight across the repair.

Step 7. Tape the remaining longitudinal edge to the laminate.

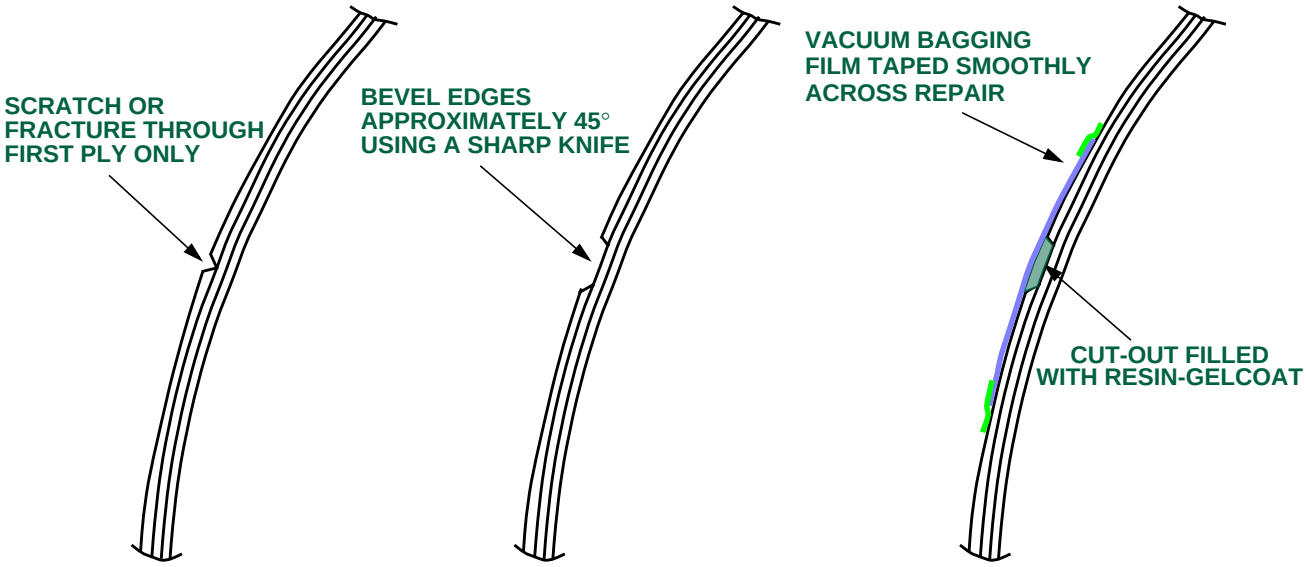


FIGURE 1 - EPOXY RESIN-GELCOAT REPAIR OF DEEP SCRATCHES AND PARTIAL FRACTURES

Step 8. Work the excess epoxy resin-gelcoat out the open ends of the vacuum bagging film using a rubber squeegee.

Step 9. Remove the excess epoxy resin-gelcoat from the laminate surface by solvent cleaning according to PPS 31.17.

Step 10. Allow the epoxy resin-gelcoat repair to cure according to Table II. Ensure that gelation is complete before beginning heat accelerated curing (to prevent repair shrinkage).

Step 11. Remove the non-perforated vacuum bagging film which was placed over the repair area.

Step 12. Blend in the repair area using 180 - 220 grit abrasive paper.

5.2.4 Epoxy Resin-Gelcoat Repair of Delaminations and Internal Voids

5.2.4.1 Repair delaminations and internal voids as follows (see Figure 2):

Step 1. Determine the approximate shape and extent of the defect by visual examination or tapping test. Outline the defect on the laminate surface using a temporary marker according to PPS 15.04.

Step 2. Solvent clean the area to be repaired according to PPS 31.17 just before beginning the repair.

Step 3. Drill 4 to 6 equally spaced holes using a #40 drill around the defect's perimeter with one 1/32" hole drilled approximately in the centre. Drill only to the depth of the defect without drilling through the laminate.

Step 4. Inject epoxy resin-gelcoat using a hypodermic needle through the centre hole until each of the vent holes is filled.

Step 5. Cover the repair with a piece of non-perforated vacuum bagging film (e.g., DSC 234-7) cut approximately 2" larger than the defect and apply pressure to the repair using weights or a suitable press.

Step 6. Work the excess epoxy resin-gelcoat out the open ends of the vacuum bagging film using a rubber squeegee.

Step 7. Remove excess resin-gelcoat from the laminate surface by solvent cleaning according to PPS 31.17.

Step 8. Allow the epoxy resin-gelcoat repair to cure according to Table II. Ensure that gelation is complete before beginning heat accelerated curing (to prevent repair shrinkage).

Step 9. Remove the non-perforated vacuum bagging film which was placed over the repair area.

Step 10. Blend in the repair area using 180 - 220 grit abrasive paper.

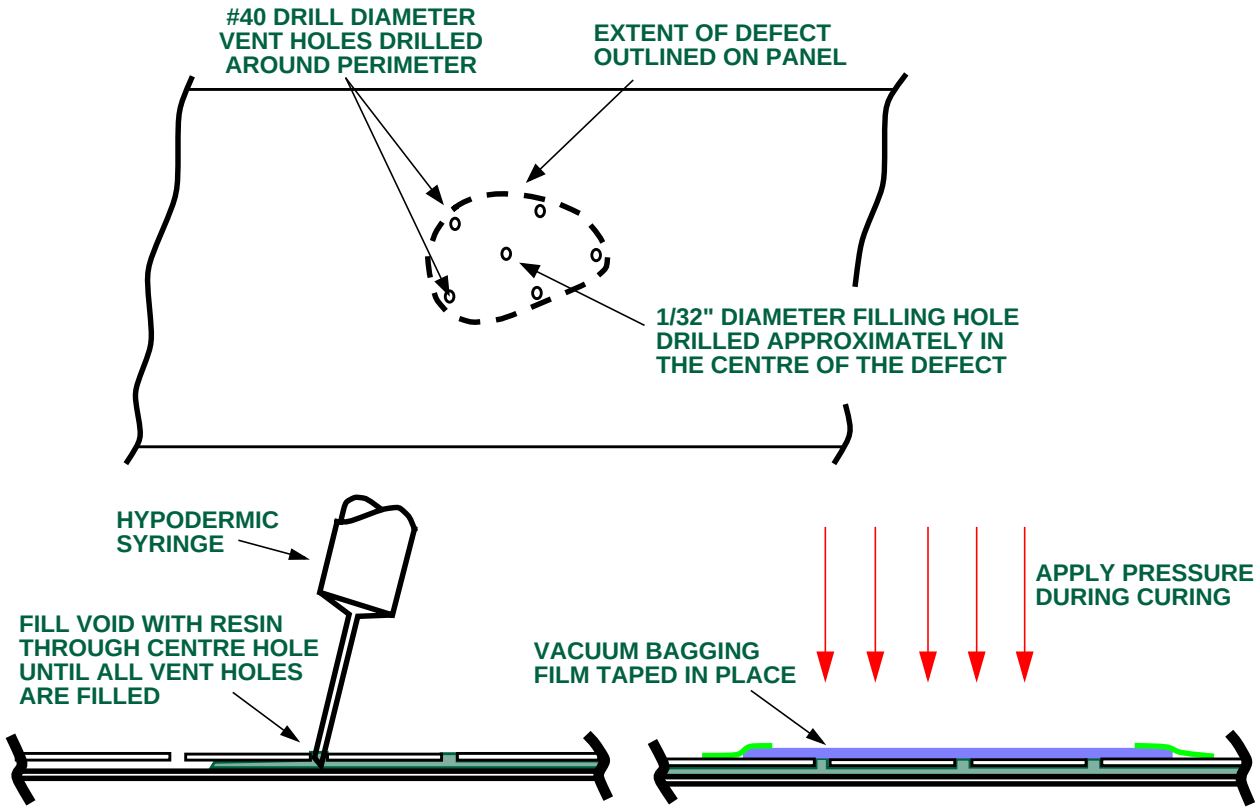


FIGURE 2 - EPOXY RESIN-GELCOAT REPAIR OF DELAMINATIONS AND INTERNAL VOIDS

5.2.5 Epoxy Resin-Gelcoat Repair of Small Holes, Punctures and Misplaced Fastener Holes

5.2.5.1 Repair small holes, punctures and misplaced fastener holes as follows (see Figure 3):

Step 1. Solvent clean the area to be repaired according to PPS 31.17 just before beginning the repair.

Step 2. Drill out punctures with a drill slightly larger in diameter than the defect.

Step 3. Break the edges of the holes to approximately 0.020" x 45° using a sharp knife (see paragraph 4.2.7) or a countersink (see paragraph 4.2.4).

Step 4. Lightly sand the hole edges with 180 - 220 grit abrasive paper to remove all loose pieces of resin and fibre. Ensure that the hole edges are smooth and well bonded with no evidence of interlaminate separation.

Step 5. Cover the inner end of the hole with tape (see Figure 3).

Step 6. If the holes are 1/8" or smaller in diameter, fill with epoxy resin-gelcoat so as to be slightly above flush with the laminate surface. If the holes are over 1/8" in diameter, fill with epoxy resin-gelcoat and a cutting of glass fabric (see paragraph 4.1.6) so as to be slightly above flush with the laminate surface.

Step 7. Cover the repair with a piece of non-perforated vacuum bagging film (e.g., DSC 234-7) cut approximately 2" x 3" and tape one longitudinal edge of the film to the laminate.

Step 8. Smooth the vacuum bagging film down onto the laminate so that it is smooth and tight across the repair.

Step 9. Tape the remaining longitudinal edge to the laminate.

Step 10. Work the excess resin-gelcoat out the open ends of the vacuum bagging film using a rubber squeegee.

Step 11. Remove excess resin-gelcoat from the laminate surface by solvent cleaning according to PPS 31.17.

Step 12. Allow the epoxy resin-gelcoat repair to cure according to Table II. Ensure that gelation is complete before beginning heat accelerated curing (to prevent repair shrinkage).

Step 13. Remove the non-perforated vacuum bagging film which was placed over the repair area.

Step 14. Blend in the repair area using 180 - 220 grit abrasive paper.

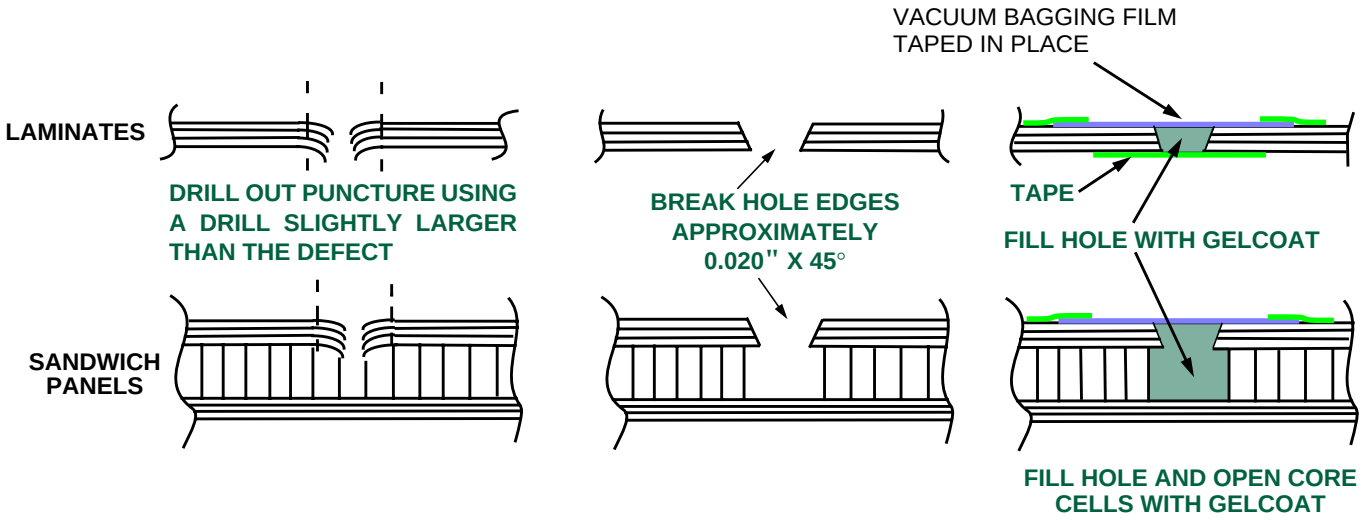


FIGURE 3 - EPOXY RESIN-GELCOAT REPAIR OF SMALL HOLES, PUNCTURES AND MISPLACED FASTENER HOLES

5.2.6 Epoxy Resin-Gelcoat Repair of Sharp Recesses to be Covered with Decorative Laminate

5.2.6.1 If specified by an RNC response, fill sharp recesses to prevent bridging of decorative laminates as follows:

Step 1. Cut the edge of a piece of glass fabric (see paragraph 4.1.6) so that the cloth separates into individual fibres approximately 1/2" long.

Step 2. Mix a sufficient amount of glass fabric into the mixed epoxy resin so that the resin/glass fibres mixture has sufficient body to retain its shape when applied to the recess to be filled.

Step 3. Apply the resin/glass fibres to the recess. Smooth the surface of the resin/glass fibres mixture so that no glass fibres protrude above the surface of the resin.

Step 4. Cover the repair with a piece of non-perforated vacuum bagging film (e.g., DSC 234-7) cut approximately 2" larger than the repair and tape the film to the laminate along one longitudinal edge.

Step 5. Work the film so that it is smooth and tight across the repair.

Step 6. Tape the remaining longitudinal edge to the support (see Figure 7).

Step 7. Work out the air bubbles and excess resin-gelcoat from the repair by working toward the open ends of the vacuum bagging film using a suitable rubber squeegee.

Step 8. Remove excess resin-gelcoat from the laminate surface by solvent cleaning according to PPS 31.17.

Step 9. Allow the epoxy resin-gelcoat repair to cure according to Table II. Ensure that gelation is complete before beginning heat accelerated curing (to prevent repair shrinkage).

Step 10. Remove the non-perforated vacuum bagging film which was placed over the repair area.

Step 11. Blend in the repair area using 180 - 220 grit abrasive paper.

5.2.7 Epoxy Resin Lay-Up Repair of Parts Trimmed Too Small

5.2.7.1 Repair of Parts Trimmed Too Small Using the Original Mould

5.2.7.1.1 If the original mould is available, repair parts trimmed too small as follows:

Step 1. Solvent clean the area to be repaired according to PPS 31.17 just before beginning the repair.

Step 2. Bevel the exterior surface of the laminate in the area to be built-up to a minimum distance of 10 times the thickness of the laminate (see Figure 4) using 180 - 220 grit abrasive paper.

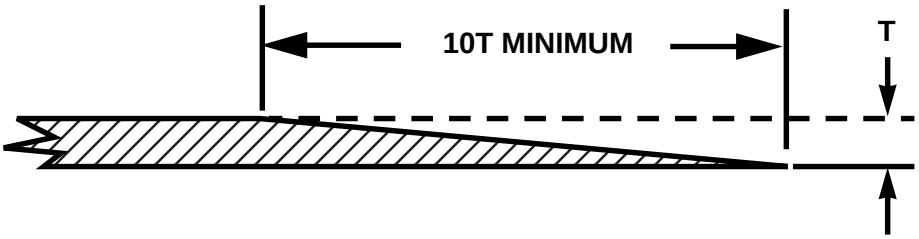


FIGURE 4 - BEVELLED EDGE OF LAMINATE

Step 3. Remove powdered material using a vacuum cleaner or by wiping with a clean dry cloth.

Step 4. Coat the mould with parting agent according to PPS 10.22.

Step 5. Place the part on the mould.

Step 6. Cut glass fabric (see paragraph 4.1.6) to the required size with each successive layer being slightly wider than the previous one. Allow extra glass fabric for trimming after curing. Match the style of the glass fabric used for the repair to the glass or organic fabric used to produce the part.

Step 7. Apply epoxy resin to the bevelled edge and impregnate the fabric pieces. Using a suitable rubber squeegee, work the resin into the cloth until it appears evenly impregnated.

Step 8. Build up the area being extended with layers of impregnated fabric to a thickness one layer greater than that of the part (see Figure 5).

Step 9. Cover the repair with non-perforated vacuum bagging film (e.g., DSC 234-7).

Step 10. Work out the air bubbles and excess resin from the repair by working towards the trim edge using a suitable rubber squeegee.

Step 11. Vacuum bag the repair according to section 5.2.7.3.

Step 12. Slowly apply a minimum vacuum of 24" Hg to vacuum bagged repairs. Adjust the bag while it is evacuating by pleating and folding to ensure complete contact and even pressure on the lay-up.

Step 13. Allow the epoxy resin repair to cure according to Table II. Ensure that gelation is complete before beginning heat accelerated curing (to prevent repair shrinkage).

Step 14. Release the vacuum and remove vacuum bagging materials.

Step 15. Blend in the repair area using 180 - 220 grit abrasive paper.

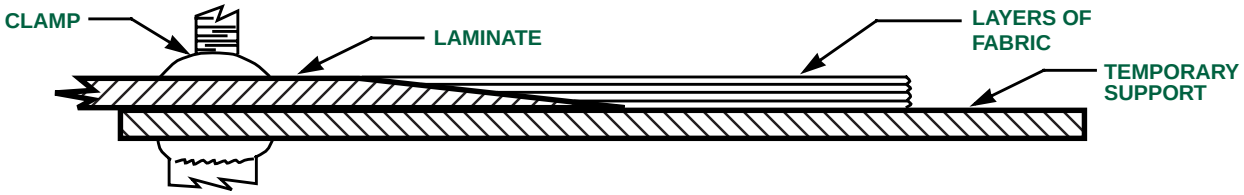


FIGURE 5 - LAY UP OF FABRIC

5.2.7.2 Repair of Parts Trimmed Too Small if Original Mould Not Available

5.2.7.2.1 If the original mould is not available, repair parts trimmed too small as follows:

Step 1. Solvent clean the area to be repaired according to PPS 31.17 just before beginning the repair.

Step 2. Bevel the exterior surface of the laminate in the area to be built-up to a minimum distance of 10 times the thickness of the laminate (see Figure 4) using 180 - 220 grit abrasive paper.

Step 3. Remove powdered material using a vacuum cleaner or by wiping with a clean dry cloth.

Step 4. Provide temporary support to the area to be built-up using aluminum, polycarbonate or similar sheet material coated with release agent according to PPS 10.22 (see Figure 6).

Step 5. Hold the support using C-clamps, toggle clamps or similar devices. Alternatively, fasteners such as Clecos, bolts, etc., smaller than 1/8" in diameter can also be used. Position the fasteners in a single row along the length to be repaired at a minimum spacing of 2".

Step 6. Cut glass fabric (see paragraph 4.1.6) to the required size with each successive layer being slightly wider than the previous one. Allow extra glass fabric for trimming after curing. Match the style of the glass fabric used for repair to the glass fabric used to produce the part.

Step 7. Apply epoxy resin to the bevelled edge and impregnate the fabric pieces. Using a suitable rubber squeegee, work the resin into the cloth until it appears evenly impregnated.

Step 8. Build up the area being extended with layers of impregnated fabric to a thickness equal to that of the part (see Figure 5).

Step 9. Cover the repair with a piece of non-perforated vacuum bagging film (e.g., DSC 234-7) cut approximately 2" larger than the repair and tape the film to the laminate along one longitudinal edge.

Step 10. Work the film so that it is smooth and tight across the repair.

Step 11. Tape the remaining longitudinal edge to the support (see Figure 7).

Step 12. Work out the air bubbles and excess resin from the repair by working toward the open ends of the vacuum bagging film using a suitable rubber squeegee.

Step 13. Remove excess resin from the laminate surface by solvent cleaning according to PPS 31.17.

Step 14. Vacuum bag the repair according to section 5.2.7.3.

Step 15. Slowly apply a minimum vacuum of 24" Hg to vacuum bagged repairs. Adjust the bag while it is evacuating by pleating and folding to ensure complete contact and even pressure on the lay-up.

Step 16. Allow the epoxy resin repair to cure according to Table II. Ensure that gelation is complete before beginning heat accelerated curing (to prevent repair shrinkage).

Step 17. Release the vacuum and remove vacuum bagging materials.

Step 18. Blend in the repair area using 180 - 220 grit abrasive paper.

Step 19. Remove the temporary attached support. Repair the small holes according to section 5.2.5.

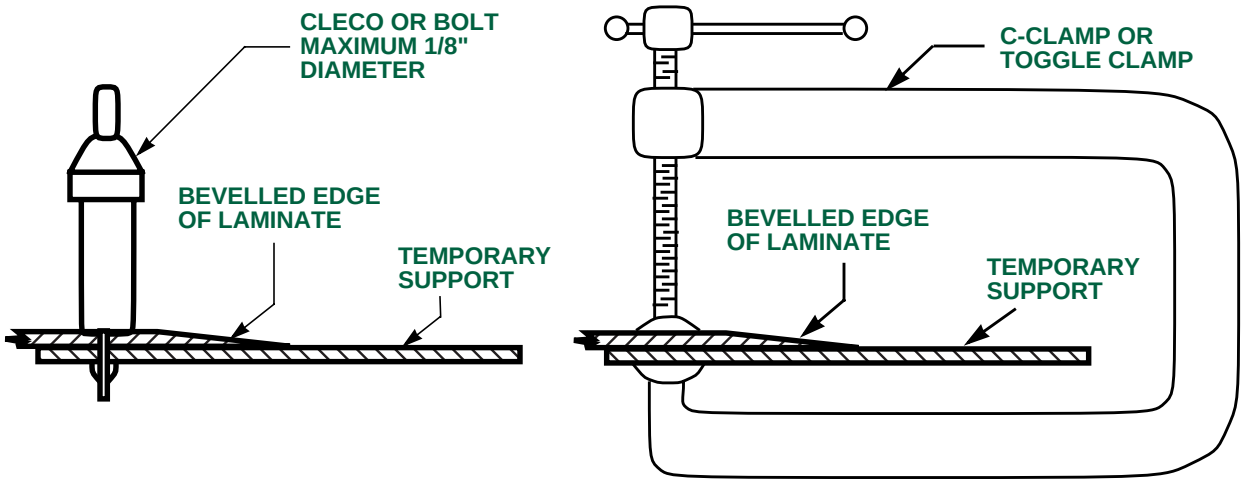


FIGURE 6 - ATTACHING TEMPORARY SUPPORT

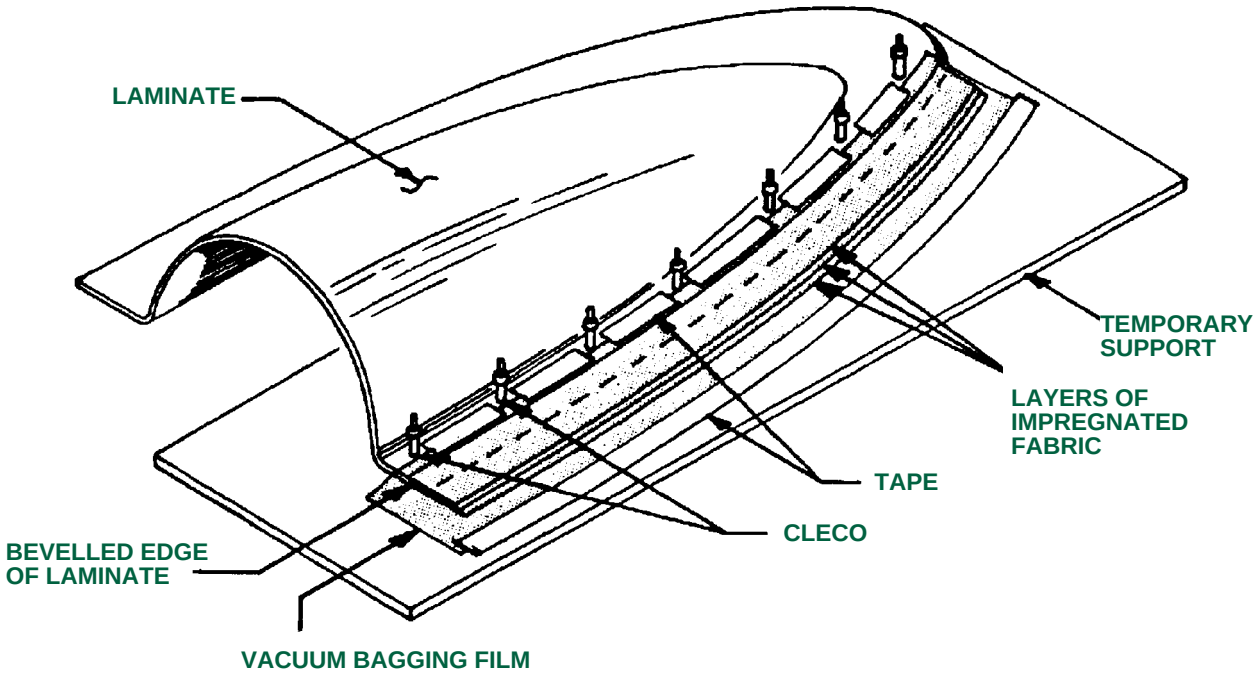


FIGURE 7 - COVERING WITH VACUUM BAGGING FILM

5.2.7.3 Vacuum Bagging

5.2.7.3.1 Vacuum bag parts as follows (see Figure 8 or Figure 9):

Step 1. Remove the non-perforated vacuum bagging film (e.g., DSC 234-7) placed over the repair area.

Step 2. Cover the repair with one layer of DSC 234-5 perforated release film cut approximately 1" larger in every dimension than the repair and tie down the film with DSC 234-15 tape.

Step 3. For parts to be oven cured, cover the lay-up with a layer of DSC 234-9 breather cloth approximately 1" larger in every dimension than the perforated release film and tie down the breather cloth to the laminate with DSC 234-15 tape. For parts to be autoclave cured, cover the lay-up with the breather cloth specified in the following table:

CURE PRESSURE	AUTOCLAVE ATMOSPHERE	
	INERT	NON-INERT
50 psi or less	1 layer of DSC 234-9 breather cloth	1 layer of DSC 234-11 breather cloth

Step 4. Place additional layers of DSC 234-9 breather cloth over protrusions, sharp edges, etc. to prevent puncturing of the bag.

Step 5. Position two thermocouple ends, wrapped with two layers of breather cloth, at opposite corners of the repair and secure the thermocouple wires to the ply surface using DSC 234-15 tape.

Step 6. Cover the breather cloth with a layer of DSC 234-7 release film approximately 1" larger in every dimension than the breather cloth.

Step 7. Cover the layer of release film with another layer of the applicable breather cloth approximately 1" larger in every dimension than the release film.

Step 8. If a heat blanket will be used to cure the repair, place a caul plate, the heat blanket and 4 to 6 layers of breather cloth over the outer layer of breather cloth (see Figure 9). Tape one thermocouple end, wrapped with two layers of breather cloth, to one end of the heat blanket edge.

Step 9. Position two vacuum outlets (one for monitoring the vacuum) at opposite corners of the breather cloth with 2 to 3 layers of the applicable breather cloth under each of the vacuum outlets. Do not place vacuum outlets directly over the repair area.

Step 10. Apply DSC 234-17 vacuum bag sealant to the laminate surface to surround the perimeter of the outermost layer of breather cloth or the heat blanket. Leave a minimum of 1" from the outermost layer of breather cloth or the heat blanket to the vacuum bag sealant.

Step 11. Cover the outermost layer of breather cloth or the heat blanket with vacuum bagging film and work the edges firmly into the vacuum bag sealant. Apply additional vacuum bag sealant in areas where the vacuum bagging film has been doubled or pleated. If vacuum bagging the whole part, pleat or drape the vacuum bag onto the part such that it makes direct contact with the entire surface without leaving any air pockets as shown below so as to avoid collapsing the part as shown in Figure 10.

Step 12. Puncture the vacuum bagging film at the vacuum outlets.

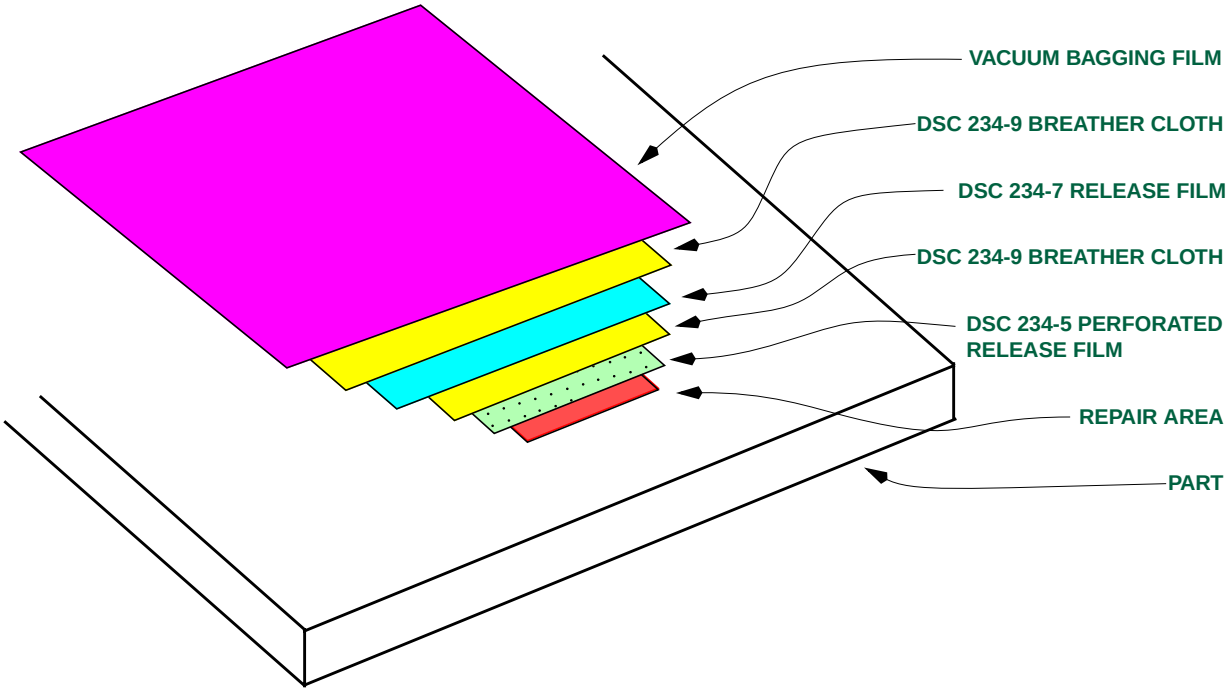


FIGURE 8 - VACUUM BAGGING FOR AUTOCLAVE OR OVEN CURING

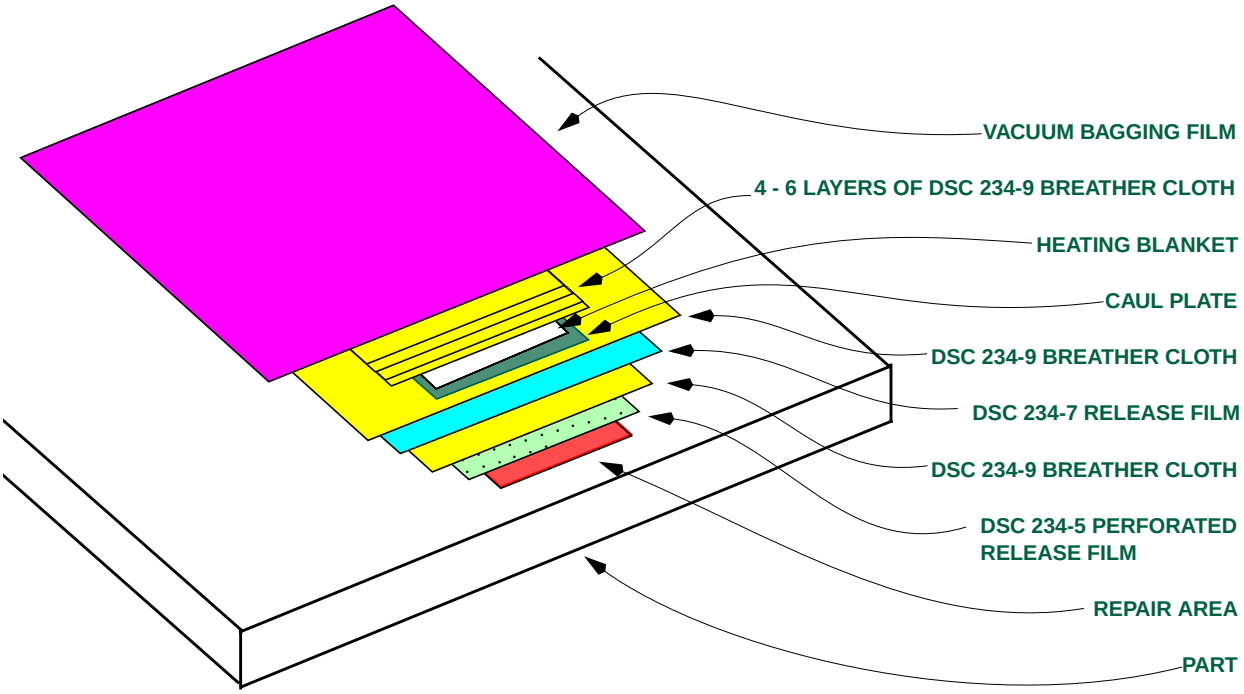
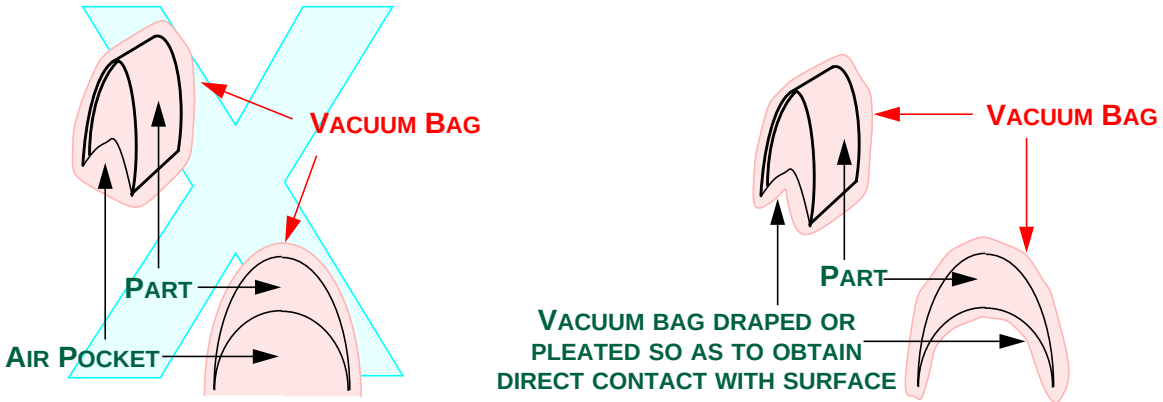


FIGURE 9 - VACUUM BAGGING FOR HEAT BLANKET CURING



UNACCEPTABLE **ACCEPTABLE**

FIGURE 10 - VACUUM BAGGING ENTIRE PARTS

5.2.7.3.2 Perform leak testing of vacuum bagged repairs as follows:

Step 1. Connect the vacuum outlets to their applicable connectors.

Step 2. Slowly apply a minimum vacuum of 24" Hg to the bagged repair. Adjust the bag while it is evacuating by pleating and folding to ensure complete contact and even pressure on the lay-up.

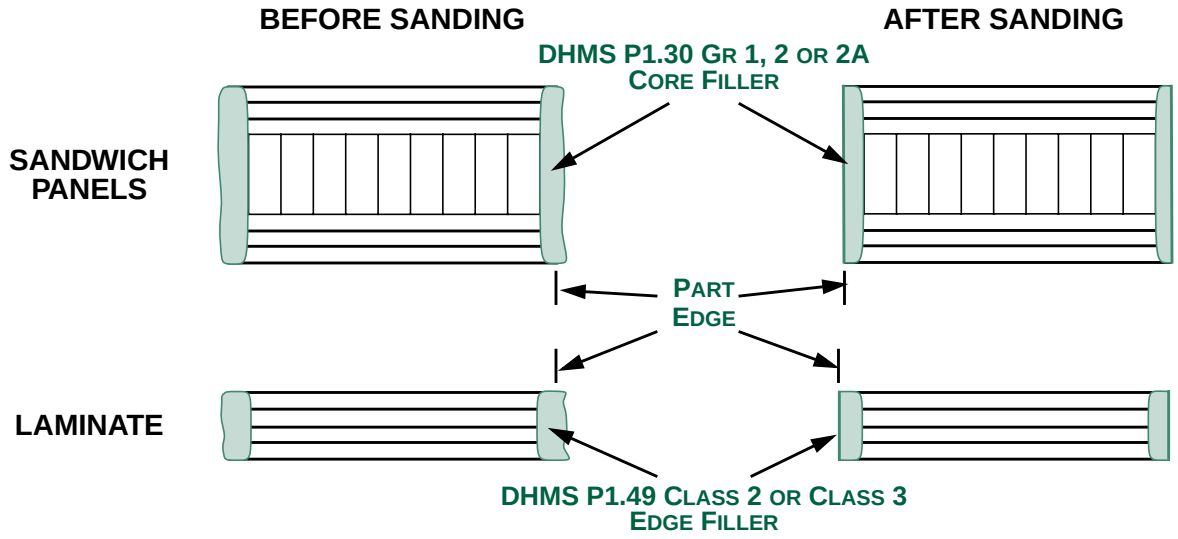
Step 3. When the vacuum is achieved, shut off the vacuum supply and check for leaks by observing the pressure gauge. The maximum acceptable leak rate is 1" Hg per minute over a 5 minute period. If the leak rate is greater than 1" Hg per minute over a 5 minute period, repair the leaks (or re-vacuum bag, if necessary) and re-test for leaks.

5.2.8 Edge Sealing Laminates and Sandwich Panels (Finishing)

5.2.8.1 If parts have been trimmed according to PPS 10.39 as part of the RNC response and unless if specifically specified on the RNC response to not edge fill parts, finish part edges as follows:

Step 1. Solvent clean all surfaces according to PPS 31.17.

Step 2. For sandwich panels, use a suitable spatula to fill all open edge cells and ply edges with the core filler specified on the RNC. For sandwich panels where the core filler is not specified, use DHMS P1.30 Grade 1, 2 or 2A epoxy resin, prepared and cured according to PPS 13.23. For laminate parts, brush coat (paragraph 4.2.2) the trimmed edges only with DHMS P1.49 Class 2 or Class 3 epoxy resin or resin-gelcoat, prepared and cured according to section 5.2.1. After the resin has fully cured, smooth to the required part profile by lightly sanding the edge with 180 - 220 grit abrasive paper.



5.3 Repair using Pre-Impregnated Ply Lay-Up as per Authorized RNC

5.3.1 Repairs using pre-impregnated plies shall only be used when specifically authorized by an approved dispositioned RNC.

5.3.2 Ensure that the machines and tools used for cutting raw materials will not deposit internal lubricating fluids onto the work surfaces.

5.3.3 Vacuum bag and cure pre-impregnated plies used for lay-up repair according to the appropriate composite fabrication PPS.

5.3.4 If the use of any of the following materials is specified by a Report of Non Conformance (RNC) response, store, handle and prepare the material according to the PPS specified in the following table before it is used for lay-up or repair:

MATERIAL	PPS
DSC 206-1 or DSC 206-3 ultra filler	PPS 34.34
DSC 164-20 or DSC 164-21 aluminum mesh (Note 1)	PPS 31.14
Pre-impregnated materials	PPS 10.23
DHMS A6.06 and DHMS A6.08 film adhesives	PPS 10.25
Core fillers	PPS 13.23
Honeycomb core materials	PPS 10.24
Thermocouples	PPS 10.28
Note 1. Clean aluminum mesh according to PPS 31.14 before lay-up and ensure that it is laid up and completely covered by pre-impregnated fabric within 24 hours of cleaning.	

6 REQUIREMENTS

6.1 General

6.1.1 The repair shall be smooth, uniform and blend into the surrounding surface of the part. The repair shall also form a good bond with the adjacent surfaces.

6.1.2 The repaired laminate or sandwich panel shall meet the requirements specified on the applicable PPS or RNC response.

6.2 Epoxy Resin-Gelcoat Repair Area Conditions

6.2.1 Clean epoxy resin-gelcoat repair areas at the intervals specified in Table III or sooner if any accumulation of dust, dirt or other contamination is evident. Maintain records of dates of cleaning.

TABLE III - SCHEDULE FOR CLEANING REPAIR AREAS

ITEMS	MAXIMUM CLEANING TIME INTERVAL	CLEANING METHOD
Tables	24 hours	Re-cover with clean Kraft paper
Floors	24 hours	Vacuum and/or damp mop
Equipment	24 hours	Wipe with damp cloth
Walls from the floor to a height of 7 ft.	6 months (check condition at least once every 7 days and clean if necessary)	Use a method that will reliably remove accumulated dirt, dust, grease, etc.
Walls above 7 ft. high, ceilings, beams, light fixtures, etc.	6 months (check condition at least once every 30 days and clean if necessary)	

6.2.2 Maintain the temperature and relative humidity of the structural repair area within the range specified in Figure 11. Repairing when the relative humidity is below 30% will increase the chance of static discharge and worker discomfort, but will not affect part acceptability. Record the temperature and relative humidity of the epoxy resin-gelcoat repair area on continuous chart recording equipment.

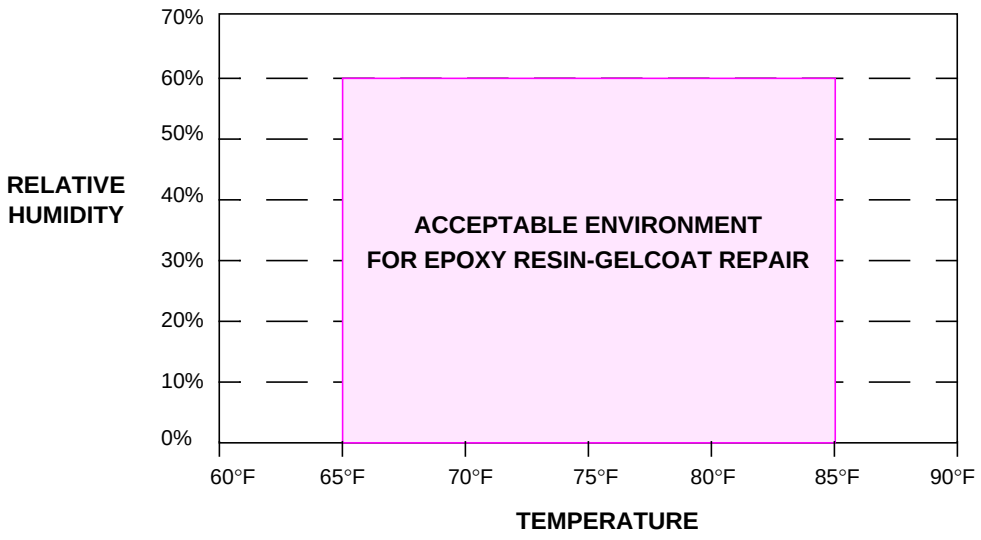


FIGURE 11 - TEMPERATURE AND RELATIVE HUMIDITY LIMITS FOR THE EPOXY RESIN-GELCOAT REPAIR AREA

6.3 Pre-Impregnated Ply Lay-Up Repair Area Conditions

6.3.1 The lay-up area shall be isolated from machining operations or conditions that will generate dust or other contaminating airborne particles.

6.3.2 The air entering the lay-up area shall be filtered and a positive air pressure differential is maintained so that unfiltered air does not enter.

6.3.3 The floors and work surfaces shall be kept clean and free of dust and other contaminants and swept or cleaned at least once a day.

6.3.4 Parting or release agents and uncured silicone bearing material shall not be used in lay-up areas.

6.3.5 Keep the lay-up area temperature and relative humidity within the limits specified in Figure 12. If the temperature or relative humidity exceeds the limits specified, suspend repair and vacuum bag partially completed parts and store them under a minimum vacuum of 24" Hg and take appropriate corrective action to restore the temperature and relative humidity back to the acceptable specified limits.

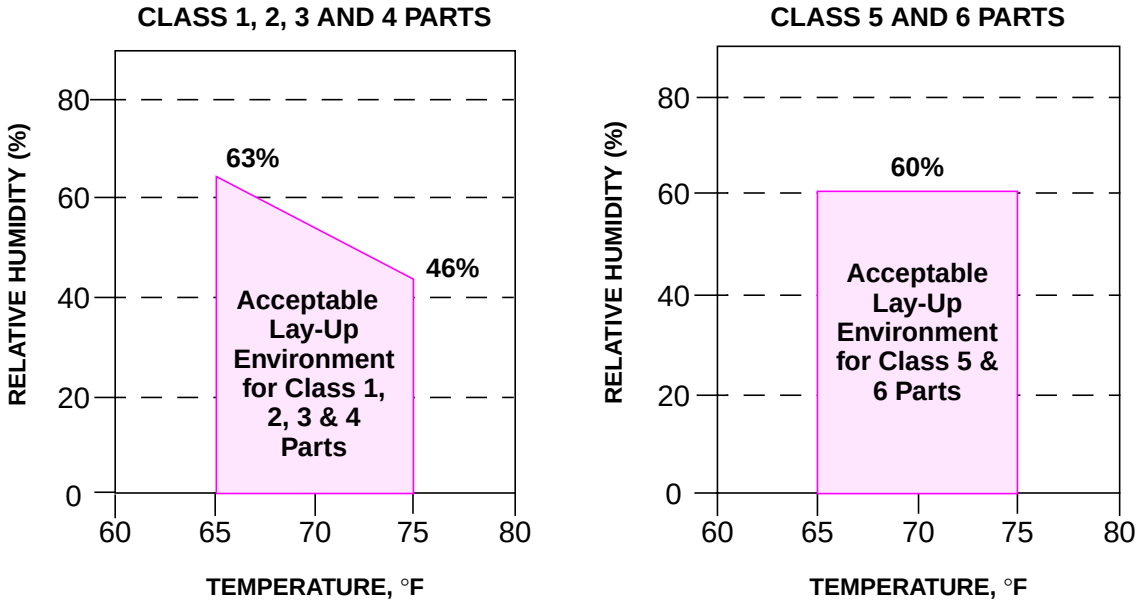


FIGURE 12 - TEMPERATURE AND RELATIVE HUMIDITY LIMITS FOR PRE-IMPREGNATED PLY LAY-UP REPAIR AREA

7 SAFETY PRECAUTIONS

7.1 Observe standard plant safety precautions when performing the procedure specified herein.

7.2 Wear leather gloves (see Equipment section, paragraph 4.2.8) when removing parts from the hot oven.

7.3 Do not open the autoclave door when the pressure gauge indicates that pressure exists in the chamber.

7.4 Do not enter the autoclave before the Oxygen Analyzer indicates a minimum of 20%.

7.5 Avoid ingestion of pre-impregnated material or resin-gelcoat components. If ingestion has occurred, immediately obtain medical attention.

7.6 Refer to PPS 31.17 for the safety precautions for handling and using solvents.

7.7 Keep resin-gelcoat away from fire and other sources of ignition. Provide sufficient ventilation when using resin-gelcoat in confined areas.

7.8 Avoid skin contact with pre-impregnated material or resin. Wear neoprene or latex rubber gloves (see Equipment section, paragraph 4.2.9) when handling the pre-impregnated materials or epoxy resin-gelcoat components specified herein. If skin contact does occur, wash skin thoroughly with soap and water.

7.9 Avoid eye contact with resin-gelcoat by wearing eye protection. If contact occurs, flush eyes with water for 15 minutes and immediately contact a physician and the Health Centre.

7.10 Wear protective respiratory equipment according to PPS 13.13 in areas where laminates are being abraded.

7.11 Soak used rags with water and store in the containers provided.

8 PERSONNEL REQUIREMENTS

8.1 This PPS has been categorized as a Controlled Critical Process according to PPS 13.39. Refer to PPS 13.39 for additional personnel requirements. Certified and/or qualified personnel shall have a good working knowledge of the following, as applicable:

- significance of imperfections such as excess resin-gelcoat (air bubbles), surface scratches, surface irregularities and resin ridges (bag wrinkles)
- significance of structural defects such as surface scratches, resin starved areas, deep scratches, partial fractures, delaminations and internal voids, small holes and punctures, misplaced fastener holes, parts trimmed too small, tackiness and incomplete bonding and their effect on the part strength and function
- how the maximum defect limits are established
- characteristics of DHMS P1.49 epoxy resin-gelcoat.
- engineering drawings and work orders.
- PPS 10.22, PPS 10.40, PPS 13.13, PPS 15.04, PPS 31.17 and PPS 34.34.
- how to use equipment such as spatula, squeegee, hypodermic needle, X-Acto knife, countersinks, sanding blocks and weighing scales which are used in the repair of fibre reinforced composite parts.

9 STORAGE OF DHMS P1.49 RESIN

9.1 Store DHMS P1.49 resin at 77°F ± 10°F in its original container according to precautions necessary for flammable materials.

9.2 Store resins in containers clearly marked with the storage life expiry date. Refer to PPS 13.28 for the storage life of resin. Issue resin on a first in/first out basis. Do not issue resin to production if the storage life expiry date has passed.

9.3 Keep containers of resins tightly closed when not in use.

9.4 Always use the oldest stock first (i.e., first in/first out (FIFO) basis).

10 DISPOSAL OF CHEMICAL WASTES

10.1 Dispose of all chemical wastes according to national legislation and local regulations. At Bombardier Toronto, dispose of chemical wastes according to EHS-OP-005.

10.2 At Bombardier Toronto, dispose of chemical contaminated work clothes, rags, etc., into Red Containers labelled “Waste Rags”.