DE HAVILLAND AIRCRAFT
OF CANADA LIMITED

PPS 10.43

PRODUCTION PROCESS STANDARD
PROPRIETARY INFORMATION

Fabrication of 350°F Cure Epoxy Resin Pre-Impregnated, Fibre Reinforced Composite Parts

Issue 17
- This standard supersedes PPS 10.43, Issue 16.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS related questions to christie.chung@dehavilland.com or (416) 375-7641.
- This PPS is effective as of the distribution date.

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	Quality	

Issue 17 - 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.

- Replaced throughout PPS where “Bombardier” is specified with “De Havilland Aircraft of Canada Limited” or “De Havilland Canada” as the DASH 8 program is under new ownership.
- Added the option to repair surface scratches and resin starved area according to PPS 10.40 in addition to PPS 34.34.
- In place of “appropriate department’, specified to notify Plant Engineering before expiry of the current autoclave Pressure Vessel Safety Certificate, so that necessary servicing may be completed and a valid certificate issued.

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1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for the fabrication of 350°F cure, epoxy resin pre-impregnated, glass, aluminized glass, aluminum foil and aramid fibre parts.

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 BAERD GEN-018 - Engineering Requirements for Laboratories.

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 10.25 - Storage and Application of Film Adhesives Used in Composite Assemblies.

3.7 PPS 10.28 - Assembly of Wire Thermocouples.

3.8 PPS 10.36 - Composite Assembly - Flammability Compliance Test Procedure (DASH 8).

3.9 PPS 10.39 - Machining of Fibre Reinforced Composite Parts.

3.10 PPS 10.40 - Repairs to Laminates & Sandwich Panels.

3.11 PPS 10.51 - Certification of Ovens.

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

3.13 PPS 13.26 - General Subcontractor Provisions.

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

3.15 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

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

3.17 PPS 31.17 - Solvent Usage.

3.18 PPS 32.02 - Manual Application of C1 Chemical Conversion Coatings.

3.19 PPS 34.08 - Application of Epoxy-Polyamide Primer (F19 & F45).

3.20 PPS 34.34 - Surface Finishing Compounds (F33).

3.21 PPS 34.41 - Application of Epoxy-Polyamide Enamel (F22).

3.22 QAMTR 029 - Testing Requirements, DHC-8 Composites and Laminates.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Abrasive paper, aluminum oxide, 180 - 240 grit size.

4.1.2 DHMS A6.06 expandable epoxy film adhesive.

4.1.3 DHMS A6.08 epoxy film adhesive. Unless specific reference is made to a particular class and type, use either DHMS A6.08 Class 2 Type 3 or DHMS A6.08 Class 4 Type 3 if DHMS A6.08 film adhesive is specified.

4.1.4 DHMS P1.26 phenolic coated aramid fibre base honeycomb core.

4.1.5 DHMS P1.27 adherent polyvinyl fluoride film (PVF), Tedlar moisture barrier.

4.1.6 DHMS P1.29 fire retardant rigid foam.

4.1.7 DHMS P1.30 honeycomb core filler.

4.1.8 DHMS P1.38, Type 3, Grade A and Grade B pre-impregnated aluminized glass cloth.

4.1.9 DHMS P1.39 high modulus, 350°F cure, epoxy resin pre-impregnated, aramid fibre cloth (for exterior use).

4.1.10 DHMS P1.40 high modulus, 350°F cure, epoxy resin pre-impregnated, aramid fibre cloth (for interior use).

4.1.11 DHMS P1.41 350°F cure, epoxy resin pre-impregnated, glass fibre cloth.

4.1.12 DHMS P1.64 aluminum foil with pre-impregnated epoxy resin or film adhesive, 250°F cure.

4.1.13 DSC 85-5 pressure sensitive metallized polyester labels.

4.1.14 DSC 164-20 or DSC 164-21 aluminum mesh.

4.1.15 DSC 234 composite manufacture expendable materials (see Table I).

4.1.16 Edge bleeder cloth, style 181 glass.

TABLE I - LIST OF EXPENDABLE MATERIALS TO DSC 234

MATERIAL DSC 234	MATERIAL TYPE
-2	Nylon Vacuum Bagging Film, 350°F Cure Cycle
-4	Nylon Tubular Vacuum Bagging Film, 350°F Cure Cycle
-5	1 Mil Perforated (pin prick) Release Film
-9	Breather/Bleeder Cloth, Non-Woven Polyester, Max Pressure 50 psi.
-10	Breather/Bleeder Cloth, Non-Woven Polyester, Max Pressure 100 psi.
-11	Breather/Bleeder Cloth, Non-Woven Polyester, Fire Retardant, Max Pressure 50 psi.
-12	Release Ply, Up to 350°F Cure Cycle (Note 1)
-12-2	Parchment Paper, Up to 350°F Cure Cycle
-12-3	Pre-Impregnated Peel-Ply (Note 1)
-15	High Temperature Pressure Sensitive Tape
-17	Vacuum Bag Sealant
-19-48	Non-Perforated Barrier/Release Film
-20	Fiberglass Tape, Pressure Sensitive Adhesive
Note 1. DSC 234-12 release ply may be used in place of DSC 234-12-3 pre-impregnated peel-ply and DSC 234-12-3 pre-impregnated peel-ply may be used in place of DSC 234-12 release ply.	

4.2 Equipment

4.2.1 Autoclave, certified according to PPS 10.21.

4.2.2 Curing oven, certified according to PPS 10.51.

4.2.3 Hot air gun, maximum temperature of 160°F.

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

4.2.5 Lint-free cotton gloves (e.g., DSC 422-1).

4.2.6 Protective gloves, neoprene (e.g., DSC 422-5), latex rubber (e.g., DSC 422-2) or PVC (e.g., DSC 422-6).

4.2.7 Sharpie 30001 felt tip markers.

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

4.2.9 Thermocouples to PPS 10.28.

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 fabrication of 350°F cure, epoxy resin pre-impregnated, glass, aluminized glass, aluminum foil and aramid fibre parts 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 fabrication of 350°F cure, epoxy resin pre-impregnated, glass, aluminized glass, aluminum foil and aramid fibre parts 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 as defined by De Havilland Canada M&P Engineering.

4.3.3.2 All testing and evaluation specified herein must only be performed by De Havilland Canada Materials Laboratory or by laboratories accredited according to BAERD GEN-018.

5 PROCEDURE

5.1 General

5.1.1 For the purposes of this PPS, the term “MRB” (Material Review Board) shall be considered to include De Havilland Canada MRB and De Havilland Canada delegated MRB.

5.1.2 Pre-impregnated material consists of woven fabric or aluminum screen/foil which has been impregnated with a heat curing epoxy resin and “B” stage cured by the manufacturer. The term “material” used throughout this PPS refers to the pre-impregnated materials listed in section 4.1 unless a particular type is specified.

5.1.3 For the purposes of this PPS, laminates are considered to consist of single or multi-ply layers of material which have been laid up and cured to form a part, part component or test specimen.

5.1.4 For the purposes of this PPS, sandwich panel assemblies consist of a honeycomb core sandwiched between two or more plies laid up and cured to form a part or part component.

5.1.5 Intermixing of material from different vendors covered by a single DHMS is not allowed. Intermixing of material from different vendors covered by different DHMS’s is allowed.

5.1.6 Trim integral test coupons, if required, from the cured part during the finishing operation according to section 5.8. Test coupon construction shall be according to the engineering drawing.

5.1.7 If specified on the engineering drawing, plies of epoxy/glass fabric, epoxy/graphite fabric, epoxy/aluminized glass cloth, etc., shall be incorporated into the lay-up following the standard procedures specified herein.

5.1.8 For class 5 parts only, if tab extensions are used, ply by ply inspection is not necessary. Ensure tabs are suitably sized and staggered to allow for the identification of the ply material, verification of orientation of the fabric or fibre and verification of the lay-up sequence as specified on requirements of the engineering drawing. Install tab extensions beyond the trim line.

5.2 Preparation of Materials and Equipment

5.2.1 Prepare core fillers according to PPS 13.23.

5.2.2 Prepare moulds according to PPS 10.22.

5.2.3 Prepare intensifiers by applying mould release agent according to PPS 10.22.

5.2.4 Prepare thermocouples according to PPS 10.28.

5.2.5 Store, handle and prepare pre-impregnated materials according to PPS 10.23.

5.2.6 Prepare honeycomb core materials according to PPS 10.24.

5.2.7 Store, handle and prepare DHMS A6.06 and DHMS A6.08 film adhesives according to PPS 10.25.

5.2.8 Clean DSC 164 aluminum mesh according to PPS 31.14 before lay-up. Ensure that the aluminum mesh is laid up in the mould and completely covered by pre-impregnated fabric within 24 hours of cleaning.

5.2.9 Solvent clean metal parts and doublers according to PPS 31.17 immediately before lay-up.

5.2.10 Protect all additional materials to be incorporated into the 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.

5.2.11 If DHMS P1.29 fire retardant rigid foam has not been stored in a controlled environment at 60 to 80°F with the relative humidity not exceeding 60%, immediately before machining and lay-up, dry the foam for a minimum of 30 minutes at 275 ± 20°F.

5.3 Lay-Up of Laminates

5.3.1 Lay-up laminates as follows:

Step 1. To tack the first ply of fabric to the tool, it is acceptable to pre-heat the tool to a maximum temperature of 120°F and/or apply 1" square patches of DHMS A6.08 film adhesive spaced approximately 6" apart. If the first ply is pre-impregnated DHMS P1.64 aluminum foil, take care to avoid wrinkles or tear. Tears up to 2" do not require repair. Repair tears 2" to 6" according to paragraph 5.3.5. Remove aluminum foils with tears exceeding 6" and lay-up a new ply of aluminum foil.

Step 2. If incorporation of DSC 164 aluminum mesh into the lay-up is specified on the engineering drawing, apply a layer of DHMS A6.08 film adhesive to the tool surface in the area to which the aluminum mesh is to be applied according to PPS 10.25.

Step 3. Lay-up the first ply by orientating it as specified on the engineering drawing. Use radiused nylon or teflon blocks to work the fabric into the mould contours.

Step 4. Peel the backing film from the laid up ply and continue the lay-up. Orient all plies as specified on the engineering drawing. If necessary, mark the position of the plies on the laid up ply using the applicable template and a Sharpie 30001 felt tip marker. If necessary, tape the plies in position outside of the trim line using DSC 234-15 pressure sensitive tape. Use a hot air gun, as required, to soften the material for forming and to increase ply tack. If required, the edge of the plies may be marked on the mould outside the trim line using a permanent Sharpie 30001 felt tip marker.

Step 5. If the material tack presents difficulties in positioning, lay a sheet of backing film on the laid up ply. Position the next ply over the film and slide the film from the plies while working down. Work each ply into intimate contact with the previously laid up ply. Take particular care on radii, complex curvatures, etc. to ensure complete contact of the material.

5.3.2 Apply the finish materials (i.e., moisture barrier film, etc.), specified on the engineering drawing to the part. Moisture barrier film may be spliced as required to the size specified on the engineering drawing. If splicing moisture barrier film, maintain a final overlap of 0" to 1/4" on a completed part.

5.3.3 Incorporate thermocouple ends under the second last ply outside the trim line. Use DSC 234-15 tape to secure the thermocouple wires to the tool. If the shape of the tooling makes it impossible to incorporate thermocouple end under the second last ply, use DSC 234-15 tape to secure thermocouple ends (covered with two layers of breather cloth) to the tool after completion of the lay-up.

5.3.3.1 Ensure there is a minimum of 1 thermocouple incorporated for every 10 square feet of part surface. If possible, place thermocouples at opposite ends and sides of each other (i.e., do not place side by side).

5.3.4 If the use of peel-ply is specified, locate peel-ply on the part with an overlap of 1" to 2". Mark the location in which the peel-ply has been applied using coloured peel-ply or a Sharpie 30001 felt tipped marker so that the location of the peel-ply will be evident after curing.

5.3.5 If splices in the plies are permitted by the engineering drawing, overlap the splices by 3/4" to 1 1/4". Overlap DHMS P1.38 aluminized glass fabric, DSC 164 aluminum mesh and DHMS P1.64 aluminum foil by 2" to 2 1/2" at splice locations.

5.3.6 If the engineering drawing allows the cutting of notches in the plies to allow forming over contours, then stagger the notches to prevent local material build-up.

5.3.7 De-Bulking and Temporary Vacuum Bagging

5.3.7.1 If de-bulking is specified on the manufacturing document, then de-bulk parts as follows:

Step 1. Vacuum bag the part according to paragraph 5.3.7.3 or paragraph 5.3.7.4.

Step 2. Apply a minimum vacuum of 24" Hg.

Step 3. Maintain the vacuum for 0.5 to 2 hours at 65 to 75°F (see section 6.8).

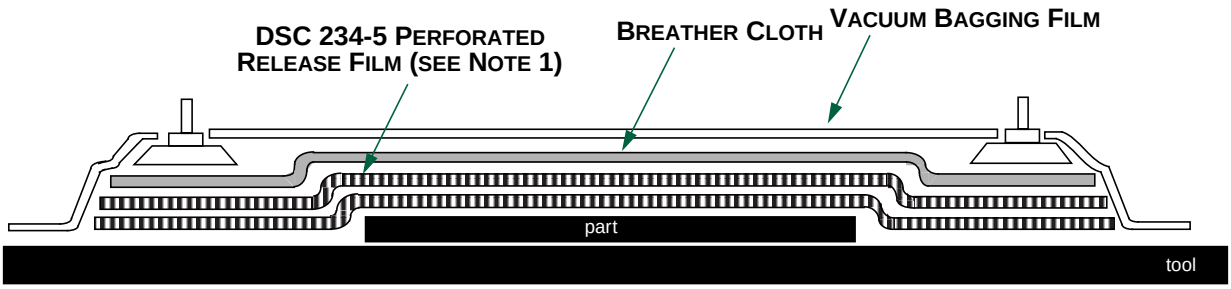
5.3.7.2 If the manufacturing document does not specify de-bulking of the parts, then either de-bulk according to paragraph 5.3.7.1 or temporary vacuum bag the part to facilitate the lay-up procedure as follows:

Step 1. Vacuum bag the part according to paragraph 5.3.7.3 or paragraph 5.3.7.4.

Step 2. Apply a minimum vacuum of 24" Hg.

Step 3. Maintain the vacuum for 5 to 30 minutes at 65 to 75°F (see section 6.8).

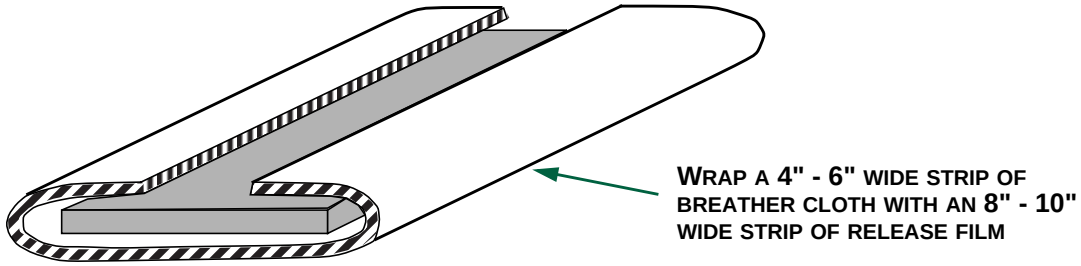
5.3.7.3 Vacuum bag parts for de-bulking or temporary vacuum bagging as follows:



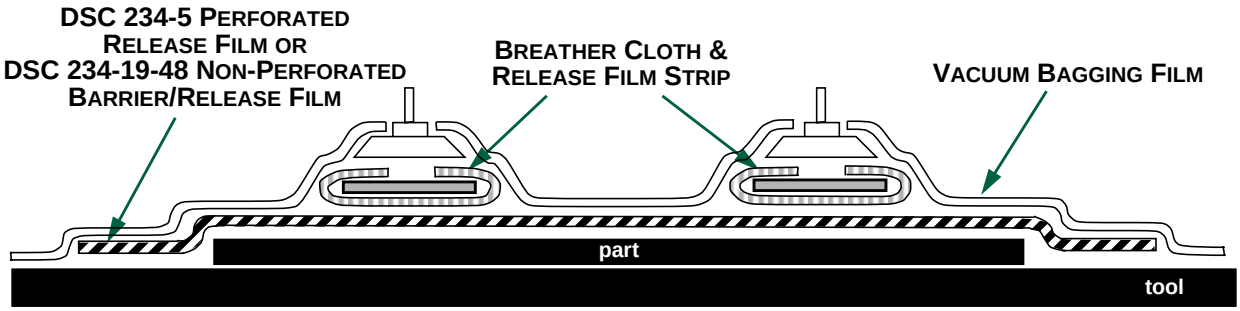
Note 1: In place of two layers of DSC 234-5 perforated release film, it is acceptable to use one layer of DSC 234-19-48 non-perforated barrier/release film.

STANDARD VACUUM BAGGING FOR DE-BULKING OR TEMPORARY BAGGING

5.3.7.4 As an alternate to vacuum bagging for de-bulking or temporary vacuum bagging as shown in paragraph 5.3.7.3, it is acceptable to substitute prepared strips for the second layer of release film and the layer of breather cloth (see following figures).



BREATHER CLOTH & RELEASE FILM STRIPS



ALTERNATE METHOD OF VACUUM BAGGING FOR DE-BULKING OR TEMPORARY VACUUM BAGGING

5.4 Lay-Up of Sandwich Panels

5.4.1 General

5.4.1.1 For DHMS P1.39 Class 1 material lay-ups, apply one layer of DHMS A6.08 to all areas where core material is to be laid up.

5.4.1.2 Lay-up sandwich panels as follows:

Step 1. Lay-up the outer laminate of the sandwich panel in the mould according to the procedure specified in section 5.3. If core stabilizing is specified on the work order or engineering drawing, lay-up the outer plies of the sandwich panel according to section 5.4.2. If core stabilizing using DHMS P1.48 flyscreen is specified on the engineering drawing, stabilize honeycomb core according to PPS 10.24.

Step 2. Press the core, prepared according to PPS 10.24, against the ply using just sufficient force to ensure contact of the cells to the fabric. If necessary, use a hot air gun to heat the material and increase its tack. If necessary, use small sections of DHMS A6.08 film adhesive to hold the core in position but limit the amount of adhesive film to 4 square inches per square foot of core.

Step 3. If the core is to be spliced as part of the laid up assembly, process the parts according to section 5.4.3.

Step 4. If potting of cells is specified on the engineering drawing, pot the applicable core cells with the specified core filler according to PPS 13.23.

Step 5. If the use of doublers is specified on the engineering drawing, add doublers to the core according to section 5.4.4.

Step 6. If the use of inserts or edging is specified on the engineering drawing, add inserts and edging to the core according to section 5.4.5.

Step 7. Complete the inner laminate lay-up according to section 5.3.

5.4.2 Core Stabilization

5.4.2.1 If the tool is equipped with a grit strip, then lay-up the two fabric plies above and below the core according to Figure 1.

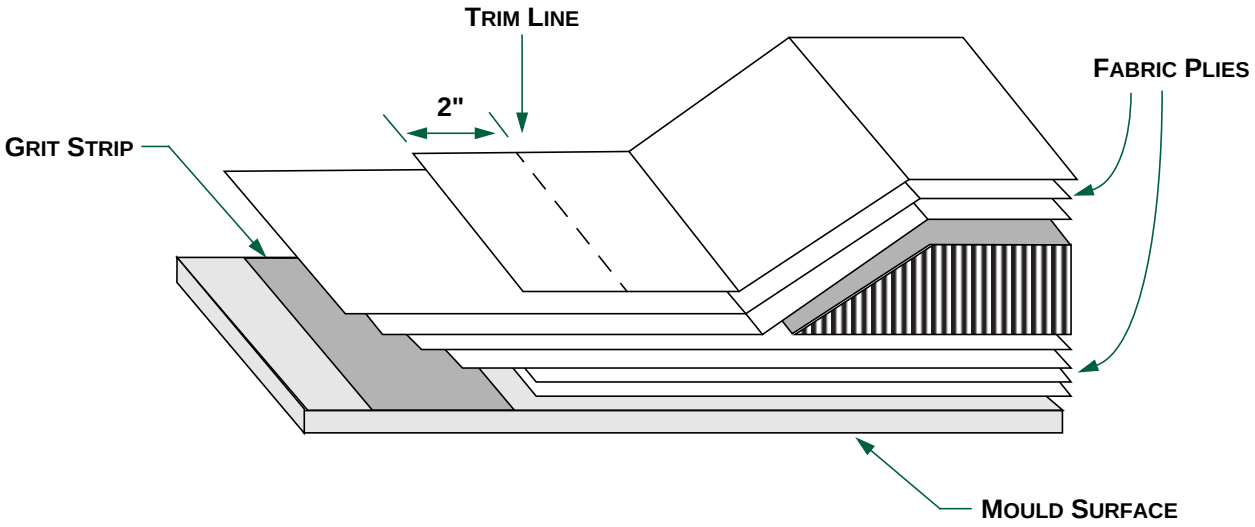


FIGURE 1 - GRIT STRIP METHOD OF CORE STABILIZATION

5.4.2.2 If the tool is not equipped with a grit strip, stabilize the core according to either paragraph 5.4.2.2.1 or paragraph 5.4.2.2.2.

5.4.2.2.1 If the tool is not equipped with a grit strip it is acceptable to stabilize the core using the edge bleeder method as shown in Figure 2. As a minimum, the two plies above and below the core shall be tied down. It is acceptable to tie down additional plies with the exception of the first ply next to the tool. Position the plies on the mould and extend the edges 2" beyond the trim line or over the holding pins (if provided). When laying a bordering strip of edge bleeder cloth (style 181 glass), ensure that it will overlap the fabric ply by approximately 1". When applying a strip of DSC 234-15 high temperature pressure sensitive tape or high temperature masking tape, ensure that it will overlap the edge bleeder cloth by approximately 1". Press the tape firmly against the tool and the edge bleeder cloth.

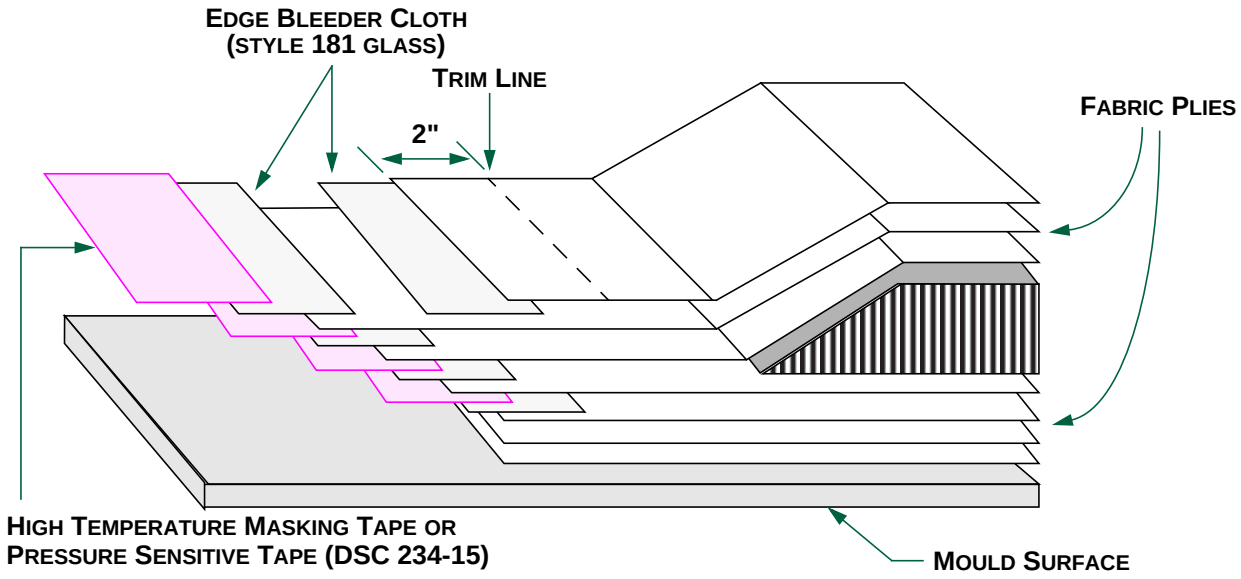


FIGURE 2 - EDGE BLEEDER METHOD OF CORE STABILIZATION

5.4.2.2.2 If the tool is not equipped with a grit strip it is acceptable to stabilize the core using the fiberglass tape method as shown in Figure 3. As a minimum the two plies above and below the core shall be tied down using fiberglass tape. It is acceptable to tie down additional plies with the exception of the first ply next to the tool. Stagger fabric plies to ensure that bordering strips of DSC 234-20 adhesive backed fiberglass tape extend at least 0.5" onto the mould surface while overlapping approximately 1 1/2" over the fabric plies (see Figure 3). Position the plies on the mould so that the edges extend at least 2" beyond the trim line or over the holding pins (if provided).

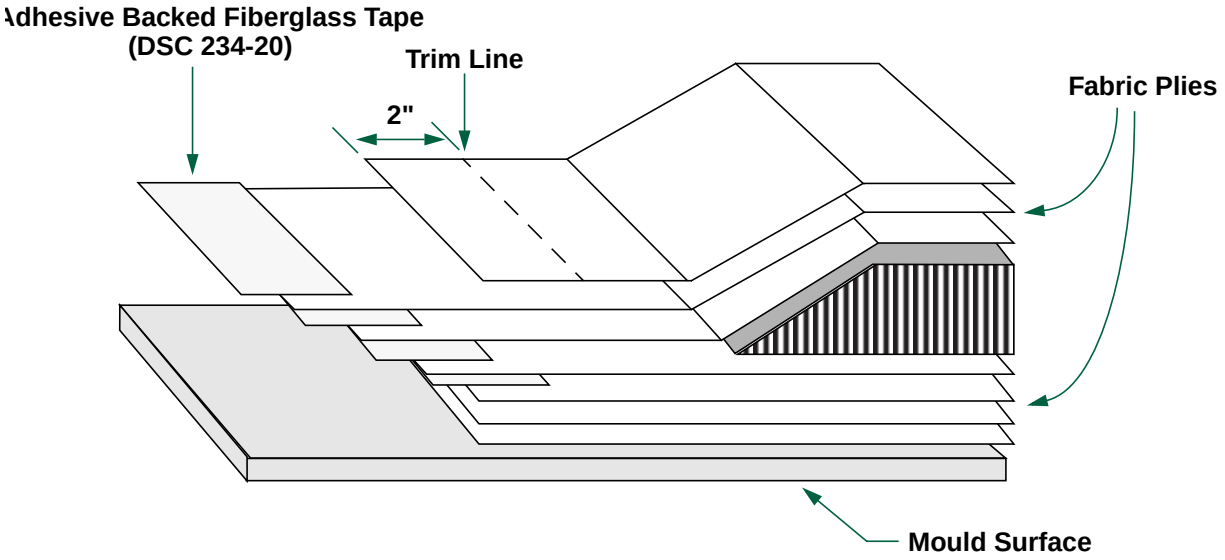


FIGURE 3 - FIBERGLASS TAPE METHOD OF CORE STABILIZATION

5.4.3 Core Splicing

5.4.3.1 Splice cores as follows:

Step 1. Thoroughly clean both splice edges according to PPS 10.24.

Step 2. Cut a strip of DHMS A6.06 expandable film adhesive the same length as the splice edge. Use 0.05" thick sheet to splice 1/8" cell sizes and 0.10" thick sheet (or two layers of 0.05" thick sheet) for splicing of 3/16" and 1/4" cell sizes.

Step 3. As the core sections are laid up in the mould, place the strip of adhesive between the cleaned splice edges and join with light hand pressure.

Step 4. Check to ensure the gap between spliced cores is approximately 0.10" or less.

5.4.4 Adding Doublers

5.4.4.1 Add doublers to the core as follows:

Step 1. Prime doublers with F19 Type 2 primer according to PPS 34.08.

Step 2. Solvent clean all doubler surfaces according to PPS 31.17.

Step 3. Apply a layer of DHMS A6.08 film adhesive to the top and bottom surfaces according to PPS 10.25.

Step 4. Insert the doubler into the core and press firmly into place. Ensure that the doubler is flush with the surface of the core.

Step 5. Fill voids in the potted areas along the doubler sides flush with core filler.

5.4.5 Addition of Inserts and Edgings

5.4.5.1 Add inserts and edgings as follows:

Step 1. Machine the insert to the required size. Edgings may be machined oversize in width to facilitate machining to the final part trim line after curing. Machine foam material using conventional clean cutting tools.

Step 2. Wipe the surfaces clean of dust and foam particles using a clean cloth.

Step 3. Apply DHMS A6.06 expandable film adhesive (0.05" thick for 1/8" core cells and 0.10" thick for 3/16" or 1/4" core cell sizes) to the sides of the insert according to PPS 10.25.

Step 4. Apply DHMS A6.08 film adhesive to the top and bottom surfaces of the insert according to PPS 10.25.

Step 5. Install the insert in position by pressing firmly against the surrounding core to ensure contact.

Step 6. If the inner ply is not to be laid up immediately, cover the exposed insert and adhesive surfaces with protective paper to prevent contamination.

5.4.5.2 Accomplish foam to foam or foam to metal bonding using DHMS A6.08 Class 2 film adhesive.

5.5 Vacuum Bagging

5.5.1 Vacuum bag parts as follows:

Step 1. Apply DSC 234-17 vacuum bag sealant to the mould surface to surround the part's perimeter. Leave a minimum of 1" from the ply ends to the vacuum bag sealant.

Step 2. Position intensifiers as specified on the engineering drawing. If the engineering drawing specifies a tool side finish on both sides of the part, apply a layer of the following material between the intensifier and the part:

INTENSIFIER MATERIAL	SITUATION	MATERIAL TO BE USED (NOTE 1)
Non Metallic	Area to be used as an attachment or mating surface	DSC 234-12-1 parchment paper or DSC 234-19-48 release film (Notes 2 & 3)
	Liquid Shimming area	DSC 234-12 release ply or DSC 234-12-3 peel-ply
	Secondary Bonding area	
	All other cases	DSC 234-19-48 release film (Note 3)
Metallic	Liquid Shimming area	DSC 234-12 release ply or DSC 234-12-3 peel-ply (Note 4)
	Secondary Bonding area	
	All other cases	DSC 234-19-48 release film, DSC 234-8 release fabric, DSC 234-13-3 or DSC 234-13-4 mould release agent

Note 1. Ensure that the release film, release fabric, release ply, peel-ply or parchment paper extends approximately 1" beyond the perimeter of the intensifier.
Note 2. If resin pooling in a particular area is encountered, use DSC 234-12 release ply or DSC 234-12-3 peel-ply in these areas in place of parchment paper or release film.
Note 3. If part geometry makes it impracticable to apply release film, release ply, peel-ply or parchment paper, it is acceptable to apply DSC 234-13-3 or DSC 234-13-4 mould release agents to the intensifier in place of release film, release ply, peel-ply or parchment paper.
Note 4. Incorporate DSC 234-19-48 release film or DSC 234-8 release fabric in between the release ply/peel-ply and the metallic intensifier.

Step 3. Cover the lay-up with one layer of DSC 234-5 perforated release film. If DHMS P1.27 moisture barrier film has been used, release film is not required.

Step 4. For parts to be oven cured, cover the lay-up with a layer of DSC 234-9 breather cloth. 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
Greater than 50 psi	1 layer of DSC 234-10 breather cloth	2 layers of DSC 234-11 breather cloth

Step 5. Place additional layers of breather cloth over protrusions, sharp edges, etc. to prevent puncturing of the bag.

Step 6. Position vacuum outlets around the part as evenly spaced as possible. Include at least one vacuum outlet for **every** 9 square feet of surface area and an additional vacuum outlet for vacuum monitoring. Add 2 to 3 layers of the applicable breather cloth under each of the vacuum outlets. Do not place vacuum outlets directly over the laid up pre-impregnated plies. In cases where it is possible that a high flow of resin may clog the vacuum outlet, add a piece of bagging film approximately twice as big as the vacuum outlet under the extra layers of breather cloth.

Step 7. Cover the lay-up with DSC 234-2 or DSC 234-4 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.

Step 8. Puncture the vacuum bagging film at the vacuum outlets.

5.6 Leak Testing

5.6.1 Perform leak testing of vacuum bagged assemblies 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 assembly. 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.

Step 4. If the leak rate is greater than 1" Hg per minute over a 5 minute period, repair the leaks (or re-vacuum bag according to section 5.5, if necessary) and re-test for leaks according to this section.

5.7 Curing

5.7.1 Cure laid up parts using the cure method specified on the engineering drawing or manufacturing document. For sandwich panels, if the cure method or pressure is not specified, oven cure the part. For laminates, if the cure method or pressure is not specified, either oven cure the part or autoclave cure at a minimum cure pressure of 14 psi. For autoclave curing of laminates only, it is acceptable to cure the part at a greater autoclave pressure than the pressure specified on the engineering drawing.

5.7.2 Prepare a cure chart and a cure plot, if available, for each autoclave and oven load. Ensure that the cure chart shows 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).

5.7.3 If curing in an oven or autoclave which is 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.

5.7.4 Record the heat-up and cool down rates each 5 minute interval.

5.7.5 When curing, verify the following:

- heat-up and cool down rates for each 5 minute interval
- cure duration
- cure pressure, if applicable
- vacuum monitoring

5.7.6 The autoclave or oven may be opened to correct bag leaks, replace thermocouples, etc. provided that the part temperature has not exceeded 140°F.

5.7.7 Autoclave or oven cure as follows:

Step 1. Transfer the laid up part, while under vacuum, to the oven or autoclave.

Step 2. Connect all thermocouple leads from the parts to the appropriate connectors in the oven or autoclave. Record on the oven or autoclave record sheet which thermocouple is attached to each part.

Step 3. Connect all vacuum outlets to the oven or autoclave vacuum connectors and apply a minimum vacuum of 24" Hg.

Step 4. For all Class 1, 2 and 3 parts, connect one of the vacuum outlets to the vacuum monitor connector (see Figure 4). Record on the oven or autoclave load record sheet which part number has been connected to each vacuum monitor connector. If there are more vacuum and vacuum monitor outlets than connectors, connect the outlets according to Figure 5. If the vacuum of one of the parts connected according to Figure 5 fails, reject both parts.

Step 5. Ensure all thermocouple and vacuum connections have been made.

Step 6. If autoclave curing using pre-programmed controllers, ensure that the correct cure cycle has been selected.

Step 7. Turn on the heaters and begin heating the parts. When oven curing, a vacuum reading of less than 24" Hg at any time during the cure cycle is cause for rejection and disposition of the represented parts.

Step 8. For autoclave curing, slowly pressurize the autoclave to the pressure specified on the engineering drawing while the parts are heating and vent the part vacuum to the atmosphere at the following specified autoclave pressure:

CURE PRESSURE SPECIFIED ON THE ENGINEERING DRAWING (psi)	AUTOCLAVE PRESSURE (psi)
< 20	5 - 8
20 - 30	8 - 15
> 30	15 - 20

Ensure that the part temperature does not exceed 130°F until the autoclave has reached full pressure. A pressure reading of more than 5 psi under the bag at any time during the cure cycle is cause for rejection and disposition of the represented parts.

Step 9. As each thermocouple reaches 130°F, maintain the heat up rate for that thermocouple at one of the following options until the cure temperature is reached:

Option 1: Maintain a heat up rate of 2 to 5°F per minute until 355 ± 10°F is reached.

Option 2: Maintain a heat up rate of 2 to 5°F per minute during heat up at 130 to 335°F followed by a heat up rate of 0.5 to 5°F per minute until 355 ± 10°F is reached.

Step 10. As each thermocouple reaches the cure temperature (355°F ± 10°F), maintain that thermocouple at the cure temperature for 120 to 180 minutes. If a thermocouple indication falls below 345°F, consider the cure time for that thermocouple to have stopped and restart the cure time only when the cure temperature (355°F ± 10°F) is restored. A thermocouple indication rise above 365°F is cause for rejection and disposition of the represented parts. Exposure to the cure temperature (355°F ± 10°F) for greater than 180 minutes is cause for rejection and disposition of those particular parts. If autoclave curing and the pressure drops more than 5 psi below the specified pressure, consider the cure time to have stopped and restart only when the specified pressure (± 5 psi) is restored. Except as noted in paragraph 5.7.1, a pressure rise greater than 5 psi over the specified pressure is cause for rejection and disposition of the parts. Indicate on the recording chart any correction made during the cure cycle.

Step 11. Upon completion of the cure cycle, shut off the heaters and allow the parts to cool at a rate no greater than 5°F per minute.

Step 12. If oven or autoclave curing, once the parts have cooled to 140°F or less, release the vacuum or pressure, remove the bag and separate the part from the mould. If autoclave curing, the autoclave pressure may be released when the parts have cooled to 175°F provided that a minimum vacuum of 24" Hg is applied as the pressure falls between 20 and 15 psi and the parts may then be removed while under vacuum and allowed to cool to 140°F.

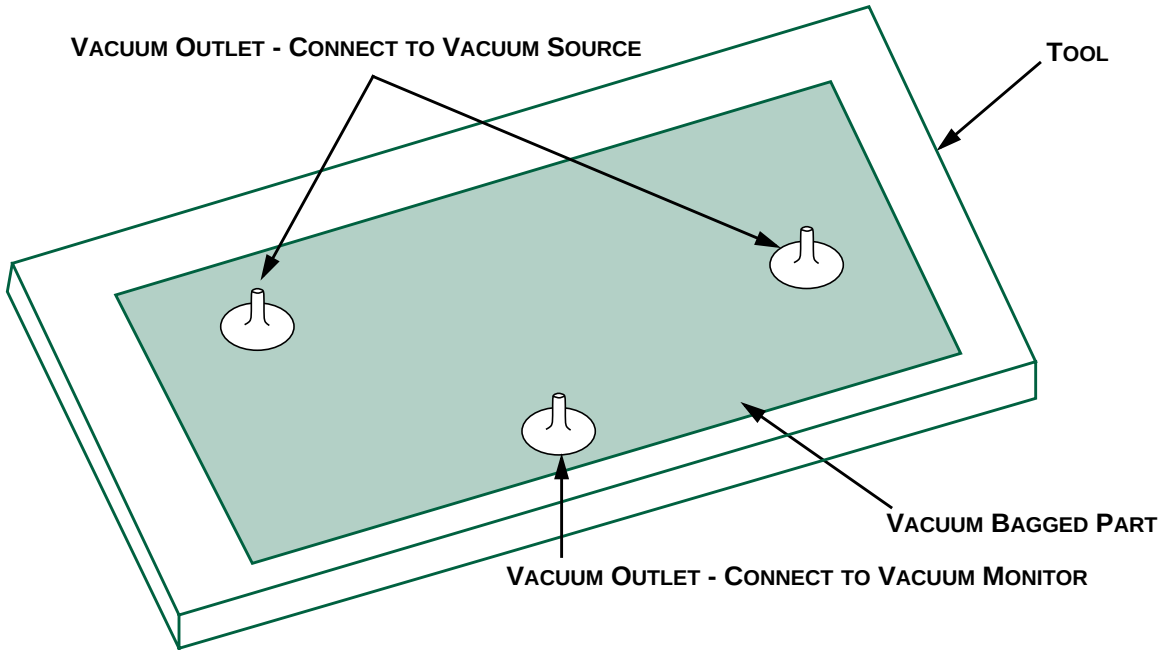


FIGURE 4 - VACUUM CONNECTION

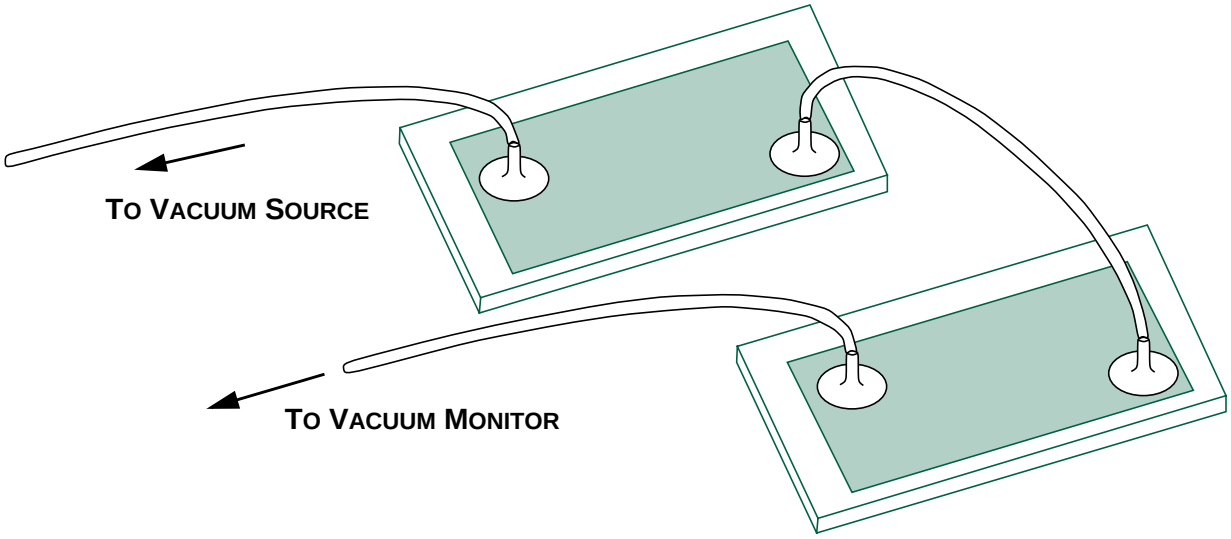


FIGURE 5 - ALTERNATE VACUUM CONNECTION

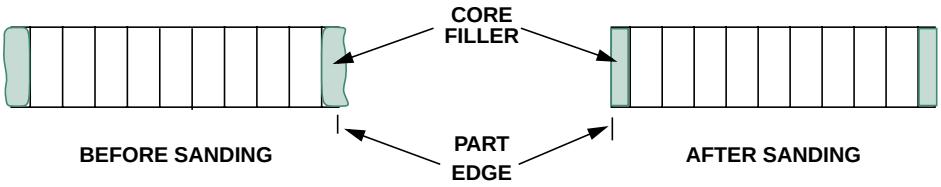
5.8 Finishing

5.8.1 Finish parts as follows:

Step 1. Trim the part to the engineering drawing requirements according to PPS 10.39.

Step 2. Solvent clean all surfaces according to PPS 31.17.

Step 3. If the engineering drawing specifies “Edge Filling” sandwich panel assemblies, use a suitable spatula to fill all open edge cells with the core filler specified. Allow DHMS P1.30 resin to cure according to PPS 13.23. Smooth to the required part profile by lightly sanding the edge with 180-240 grit abrasive paper.



Step 4. If the engineering drawing specifies “Under Cutting”, process sandwich panel assemblies after curing and de-moulding by using a suitable rotary file to remove the core cells to the depth specified on the engineering drawing and fill the cavity and allow the material to cure according to PPS 13.23.

Step 5. Repair structural defects according to the applicable repair procedure specified in Table II. If the defect magnitude exceeds the limits as specified in Table II, refer the part to MRB for disposition.

Step 6. If the part is to be covered with a decorative laminate, repair imperfections as listed in Table III according to PPS 34.34.

Step 7. If the engineering drawing specifies “Surface Finish - F33” or “Surface Finish - PPS 34.34”, repair imperfections as listed in Table III and pin holes according to PPS 34.34.

Step 8. Remove excess epoxy from the exterior surfaces of aluminum mesh by sanding with 180 - 240 grit abrasive paper. Take care to avoid sanding through the mesh or exposing fibres.

Step 9. Apply chemical conversion coating by brush to all exposed aluminum mesh surfaces, including countersinks and holes, according to PPS 32.02 to prevent surface oxidation.

5.8.2 Ensure all vacuum bagging material is removed after curing and before any further processing.

5.8.3 Except as specified in paragraph 5.8.3.1, any details to which release ply, peel-ply and/or parchment paper has been incorporated shall have the release ply, peel-ply and parchment paper removed after curing and only immediately before any secondary bonding or lay-up applications.

5.8.3.1 Do not remove release ply, peel-ply and/or parchment paper if details are to be machined or stored, or when details are not laid up within the same work shift.

5.8.4 Repair localized damage to DHMS P1.27 moisture barrier film that does not extend to the plies below (e.g., scuffing) by touch up with F22 enamel according to PPS 34.41.

5.8.5 Minimize the possibility of damaging completed composite parts during handling. Do not leave completed parts unprotected in the work area. Remove completed parts from the work area as soon as possible.

TABLE II - STRUCTURAL DEFECTS (NOTE 1)

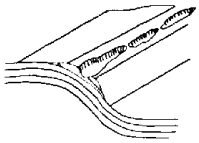
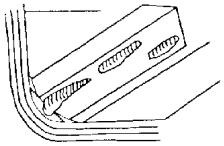
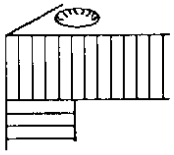
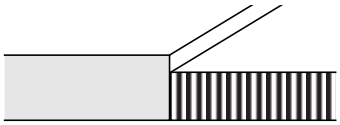
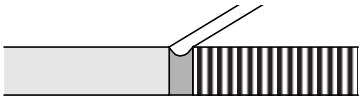
DEFECT	DESCRIPTION (Note 2)	REPAIR PROCEDURE
Surface Scratches (Note 3)	• Fibre damage • First ply only • Maximum depth of 0.005" • Maximum length of 1"	PPS 10.40 or PPS 34.34
Resin Starved Area (Note 4)	• Maximum 10% of surface	
Deep Scratches	• Penetrating through first ply only • Maximum depth of 0.010"	PPS 10.40
Partial Fractures	• Penetrating through first ply only • Maximum depth of 0.010"	

Delamination (Note 5) and Internal Voids	• Class 6 components only
	  • No more than 1 such defect per square foot
	  • Maximum size of 1 square inch
	  • Maximum length of 2"
	• Class 1 through Class 5 components
	  • Refer to MRB	

Small Holes and Punctures	• No more than 1 such defect per square foot • Maximum diameter of 1/4"	
Misplaced Fastener Holes	• Maximum 10% of pattern • Maximum diameter of 1/4"	
Parts Trimmed Too Small	• No fastener holes in area to be built up • Maximum width of 1" • Maximum length 25% of the part's periphery	
Tackiness (i.e., not fully cured)	• MRB authority is required	

Note 1. These defects are structural in nature, affecting the strength or performance of the part. This type of defect shall be repaired before placing the part in service.
Note 2. These are the limitations to which these defects may be repaired without MRB authorization. Defects exceeding the stated limits require MRB authorization for repair.
Note 3. Refer surface scratches exceeding 1" in length to MRB for disposition.
Note 4. Not including pin holes - pin holes are not a structural defect.
Note 5. Refer parts with incomplete bonding or delaminations at doublers, edging or core to MRB for disposition.

TABLE III - IMPERFECTIONS (NOTE 1)

IMPERFECTIONS	DESCRIPTION	ILLUSTRATION
Excess Resin	• Air bubbles in resin at corners	
	• Air bubbles in fillets	
Surface irregularities	• Depressions at panel pins • Maximum 0.010" deep	
	• Telegraphing of core inserts, edgings, core splices, etc. • Maximum 0.010"	
	• Depressions at core splices • Maximum 0.010"	
	• Dents and dimples • Maximum 0.010" deep • Maximum 1" diameter	
Surface Scratches (Note 2)	• No fibre damage • Maximum length of 1"	
Wrinkles & Depressions	• Mark-offs from bag folds which do not include a ply in the wrinkle/depression • No fibre damage	
Pin Holes	• Air bubbles between yarns	

Note 1. These defects are confined to the surface of the part and have little or no effect on the strength or performance of the part but will result in an undesirable appearance in the finished part. This type of defect or imperfection does not require repair unless the part is to be covered with a decorative laminate or the engineering drawing specifies “Surface Finish - F33” or “Surface Finish - PPS 34.34”. These defects are repairable without MRB authorization. However, for parts where the engineering drawing specifies a flammability requirement to FAR 25.853, repair of a surface area up to 9 square inches is allowed. Refer parts exceeding this limit to MRB for disposition.

Note 2. Refer surface scratches exceeding 1" in length to MRB for disposition.

6 REQUIREMENTS

6.1 In-Process Inspection of Production Parts

6.1.1 In-process inspect all parts according to all applicable facility Quality specifications.

6.1.2 Check all pre-impregnated materials before use to ensure that the remaining shop time and storage life will allow sufficient time for lay-up and cure before the expiry of their shelf life.

6.1.3 Except for class 5 parts, inspect ply by ply to ensure the correct number of plies, ply orientation, lay-up sequence and ply dimensions as specified by the engineering drawing. For class 5 parts only, it is permissible to perform inspection with use of tab extension from each ply laid up in the mold instead of ply by ply inspection. For parts that conform to the engineering drawing, apply an inspection stamp to the manufacturing document.

6.1.4 The splices in the plies, if permitted by notation on the engineering drawing, shall overlap by 3/4" - 1 1/4". DHMS P1.38 aluminized glass fabric, DSC 164 aluminum mesh and DHMS P1.64 aluminum foil shall overlap by 2" - 2 1/2" at splice locations.

6.1.5 The edges of contour forming reinforcing plies shall have been positioned within ± 0.125" of the location specified by the engineering drawing.

6.1.6 The edges of flat reinforcing plies shall have been positioned within ± 0.062" of the location specified by the engineering drawing.

6.1.7 For parts that conform to the engineering drawing, apply an inspection stamp to the manufacturing document. Refer production parts that do not meet the requirements of this PPS to Quarantine Parts Areas (QPA) for disposition.

6.2 Visual Inspection of Finished Components

6.2.1 The parts shall be uniform in quality, appearance and condition and free of foreign material and internal or external imperfections that would be detrimental to the appearance or performance of the parts.

6.3 Dimensional Inspection of Finished Components

6.3.1 The parts shall meet the dimensional requirements specified on the engineering drawing.

6.3.2 The maximum panel warpage shall be below 0.025" per foot length of panel.

6.3.3 The irregularities in panel facings due to telegraphing of fabric around inserts, edges and core cells shall be below ± 0.010".

6.3.4 Reject parts exceeding the dimensional limits specified herein and refer them to QPA's for deposition.

6.4 Test Panel Requirements

6.4.1 If the engineering drawing specifies that the component or assembly shall meet flammability requirements of FAR 25.853, flammability compliance testing shall be completed as specified in PPS 10.36 prior to the manufacture of production parts.

6.4.2 Prepare process control test panels, part test coupons, qualification testing for first-off article inspection and periodic production article inspection according to QAMTR 029. Ensure the following data for each component/test panel is recorded on the manufacturing document:

- Identification of component.
- Serial number for traceability.
- Cure batch number.
- Material and core batch numbers.
- Lay-up date and processing information.
- Ambient temperature and humidity during lay-up.
- Testing results.

6.5 Receipt and Storage Life Extension Testing

6.5.1 Subject all batches of pre-impregnated material and film adhesives to acceptance, receipt and storage life extension testing according to PPS 10.23 or PPS 10.25.

6.6 Recording of Processing Information

6.6.1 The temperature measurements from each thermocouple shall be recorded during the entire curing cycle. Multi-point recorders may be used, providing that each thermocouple is monitored at least once every 5 minutes.

6.6.2 The recorder shall be capable of recording the temperature to within ± 1°F. Calibration of recording equipment against equipment of known accuracy, traceable to the National Institute of Standards and Technology, National Research Council or equivalent shall be carried out periodically.

6.6.3 The temperature chart shall be related to time so that the heat-up and cure time may be checked and recorded. Record vacuum and pressure applied to the assemblies during curing. Alternatively, data may be recorded and inspected on the cure cycle chart.

6.6.4 Ensure that each item on the cure chart and cure plot, if applicable, as specified in paragraph 5.7.3 and paragraph 5.7.4 has been inspection stamped. All temperature charts and vacuum and pressure records shall be readily available upon De Havilland Canada's request.

6.7 Part Marking

6.7.1 If the part has been in-process labelled with the part number, it is not necessary to part mark after curing.

6.8 Lay-Up Area Conditions

6.8.1 The work areas shall be isolated from machining operations or conditions that will generate dust or other contaminating airborne particles.

6.8.2 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.

6.8.3 The machines and tools used for cutting raw materials shall not deposit internal lubricating fluids onto the work surfaces.

6.8.4 The floors, work surfaces, all tooling and shelvings shall be kept clean and free of dust and other contaminants and swept or cleaned at least once a day.

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

6.8.6 Keep the lay-up area temperature and relative humidity within the limits specified in Figure 6. If the temperature or relative humidity exceeds the limits specified in Figure 6, vacuum bag partially completed parts and store them under a minimum vacuum of 24" Hg.

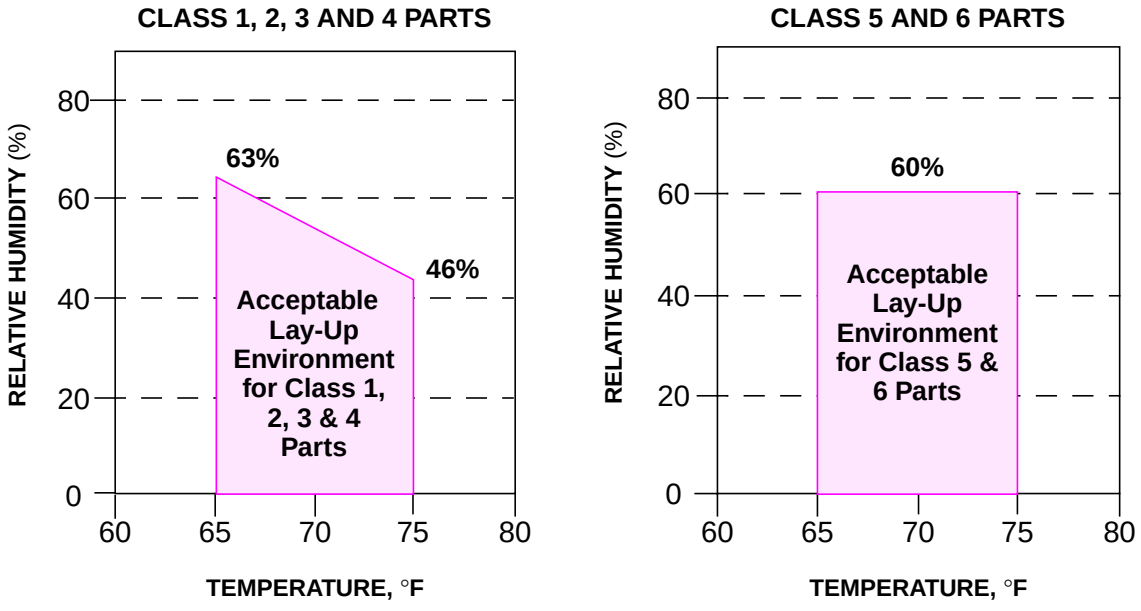


FIGURE 6 - TEMPERATURE AND RELATIVE HUMIDITY LIMITS

7 SAFETY PRECAUTIONS

7.1 Safety precautions applicable to the materials and procedures specified herein shall be defined by the subcontractor performing the work for De Havilland Canada. However, suppliers, subcontractors and partners are responsible for ensuring that their own environmental, health and safety precautions satisfy the appropriate local government regulations.

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:

8.2 Upon completion of training for laying up composite parts, trainees shall have a good working knowledge of the following, as applicable:

- engineering drawing and work order notes regarding the lay-up of composite parts
- sections regarding the lay-up of composite parts in the following PPS's: 10.23, 10.24, 10.25, 10.35, 10.43, 10.48, 13.23, 31.14 and 31.17
- equipment used in the lay-up of composite parts (i.e., cutting tools, radiused Teflon and nylon blocks, etc.)
- benefit of pre-heating the mould before beginning the lay-up
- significance of ply orientation
- purpose of aluminum mesh and aluminum foil
- why moisture barrier film is sometimes required
- why it is necessary to mark splice locations
- why de-bulking is sometimes necessary
- purpose of core edge stabilization and core stabilization
- purpose of potting cells

8.3 Upon completion of training for vacuum bagging composite parts, the trainees shall have a good working knowledge of the following, as applicable:

- engineering drawing and work order notes regarding the vacuum bagging of composite parts
- sections regarding the vacuum bagging of composite parts in the following PPS's: 10.23, 10.24, 10.25, 10.35, 10.43, 10.48, 13.23, 31.14 and 31.17
- equipment used in the lay-up of composite parts (i.e., vacuum gauges, leak detector gun, thermal impulse heater, etc.)
- role and purpose of vacuum bagging materials (i.e., release film, vacuum bag, barrier film, vacuum bag sealant, breather cloth, etc.)
- significance of moisture barrier film in the lay-up
- why vacuum outlet placement is important
- significance of leak testing
- why it may be necessary to strip thermocouple wire in the area of the vac-seal
- purpose of pleating the vacuum bag
- purpose of vacuum monitoring

8.4 Upon completion of training for curing composite parts, the trainees shall have a good working knowledge of the following, as applicable:

- significance of cure temperature, pressure and time limits
- why the heat-up rate varies between certain parts in the same load
- significance of the heat-up and cooling rates
- effect of temperature and pressure on laid up composite parts
- properties and characteristics of oven and autoclave curing
- how to prepare a cure chart
- how to set up and operate the curing oven and autoclave
- which parts have to be equipped with thermocouples
- cure charts and know which readings shall be recorded
- procedure for attaching thermocouple leads to connectors
- when to connect vacuum outlets to vacuum monitors
- limits on the heat-up and cool down rates
- 250°F, 280°F and 350°F cure cycles
- engineering drawing notes, PPS's and manufacturing documents

9 MAINTENANCE OF EQUIPMENT

9.1 Notify Plant Engineering before expiry of the current autoclave Pressure Vessel Safety Certificate, so that necessary servicing may be completed and a valid certificate issued.

9.2 Keep tools free from oil, dirt, moisture and other contaminants.

9.3 Calibrate pressure gauges, temperature indicating/recording equipment, etc., according to De Havilland Canada Quality requirements.

9.4 Autoclaves shall be approved by De Havilland Canada Quality as meeting the requirements of this PPS. Perform temperature uniformity checks on a scheduled basis and the results shall be approved by De Havilland Canada Quality.

10 STORAGE LIFE OF COMPOSITE MATERIALS

10.1 Refer to PPS 13.28 for the storage life of composite materials and products (e.g., DHMS A6.06, DHMS A6.08, DHMS P1.30, DHMS P1.38, etc.).