BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 10.04

PRODUCTION PROCESS STANDARD

WET LAY-UP OF GLASS FABRIC/POLYESTER RESIN LAMINATES

Issue 18
- This standard supersedes PPS 10.04, Issue 17.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS related questions to christie.chung@aero.bombardier.com or (416) 375-7641.
- This PPS is effective as of the distribution date.

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1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for the fabrication of polyester resin/glass fabric reinforced laminates, using the low pressure laminating wet lay-up procedure.

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.

1.1.3 Procedure or requirements specified in a Bombardier BAPS, MPS, LES or P. Spec. do not supersede the procedure or requirements specified in this PPS. Similarly, the procedure and requirements specified in this PPS are not applicable when use of a BAPS, MPS, LES or P. Spec. is specified.

2 HAZARDOUS MATERIALS

2.1 Before receipt at Bombardier Toronto, all materials shall be approved and assigned Material Safety Data Sheet (MSDS) numbers by the Bombardier Toronto 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 Bombardier Toronto Environment, Health and Safety Department.

3 REFERENCES

3.1 SAE AMS-C-9084 - Cloth, Glass, Finished, for Resin Laminates.

3.2 ASTM 2196 - Viscometer, Rotational (Brookfield Type), Rheological Properties of Non-Newtonian Materials by.

3.3 BAERD GEN-018 - Engineering Requirements for Laboratories.

3.4 DHMS F5.04 - Woven Glass Cloth.

3.5 Federal Test Method Standard No. 406.

3.6 PPS 10.22 - Preparation of Moulds.

3.7 PPS 10.39 - Machining of Fibre Reinforced Composite Parts.

3.8 PPS 10.40 - Repairs to Laminates & Sandwich Panels.

3.9 PPS 13.13 - Personal Protective Respiratory Equipment.

3.10 PPS 13.26 - General Subcontractor Provisions.

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

3.12 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.13 PPS 31.17 - Solvent Usage.

3.14 PPS 34.34 - Surface Finishing Compounds (F33).

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

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

4.1.2 Glass fabric, as specified on the engineering drawing (Table I).

TABLE I - GLASS FABRICS

SPECIFICATION	COMMERCIAL DESIGNATION
SAE AMS-C-9084, Class 1, Type III	120
SAE AMS-C-9084, Class 1, Type VIII	181
SAE AMS-C-9084, Class 1, Type VIIIA	181-150
SAE AMS-C-9084, Class 1, Type VIIIB	181-75DE
DHMS F5.04	045 or #173

4.1.3 Lubricating oil, SAE 10W, automotive, non-detergent.

4.1.4 Polyester resin components: Vibrin 117, Vibrin 563, Cobalt naphthenate solution (6%) and 60% MEK (Methyl Ethyl Ketone) peroxide in DMP (dimethyl phthalate). All batches of Vibrin 117, Vibrin 563, Cobalt naphthenate solution or catalyst (60% MEK peroxide in DMP) shall be received with a copy of the Acceptance Test Report relating to each material batch delivered by the supplier. Maintain all Acceptance Test Reports on file. Upon receipt and before use in production, test resin components as follows:

Step 1. Mix a 100 gram batch of catalyzed resin in a standard 1/2 pound unwaxed paper cup according to section 5.2.

Step 2. Determine the viscosity of the mixed sample at a temperature of 73 to 77°F according to ASTM 2196. The viscosity of the mixed sample shall be 500 to 2500 centipoises.

Step 3. Determine the gel time of the mixed sample at a temperature of 70 to 80°F and a relative humidity of 40 to 60% using a Randolf gel time tester. The gel time of the sample shall be no less than 30 minutes and no more than 3 hours for acceptability.

Step 4. Prepare three 3" x 12" x 1/8" test specimens according to the procedure specified herein, and subject them to horizontal flammability testing according to FAR 25.853 (b) Amdt. 25-83. The average burn rate for the three specimens shall not exceed 4" per minute.

Step 5. Prepare and test Federal Test Method Standard No. 406, Test Method 1011, Type 2 tensile test specimens according to the procedure specified herein. The minimum average tensile strength of the test specimens shall be as shown in Table II.

TABLE II - TENSILE STRENGTH REQUIREMENTS

GLASS CLOTH	MINIMUM AVERAGE TENSILE STRENGTH
181	1800 lbs/in width
173	1250 lbs/in width

4.1.4.1 Resin components which have exceeded their shelf life may be used if the gel time of a mixed sample prepared according to section 5.2 is 30 to 180 minutes when tested at a temperature of 70 to 80°F and a relative humidity of 40 to 60% using a Randolf gel time tester.

4.1.5 Vacuum bag material: 0.002", 0.004" and 0.006" PVA sheets or bags.

4.2 Equipment

4.2.1 Neoprene gloves (e.g., DSC 422-5).

4.2.2 Nitrile gloves (e.g., DSC 422-8).

4.2.3 Plastic scraper (e.g., SD9265).

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

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 polyester resin/glass fabric reinforced laminates, using the low pressure laminating wet lay-up procedure according to this PPS.

4.3.2 Bombardier subcontractors shall direct requests for approval to Bombardier Aerospace Supplier Quality Management. Bombardier Aerospace facilities shall direct requests for approval to the appropriate internal Quality Manager.

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, Bombardier Toronto Materials Technology 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 Bombardier Aerospace Supplier Quality Management.

4.3.3.1 For approval of subcontractor facilities to perform the fabrication of polyester resin/glass fabric reinforced laminates, using the low pressure laminating wet lay-up procedure 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 by Toronto Materials Technology.

4.3.3.2 All testing and evaluation specified herein shall only be performed by Bombardier Toronto 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 Bombardier Toronto MRB and Bombardier Toronto delegated MRB.

5.1.2 Unless otherwise specified on the engineering drawing, consider fiberglass laminates used as exterior parts Class A (i.e., structural) and interior parts Class B (i.e., non-structural).

5.2 Preparation of Materials

5.2.1 Prepare resin as follows:

Step 1. Thoroughly stir Vibrin 117 in its original container.

Step 2. Weigh out the required amount, according to Table III, of Vibrin 117 into a mixing container.

Step 3. Thoroughly stir Vibrin 563 in its original container.

Step 4. Weigh out the required amount, according to Table III, of Vibrin 563 into the mixing container and mix the Vibrin 117 and Vibrin 563 thoroughly.

Step 5. Add Cobalt naphthenate to the Vibrin 117/563 mixture in the ratio specified in Table III and thoroughly stir in.

Step 6. Add catalyst to the mixture and stir thoroughly to obtain a homogeneous mixture. Thoroughly stir mixtures of Cobalt naphthenate/Vibrin 117/Vibrin 563 which have been left standing for more than 24 hours before adding catalyst. **Do not** mix Cobalt naphthenate directly with the catalyst under any circumstances, as a violent reaction will occur.

Step 7. Allow the final mixture to stand for 5 to 10 minutes before use.

TABLE III - PREPARATION OF RESIN

RESIN COMPONENTS	MIXING QUANTITIES (PER POUND OF RESIN)
Vibrin 117	0.9 lbs
Vibrin 563	0.1 lbs
6% Cobalt Naphthenate Solution	1.2 to 1.6 mL
Catalyst (60% MEK Peroxide in DMP)	4.1 mL

5.2.2 Prepare moulds according to PPS 10.22.

5.2.3 Prepare glass fabric as follows:

Step 1. Ensure that the glass fabric is free of broken or damaged strands, streaks, stains or any other contamination.

Step 2. If possible, pre-cut the material, allowing a minimum of 1/2" beyond the trim line.

Step 3. If the relative humidity exceeds 60%, dry the glass fabric in an oven at 150 to 200°F for approximately 1 1/2 hours. If the fabric is not to be used immediately, place it in a PVA bag after removal from the oven. If the fabric is to be used immediately, place the fabric on the lay-up table as soon as it is removed from the oven and allow it to cool to room temperature.

Step 4. Immediately upon cooling or removal from the PVA bag, as applicable, impregnate the fabric using a paint roller. If it is not possible to impregnate the cloth before lay-up, coat the mould with one coat of catalyzed resin before applying the first layer of cloth and impregnate the cloth on the mould. Avoid touching the resin impregnated fabric with bare hands.

5.3 Lay-Up and Cure

5.3.1 Lay-up parts as follows:

Step 1. Position the mould on a vacuum table, ensuring that the vacuum ports are not blocked.

Step 2. Transfer the resin impregnated glass fabric to the mould, one ply at a time. Tailor and shape the material, taking care to avoid the entrapment of air. Unless otherwise specified on the engineering drawing, orient plies at random. Overlap any spliced areas by 1/2" to 1". Stagger overlapped areas in order to produce as uniform a laminate as possible.

Step 3. If necessary, position bleeder material leading from the edge of the laminate to the vacuum ports.

Step 4. Place a sheet of vacuum bagging material (PVA) over the lay-up and pull the sheet down around the edges of the vacuum table.

Step 5. Apply and maintain a minimum vacuum of 24" Hg.

Step 6. Distribute a small quantity of lubricating oil (see paragraph 4.1.3) over the surface of the vacuum bagging sheet and remove excess resin and air bubbles from the laminate by working toward bleeders using a rubber block.

Step 7. Place a heating blanket or a heat lamp canopy over the work so as to heat it to approximately 120°F. Maintain this temperature until gelation is complete (approximately 2 hours), taking great care to avoid local overheating of the work or the PVA sheet.

Step 8. Release the vacuum, remove the vacuum bag and carefully lift the part from the mould.

Step 9. Allow the part to cure for a minimum of 24 hours at room temperature before further working.

5.4 Hardness Testing

5.4.1 After full cure and before finishing, hardness test one part from each batch of parts using a Barcol comparator in at least 5 different areas. If possible make this check on areas that will be trimmed off or cut out. Except for extremely low readings which are the result of piercing of blisters, consider any reading less than 45 or greater than 70 a failure of the test. If the tested part fails the test, refer the entire represented batch to MRB for disposition, determine the cause of the failure and correct. After correction of the cause of failure, prepare and test a hardness test panel before any further manufacture of parts from the glass cloth represented.

5.5 Finishing

5.5.1 After the part is fully cured, finish the part as follows:

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

Step 2. Remove adhering parting agent and other loose particles from the laminate by solvent wiping according to PPS 31.17.

Step 3. Excess resin shall be kept to a minimum. Remove resin ridges on visible surfaces and on surfaces to be painted with 180 - 220 grit abrasive paper. Take care not to expose or damage the glass fibres. Excess resin in corners and fillets is acceptable provided that there is no tendency for the resin to crack or chip.

Step 4. Check the part for defects as listed in Table IV. If the part contains a defect within the limits specified in Table IV which is not in an area designated as critical on the engineering drawing, repair the defect according to PPS 10.40. If the part contains a defect in an area designated as critical on the engineering drawing or the extent of the defect exceeds the limits specified in Table IV, refer the part to MRB for disposition.

Step 5. Only if specified on the engineering drawing, apply surface finishing compound according to PPS 34.34.

TABLE IV - APPLICABILITY OF REPAIRS

TYPE OF DEFECT	MAXIMUM EXTENT OF DEFECT (NOTE 1)	
	CLASS A PARTS (NOTE 2)	CLASS B PARTS
Surface Scratches, Abrasions and Partial Fractures	• Penetrating through first ply of cloth only • Maximum depth of 0.020" • Maximum length of 1"	
Delamination and (Note 3) Internal Voids	• No more than 1 such defect per square foot • Maximum size of 1 square inch • Maximum length of 2"	• No more than 2 such defect per square foot • Maximum size of 3 square inches • Maximum length of 2"
Resin Voids on Surface	• Maximum 10% of surface	• Maximum 20% of surface
Parts Trimmed Too Small	• No fastener holes in area to be built up • Maximum width of 1" • Maximum length of 25% of the part's periphery	• Maximum width of 1" • Maximum length of 25% of the part's periphery
Excess Resin on Surface	• Corners and fillets - resin cracked or chipped	
Small Holes and Punctures	• No more than 1 such defect per square foot • Maximum diameter of 1/4"	• No more than 2 such defect per square foot • Maximum diameter of 1/4"

Note 1. 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 2. 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 3. Refer parts with incomplete bonding or delaminations at doublers, edging or core to MRB for disposition.

6 REQUIREMENTS

6.1 General

6.1.1 All testing and evaluation specified herein shall only be performed by Bombardier Toronto Materials Laboratory or by laboratories accredited according to BAERD GEN-018.

6.2 Process Qualification Testing

6.2.1 Before commencing production of parts as specified herein, qualify the process as follows:

Step 1. Prepare a four ply 12" X 12" flat test panel laminate according to the procedure specified herein. Ensure test panels are representative of production of Class A parts. Identify test panels by glass cloth fabric and lot number.

Step 2. Hardness test the test panel laminate using a Barcol comparator in at least 5 different areas. Except for extremely low readings which are the result of piercing of blisters, consider any reading less than 45 or greater than 70 a failure of the test.

Step 3. Prepare Federal Test Method Standard No. 406, Test Method 1011, Type 2 specimens according to the procedure specified herein and test tensile according to Federal Test Method Standard No. 406, Test Method 1011. The minimum average tensile strength of the test specimens shall be as specified in Table II.

Step 4. Prepare and test a test sample according to Federal Test Method Standard No. 406, Test Method 7061. An acceptable reading of the resin content shall fall within the range of 30% to 42%.

6.2.2 If any of the test specimens do not meet the requirements specified, determine the cause of the failure and correct. After correction, re-test as specified in this section before any further manufacture of parts from the glass cloth represented.

6.3 Lay-Up Area Conditions

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

6.3.2 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.

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

6.3.4 Parting or release agents, uncured silicone bearing material, and solvents 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 1. If the temperature or relative humidity exceeds the limits specified in Figure 1, vacuum bag partially completed parts and store them under a minimum vacuum of 24" Hg.

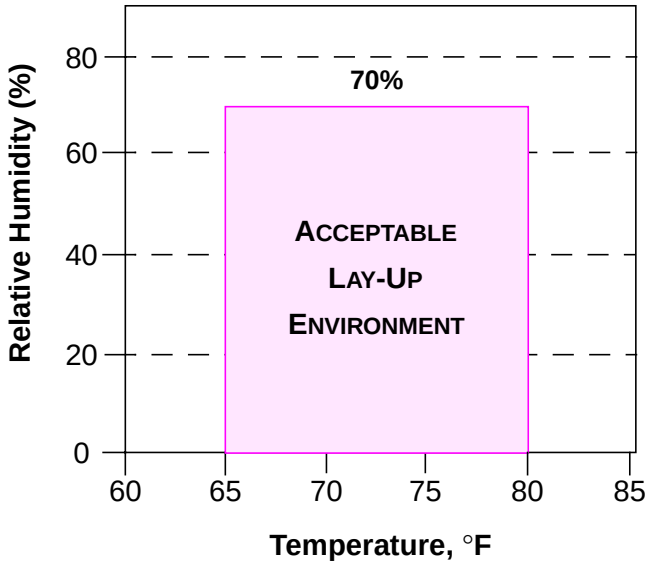

FIGURE 1 - TEMPERATURE AND RELATIVE HUMIDITY LIMITS

6.4 Production Parts

6.4.1 All finished parts shall meet the dimensional and material requirements of the engineering drawing. If the engineering drawing designates critical areas, consult Bombardier Engineering as to specific requirements.

6.4.2 Parts shall be smooth and free from wrinkles on the visible surface as installed in the aircraft, while the other side may show the pattern of the fabric.

6.4.3 Parts shall be free of the following defects:

- Tackiness, crazing, internal voids (air pockets), delaminations or embedded foreign particles
- Resin voids (resin starved areas), although isolated pin holes are acceptable
- Surface scratches, abrasions, deep scratches, fractures, holes or punches

6.4.4 Class A parts (i.e., structural parts) shall be free of white or flushed areas caused by contamination of the resin or fabric, or too high a curing temperature.

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 Bombardier Toronto.

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:

- understand the difference between Class A and Class B parts
- have a good working knowledge of the procedure for and significance of receipt testing of polyester resin components
- know how to prepare resin, moulds and glass fabric
- be familiar with the required lay-up area conditions
- understand the need for process qualification testing
- know how to lay-up and cure parts
- have a good working knowledge of the finishing procedure, including hardness testing, repair limitations and filling requirements
- know and understand the final part requirements
- know how to store unused resin components
- know how to maintain tools, including solvent cleaning procedure

9 STORAGE OF RESIN COMPONENTS

9.1 Keep unused resin components tightly sealed in their original containers and store in a cool, dry location. Do not return unused catalyst to its original container; store unused catalyst in a suitable clean, sealed container.

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

9.3 The storage life of resin components shall be as specified in PPS 13.28.

10 MAINTENANCE OF EQUIPMENT

10.1 Keep tools clean and free from oil, moisture, dirt or other foreign matter.

10.2 Remove hardened resin on tools manually using a plastic scraper (avoid scratching tool surface) followed by solvent cleaning according to PPS 31.17 to remove the residual resin.