BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 10.39

PRODUCTION PROCESS STANDARD

MACHINING OF FIBRE REINFORCED COMPOSITE PARTS

Issue 12
- This standard supersedes PPS 10.39, Issue 11.
- Vertical lines in the left hand margin indicate 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.

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

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1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for machining of fibre reinforced composite parts manufactured according to PPS 10.04, PPS 10.15, PPS 10.35, PPS 10.43, or PPS 10.48.

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 BAERD GEN-023 - Contamination Control for Compressed Air.

3.2 PPS 10.04 - Wet Lay-Up of Glass Fabric/Polyester Resin Laminates.

3.3 PPS 10.06 - Repairs to Wet Lay-Up Glass Fabric/Polyester and Epoxy Resin Laminates.

3.4 PPS 10.15 - Wet Lay-Up Fabrication of Epoxy Resin/Glass Fabric Reinforced Laminates.

3.5 PPS 10.20 - Set-Up and Operation of the Waterjet.

3.6 PPS 10.35 - Fabrication of 250°F Cure, Epoxy Resin Pre-Impregnated, Fibre Reinforced Composite Parts.

3.7 PPS 10.40 - Repairs to Laminates & Sandwich Panels.

3.8 PPS 10.43 - Fabrication of 350°F Cure, Epoxy Resin Pre-Impregnated, Fibre Reinforced Composite Parts.

3.9 PPS 10.48 - Fabrication of 280°F Cure, Phenolic Resin Pre-Impregnated, Fibre Reinforced Composite Parts.

3.10 PPS 13.13 - Personal Protective Respiratory Equipment.

3.11 PPS 13.26 - General Subcontractor Provisions.

3.12 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.13 PPS 31.17 - Solvent Usage.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

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

4.1.2 Sanding discs, 100 - 180 grit size.

4.2 Equipment

4.2.1 Compressed air shall meet the requirements of BAERD GEN-023.

4.2.2 Standard metal cutting machines and equipment, including drillmotors, drill presses, band saws, jig saws, table saws, routers, disc and oscillating sanders, as required.

4.2.3 TS.561.11.27 piloted No-Land drills, as listed in Table I.

4.2.4 TS.561.11.20 modified Brad type twist drills, as listed in Table II.

4.2.5 TS.561.11.43 carbide drills for graphite, as listed in Table III.

4.2.6 TS.561.31.13 micro-stop countersink cutters for Kevlar, as listed in Table V and TS.561.71.19 micro-stop countersink adaptor, as required.

4.2.7 TS.561.11.41 double margin drill for Kevlar, as listed in Table IV.

4.2.8 Router bits (e.g., TS.561.11.21 as listed in Table VI).

4.2.9 Disc sander (3" diameter maximum).

4.2.10 Drillmotor vacuum attachment, for drilling operations (e.g., Desoutter Dust Extractor Kit #51662 or ATI (Wesco) AT 2520 Micro-Vac).

4.3 Facilities

4.3.1 This PPS has been categorized as a Controlled Special Process according to PPS 13.39 and as such only facilities specifically approved according to PPS 13.39 are authorized to perform machining of fibre reinforced composite parts manufactured according to PPS 10.04, PPS 10.15, PPS 10.35, PPS 10.43, or PPS 10.48 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 Toronto Materials Technology.

4.3.3.1 For approval of subcontractor facilities to perform machining of fibre reinforced composite parts manufactured according to PPS 10.04, PPS 10.15, PPS 10.35, PPS 10.43, or PPS 10.48 according to this PPS, completion of a test program and submission of suitable test samples representative of production parts may be required. Test samples shall meet the requirements specified by Bombardier Toronto Materials Technology.

5 PROCEDURE

5.1 General

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

5.1.2 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.

5.1.3 Organic fibres of laminates and sandwich panels are extremely tough and pliable and will tend to fray when cut by an improper or damaged tool, causing excessive fuzzing of the cut edge. Therefore, only tools specified herein, in good operating condition, shall be employed for machining laminates and sandwich panels.

5.1.4 Use sufficient machining speed, according to Table I, Table II, Table III, Table IV, Table V, or Table VI, as applicable, and a minimum pressure exerted on the tool to limit the tendency of the epoxy resin to degrade.

5.1.5 Check all tools before use, to ensure that the cutting edges are sharp and free from nicks or burrs.

5.1.6 Use water or compressed air as a coolant, if necessary, to reduce heat build-up on the tools.

5.1.7 If possible, provide clamping pressure on the part to prevent slipping or chatter while machining.

5.1.8 Replace tools when their cutting edges become dull, in order to prevent fuzzing of cut edges.

5.1.9 Unless otherwise specified, the machining operations specified herein are equally applicable to laminates and sandwich panel assemblies.

5.1.10 The cutting efficiency of the cutting tool will decrease rapidly due to resin build-up on the cutting edges, therefore, clean tools frequently by solvent cleaning according to PPS 31.17.

5.1.11 Heavy build-up of resin and fibre particles may be removed with the assistance of a non-metallic, stiff bristled brush.

5.2 Drilling

5.2.1 Except as follows, drill holes in laminates and sandwich panels using drills selected from Table I or Table II, as applicable:

- If the required modified Brad Point type twist drill is not available, use standard HSS twist drills for holes up to 1/4" in diameter.
- Drill parts that are drilled in situ with a metal backing or facing using standard HSS twist drills.
- Drill composite parts containing DHMS P1.35 graphite with carbide drills (see Table III).

5.2.2 If using Table I drills, drill parts at 1000 or 1500 rpm. If using Table II drills, drill parts at 500 to 2000 rpm as applicable. If using Table III or Table IV drills, drill parts at 600 rpm.

5.2.3 If possible, back parts with wood when drilling. Take extreme care when drilling unsupported parts, as at the point of breakthrough unsheared fibres will cause the part to run up the drill. If drilling holes in unsupported parts, the amount of pressure exerted when drilling through shall be minimal to avoid delaminations.

5.2.4 If possible, use drillmotors equipped with a vacuum attachment (see paragraph 4.2.10).

TABLE I - PILOTED NO-LAND DRILLS

CUTTER DIAMETER	DRILL TS.561.11.27	PILOT DIAMETER	RECOMMENDED RPM
0.312"	MK 2	0.093"	1500
0.437"	MK 1	0.187"	1000
0.453"	MK 5	0.250"	
0.472"	MK 3	0.187"	
0.562"	MK 4	0.193"	
0.562"	MK 6	0.250"	
0.687"	MK 7	0.250"	

TABLE II - MODIFIED BRAD POINT TYPE TWIST DRILLS

CUTTER DIAMETER	DRILL TS.561.11.20	RECOMMENDED RPM
0.130"	MK 13	2000
0.161" (#20)	MK 14	
0.190"	MK 11	
0.191" (#11)	MK 20	
0.196" (#9)	MK 21	
0.201"	MK 16	
0.219" (7/32")	MK 22	
0.220"	MK 17	
0.250" (E or 1/4")	MK 23	1500
0.250" (E or 1/4")	MK 15	
0.257" (F)	MK 24	
0.312"	MK 12	
0.375" (3/8")	MK 25	1000
0.386" (W)	MK 26	
0.386" (W)	MK 28	
0.406"	MK 10	
0.453"	MK 1	
0.469" (15/32")	MK 19	
0.500" (1/2")	MK 2	
0.562"	MK 3	
0.562"	MK 29	
0.562"	MK 27	
0.562" (9/16")	MK 18	
0.625" (5/8")	MK 9	750
0.687"	MK 4	
0.687"	MK 30	
0.750" (3/4")	MK 5	
0.812"	MK 6	500
0.843"	MK 7	
0.875" (7/8")	MK 8	

TABLE III - CARBIDE DRILLS

CUTTER DIAMETER	DRILL TS.561.11.43	RECOMMENDED RPM
0.1562"	MK 1	600
0.1695"	MK 2	
0.1730"	MK 3	
0.1910"	MK 4	
0.3110"	MK 5	

TABLE IV - DOUBLE MARGIN DRILL FOR KEVLAR

CUTTER DIAMETER	DRILL TS.561.11.41	RECOMMENDED RPM
0.1440"	MK 1	600

5.3 Countersinking

5.3.1 Accomplish countersinking of fastener holes using the micro-stop countersink cutters, as listed in Table V. If necessary, use countersink cutter extensions according to TS.561.71.19.

5.3.2 Drill fastener holes according to section 5.2 to the final size, according to the fastener PPS, before countersinking.

5.3.3 Accomplish countersinking at the speed indicated in Table V.

5.3.4 Remove all frayed fibres or fuzzing at the countersink and exit hole by sanding according to section 5.7.

5.3.5 If possible, use drillmotors equipped with a vacuum attachment (see paragraph 4.2.10).

TABLE V - MICRO-STOP COUNTERSINK CUTTERS

MICRO-STOP COUNTERSINK CUTTER TS.561.31.13	MAXIMUM COUNTERSINK DIAMETER	PILOT DIAMETER	RECOMMENDED RPM
MK 8	0.31"	0.098"	150 - 250
MK 1	0.31"	0.125"	
MK 10	0.37"	0.144"	
MK 2	0.37"	0.156"	
MK 6	0.50"	0.172"	
MK 11	0.50"	0.177"	
MK 3	0.50"	0.187"	
MK 9	0.50"	0.191"	
MK 7	0.50"	0.195"	
MK 4	0.50"	0.250"	
MK 5	0.50"	0.250"	

5.4 Blanking & Piercing

5.4.1 Unless otherwise specified by the engineering drawing, blanking and piercing of fibre reinforced composites is not permitted.

5.5 Sawing

5.5.1 General

5.5.1.1 Complete sawing using either a band saw, jig saw or table saw as follows.

5.5.2 Band Saw

5.5.2.1 Cut laminates and sandwich panels on a band saw using a fine tooth blade (14 to 22 teeth per inch).

5.5.2.2 If possible, provide a coolant spray of water to reduce blade wear and to prevent the melting of the epoxy resin.

5.5.2.3 The band saw cutting speed shall be 4500 to 6500 feet per minute (fpm).

5.5.2.4 Remove fuzzing of the back side of the part by sanding according to section 5.7.

5.5.3 Jig Saw

5.5.3.1 Operate jig saws at approximately 2500 strokes per minute, with a minimum stroke of 0.75" and a feed rate of 3 fpm.

5.5.3.2 If fuzz appears at the saw cut, remove the fuzz by sanding according to section 5.7 and repair or replace the worn blade.

5.5.4 Table Saw

5.5.4.1 If cutting laminates or sandwich panels using a table saw, use a 2.5 teeth per inch saw blade with carbide edged teeth.

5.5.4.2 The table saw cutting speed shall be approximately 900 fpm.

5.5.4.3 Remove fuzzing of the back side of the part by sanding, according to section 5.7.

5.6 Routing

5.6.1 Accomplish routing of laminates and sandwich panels using either a router bit selected from Table VI or a waterjet cutter. Refer to PPS 10.20 for the procedure and requirements of trimming using the waterjet.

TABLE VI - ROUTERS BITS (SEE FIGURE 1)

ROUTER BITS TS.561.11.21	EFFECTIVE CUTTING LENGTH	CUTTER SPEED
MK 3	0.75"	20000 - 35000 RPM
MK 4	1.25"	
MK 5	1.50"	

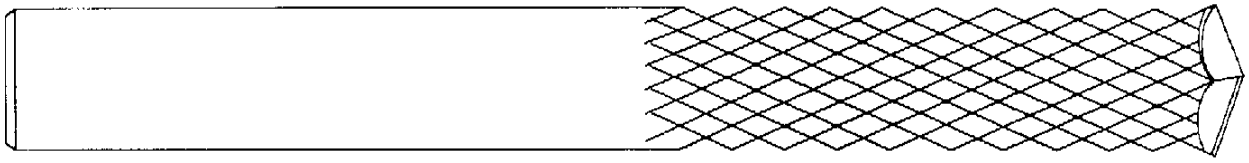

FIGURE 1 - DIAMOND CUT ROUTER BIT

5.7 Sanding

5.7.1 Carry out sanding either by hand, disc or oscillating type sanders, as specified in Table VII.

5.7.2 Take care at all times during sanding to ensure that the fibres of the cloth laminate are not exposed or damaged.

5.7.3 If possible, use a light water mist on the grit paper to prevent build-up of resin between the grit particles, and to act as a coolant.

5.7.4 Use short quick strokes and moderate the pressure when wet sanding by hand.

5.7.5 Initiate sanding from the edges of the part, working towards the centre.

5.7.6 Take care at all times during sanding to avoid the introduction of sanding residue into insert holes.

TABLE VII - SANDING PROCEDURES

SANDING OPERATION	PROCEDURE
Removal of edge burrs, fuzzing and loose strands	Disc or oscillating sander and 180 grit aluminum oxide abrasive.
Edge sanding to size or profile	Disc sander, 100 grit aluminum oxide abrasive and water coolant.
Removal of resin ridges on part surfaces	Oscillating sander and 180 grit aluminum oxide abrasive paper or hand sanding using 240 grit aluminum oxide abrasive.
Edge chamfering	Disc sander and 180 grit aluminum oxide abrasive.
Edge finishing	Wet sand by hand using 180 - 240 grit aluminum oxide abrasive (sand longitudinally along the edge).
Deburring countersinks	Disc sander, small rubber backed disc, 180 - 240 grit aluminum oxide abrasive - inert rivet into prepared countersink and lightly sand off loose fibres.
Note 1. Take care to avoid sanding through the surface resin layer, exposing fabric strands. Note 2. Use water coolant if practical. Note 3. Take care at all times during sanding to avoid the introduction of sanding residue into insert holes.	

5.8 Repair

5.8.1 In case of damage, repair the laminates or sandwich panels according to PPS 10.06 or PPS 10.40, as applicable.

6 REQUIREMENTS

6.1 Machined parts shall meet the dimensional requirements of the engineering drawing.

6.2 Fastener hole sizes and, if applicable, countersink diameters shall be as specified in the fastener PPS.

6.3 Machined edges shall be free from burrs, fuzzing, loose fibre strands and tool chatter marks.

6.4 There shall be no evidence of delamination of assemblies nor separation of the laminate from the core material on sandwich panel assemblies.

7 SAFETY PRECAUTIONS

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

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

7.3 Ensure adequate ventilation at all times where machining of organic materials is being carried out.

7.4 Due to the fibrous nature of the resultant machining dust, wear protective respiratory equipment according to PPS 13.13 when performing machining operations on organic fabric parts.

7.5 Remove dust particles from machining and sanding by vacuum cleaning. Under no circumstances are parts, tools, equipment or work area to be cleaned by blowing off the particles with compressed air.

8 If possible, equip drillmotors with the appropriate vacuum attachment (see paragraph 4.2.10) in order to control the dispersion of drilling chips and dust.

9 PERSONNEL REQUIREMENTS

9.1 This PPS has been categorized as a Controlled Special Process according to PPS 13.39. Refer to PPS 13.39 for personnel requirements.