BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 10.17

PRODUCTION PROCESS STANDARD

MACHINING OF PLASTICS

Issue 11
- This standard supersedes PPS 10.17, Issue 10.
- 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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Signed original on file. Validation of paper prints is the responsibility of the user.

TABLE OF CONTENTS

Sections **Page**

Tables

Figures

1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for the machining of plastics.

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.

1.2 For machining of laminates and sandwich panels, refer to PPS 10.39.

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 10.01 - Handling, Care and Finishing of Transparent Parts.

3.3 PPS 10.39 - Machining of Fibre Reinforced Composite Parts.

3.4 PPS 13.13 - Personal Protective Respiratory Equipment.

3.5 PPS 13.26 - General Subcontractor Provisions.

3.6 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.7 PPS 27.07 - Vibratory Tumble Deburring.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Abrasive sanding discs, aluminum oxide, 80 to 120 grit.

4.1.2 Abrasive paper, aluminum oxide (waterproof), 180 to 220 grit.

4.2 Equipment

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

4.2.2 Conventional metal and wood working equipment and high speed tool steel (HSS) accessories.

4.2.3 Recirculating air type electric oven, capable of maintaining an operating temperature of 225°F ± 25°F.

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

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 plastics 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 machining of plastics 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 Use of the high speed, slow feed techniques similar to those used for machining brass or aluminum will normally produce the best results when machining plastic materials.

5.1.2 Fabricate cutting tools used to machine plastic from high speed tool steel, freshly ground to a keen edge.

5.1.2.1 Clearance on cutting tools shall be adequate to prevent overheating of the plastic material.

5.1.3 It is necessary to prevent overheating of the plastic material during machining due to the relatively low melting point of plastic. Excessive heat may cause the plastic to turn gummy thereby clogging and binding the cutting tool.

5.1.3.1 If possible, use coolant during machining of plastics. Coolants shall be of the water soluble type (e.g., water-soap solution or a compressed air jet).

5.1.4 Machine set-up and support of the plastic during machining shall be adequate to prevent chatter marks, chipping and cracking of the plastic.

5.1.5 Make frequent checks of the machining process to ensure that the working surface of the tool is free from chips and is not binding.

5.1.6 Handling and care of transparent plastic sheet shall be according to PPS 10.01.

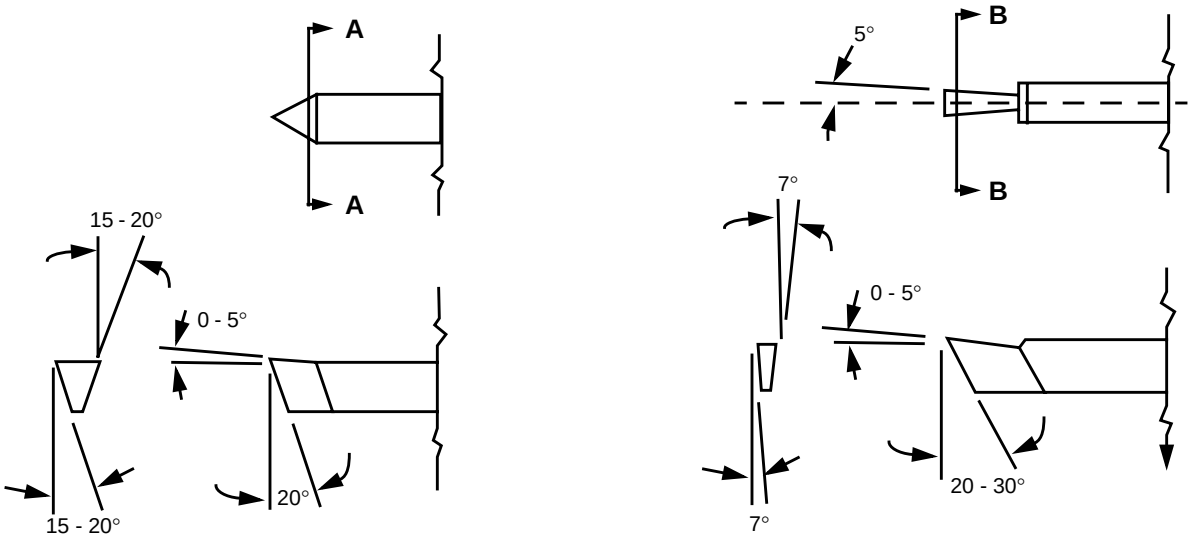
5.1.6.1 Do not remove the protective paper backing on transparent plastic sheet for any machining operation.

5.2 Turning

5.2.1 Turning may be accomplished with conventional metal working lathes on which the plastic material shall be tightly clamped.

5.2.2 Turning tool bits shall have back rake and a large clearance to effect removal of the continuous chip. Recommended tool bit shapes are as shown in Figure 1.

5.2.3 Avoid the use of sharply pointed tools. The tool point shall be ground to a slight radius to avoid scarring the finished surface and to provide longer tool life.



Section AA **Section BB**

FIGURE 1 - LATHE TOOLS

5.3 Milling

5.3.1 Conventional milling cutters, with keenly honed edges, may be used to mill plastics.

5.3.2 Climb milling shall be the preferred method, a minimum burr is produced with this method.

5.3.3 Tightly clamp material to be milled.

5.4 Sawing

5.4.1 Circular saws, metal cutting band saws and veneer saws running at their normal speeds as well as hacksaws, may be used for cutting plastics.

5.4.2 To prevent chipping and overheating it is essential that the saws run true and that the teeth are sharp and have sufficient set to provide adequate clearance.

5.4.3 Hollow ground circular saws are the most suitable for cutting sheet up to 0.015” thick, for thicker sections use blades with spring set or swaged teeth.

5.4.4 For thin stock, use blades with 12 - 14 TPI (teeth per inch). Saw thicker stock using blades with fewer TPI.

5.4.5 Leave the masking paper on the transparent plastic sheet when sawing. Gumming of the blade by the plastic material can be kept to a minimum by applying a small amount of oil or grease to the blade. If a deposit starts to collect on the saw it shall be cleaned off.

5.4.6 Hold sheet firmly to the table and maintain an even feed. Reduce the feed as the blade is leaving the cut to avoid chipping the corners.

5.4.6.1 Too fast a feed may cause chipping and to slow a feed or idling in the cut will cause overheating and gumming of parts and tools.

5.4.6.2 When considered necessary, water may be used as a coolant.

5.5 Drilling

5.5.1 For safety and accuracy, clamp and hold parts rigidly during drilling and back the area around the hole with wood.

5.5.2 Modified standard twist drills, free of burrs or scores, may be used for drilling plastic.

5.5.2.1 The included angle of the drill shall be ground to approximately 60° for shallow small holes and should be increased up to 140° for large deep holes.

5.5.2.2 The lip clearance angle should be approximately 15° and the cutting edge dubbed-off to zero rake angle so that the drill scrapes rather than cuts the material.

5.5.3 Control the feed of the drill so that a continuous flow of chips is removed without overheating the plastic at the tip of the drill. Reduce the pressure just before break-through.

5.5.3.1 A coolant such as compressed air or water is necessary when drilling deep holes to avoid scoring or burning the surface of the hole.

5.5.3.2 Frequent raising and lowering of the drill will aid in effecting both cooling and chip removal.

5.5.3.3 A suitable wax plugged into a pilot hole (about the size of the finished hole) may be used to lubricate the drill and clear the chips. This results in a cleaner, smoother hole than is otherwise obtainable.

5.5.4 Fly cutters or trepanning tools may be used for cutting large holes.

5.5.5 Refer to Table I for the recommended drill speeds. Use slower speeds if there is evidence of overheating or chatter.

TABLE I - RECOMMENDED DRILL SPEEDS

DRILL SIZE	R.P.M.
No. 1 to No. 16	2500
No. 17 to No. 32	3300
No. 33 and up	5000
1/16"	5000
1/8"	3000
3/16"	2500
1/4"	1700

DRILL SIZE	R.P.M.
5/16"	1700
3/8"	1300
7/16"	1000
1/2"	1000
A to D	2500
E to M	1700
N to Z	1300

5.6 Routing

5.6.1 Plastics may be routed on standard metal and wood cutting machines.

5.6.2 To prevent chipping and heavy router marks, rout plastic parts as follows:

Step 1. Use a roughing cut of approximately 0.030" oversize, utilizing a bushing on the pin rout follower.

Step 2. Follow the roughing cut with a finishing cut to obtain the required final dimensions.

5.6.3 Use appropriate supports and clamps to prevent part slippage.

5.6.4 The cutters shall be kept sharp and shall be ground with a back clearance angle of about 10° and no rake.

5.6.5 For stepped or rabbet routing, back the cutting edges on the underside to prevent drag and grind the corners to give a minimum fillet of 1/16” radius in the shoulder of the rout.

5.6.6 If a rotating collar used as a guide bears on the plastic, well grease the collar or plastic to prevent overheating the part.

5.6.7 An air blast may be used to cool the cutter and simultaneously remove chips.

5.6.8 Portable routers may be used if the part is too awkward to bring to the machine.

5.7 Tapping

5.7.1 Accomplish tapping using conventional metal-working taps.

5.7.2 Normally there is no need to use a starting tap and in small diameter holes the finishing tap only is required.

5.7.3 In resilient plastic material, use a tap 0.005" oversize unless a self-locking thread is desired.

5.7.4 A wax stick inserted into the drilled hole ahead of the tap will provide lubrication and serve to expel chips.

5.8 Filing and Grinding

5.8.1 Use mill files with deep, single cut, coarse, curved teeth to remove excess material by hand.

5.8.2 High speed power driven rotary steel files and abrasive discs may be used with a coolant for longer production runs.

5.9 Reaming

5.9.1 Accomplish reaming using conventional metal working reamers.

5.10 Blanking and Piercing

5.10.1 Except as noted in paragraph 5.10.2 and paragraph 5.10.3, plastic materials can be blanked and pierced cold, utilizing a steel rule or plate die type tool.

5.10.2 Do not blank or pierce acrylic plastic.

5.10.3 Blank and pierce phenolic laminate sheet as follows:

Step 1. Heat the part in an oven for 30 minutes at a temperature of approximately 225°F. Do not stack parts in the oven. Rack sheets so as to allow air to circulate freely.

Step 2. Immediately blank or pierce hot phenolic sheet after withdrawal from the oven.

5.10.3.1 Wear leather faced gloves when handling hot phenolic sheet.

5.10.3.2 Cracking during blanking or piercing indicates that the sheet temperature has dropped below the requirement of Step 1. If the sheet starts to crack during blanking or piercing, re-heat the sheet to the required temperature as specified in Step 1 and complete the operation. The final part shall not be cracked.

5.10.4 Maximum thickness of plastic sheet for blanking or piercing shall be 0.125". Machine or drill thicker sheet as required.

5.10.5 Do not stack thin sheets for multiple blanking or piercing.

5.10.6 Reject all cracked parts.

5.11 Shearing

5.11.1 Ordinary sheet metal cutting guillotines and hand or power operated shears may be used for shearing plastic sheet (except acrylic) up to a thickness of 0.060".

5.11.1.1 Saw plastic sheet of gauges thicker than 0.060" to size according to section 5.4.

5.11.2 Do not stack thin plastic sheets for multiple shearing.

5.12 Finishing

5.12.1 Carefully blend edges from which tooling lugs have been removed into the shape of the part.

5.12.2 When blending tooling lugs, avoid excessive removal of material.

5.12.2.1 Lugs on Kydex, PVC and thin polycarbonate parts (up to 0.060") may be removed by shearing only.

5.12.2.2 On polycarbonate and phenolic laminate parts thicker than 0.060" and on all acrylic parts, remove tooling lugs as follows:

Step 1. Use a band saw to remove the lug, but leave approximately 1/16" of excess material.

Step 2. File off the excess material according to section 5.8.

Step 3. Final finish with abrasive paper.

5.12.3 For complete instructions on edge finishing of transparent plastic parts, refer to PPS 10.01.

5.12.4 Except as noted in paragraph 5.12.4.1, plastic parts made from nylon, polyethylene or Teflon may be vibratory tumbled deburred according to PPS 27.07.

5.12.4.1 If the shape, size or function of the part will not allow vibratory tumble deburring, edge finish the part by light sanding with abrasive paper.

5.13 Annealing Acrylic

5.13.1 Anneal acrylic plastic (Plexiglas) according to PPS 10.01 after machining.

5.14 Annealing Nylon

5.14.1 Perform annealing of nylon machined parts if specified on the engineering drawing, shop order or process sheet.

5.14.2 Accomplish annealing by the immersion of the parts in boiling water for 15 minutes per 1/8" of thickness.

5.14.2.1 If annealing at 300°F is specified on the engineering drawing, shop order or process sheet, immerse the parts in a suitable oil or wax bath at 300°F for 15 minutes per 1/8" thickness.

5.14.3 Upon removal from the annealing bath, place the parts in a clean cardboard box and cover the parts with clean cloths. Placing the parts in a cardboard box and covering them with cloths prevents rapid cooling of the part surfaces, thus preventing stresses from being set-up during the cooling period.

5.14.4 Parts shall remain covered in the cardboard box until the parts have reached room temperature.

6 REQUIREMENTS

6.1 All machined plastic parts shall conform to the dimensional limits shown on the engineering drawings.

6.2 Finished parts shall be free of chips and burrs.

6.3 Reject damaged or cracked parts.

6.4 Machined transparent plastic parts shall also meet the requirements of PPS 10.01.

7 SAFETY PRECAUTIONS

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

7.2 Wear Bombardier approved safety glasses at all times when machining and sanding plastic parts with power equipment.

7.3 Wear protective respiratory equipment according to PPS 13.13 when machining plastics as specified herein.

7.4 Wear leather faced gloves when handling hot phenolic sheets.

8 PERSONNEL REQUIREMENTS

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