BOMBARDIER

Toronto Site

PROPRIETARY INFORMATION

PPS 10.08

PRODUCTION PROCESS STANDARD

FORMING THERMOPLASTIC SHEET

Issue 16
- This standard supersedes PPS 10.08, Issue 15.
- 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.

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TABLE OF CONTENTS

Sections **Page**

Tables

Figures

1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for vacuum forming, hand drape forming and cold forming of thermoplastic sheet material.

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 PPS 10.01 - Handling, Care and Finishing of Transparent Plastic.

3.2 PPS 10.17 - Machining of Plastics.

3.3 PPS 13.26 - General Subcontractor Provisions.

3.4 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Thermoplastic sheet material as listed in Table II.

4.1.2 Silicone-free grease, N-release type.

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

4.1.4 Polyfoam, polyethylene foam sheet.

4.1.5 Tack cloth (e.g., DSC 375-1).

4.1.6 Cotton wipers (e.g., DSC 378).

4.2 Equipment

4.2.1 Vacuum forming machine (e.g., Brown M1800 Automatic Former).

4.2.2 Forming moulds according to TS.292.11.00.

4.2.3 Drying oven, electric, re-circulating air type, capable of maintaining a temperature of 400°F ± 25°F. The rack and support structure shall be such that moisture dissipation in the forming area is assured.

4.2.4 Gloves, leather (e.g., DSC 422-3).

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 vacuum forming, hand drape forming and cold forming of thermoplastic sheet material 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 vacuum forming, hand drape forming and cold forming of thermoplastic sheet material according to this PPS, completion of a test program and submission of suitable test samples representative of production parts is required. Test samples shall meet the requirements specified in section 6.

5 PROCEDURE

5.1 General

5.1.1 Vacuum forming of thermoplastic sheet material is basically a two step process of heating a thermoplastic material to the required forming temperature and immediately forming the material into the desired shape by vacuum forming against a suitable mould.

5.1.2 Hand drape forming consists of placing a pre-heated thermoplastic sheet over a mould and allowing the sheet to drape form to the shape of the mould. This process is used only for forming simple curved or shallow dished parts too large to fit into the vacuum forming machine.

5.1.3 Cold forming consists of bending or brake forming a straight line flange or angle at room temperature.

5.1.4 Do not hand drape form or cold form DHMS P1.46 Aerform LHR.

5.2 Handling of Plastic Sheet

5.2.1 Protect and handle transparent plastic sheet according to PPS 10.01.

5.2.2 Thoroughly clean and remove any burrs or embedded material on the working surface of benches or machines on which plastic sheet is placed.

5.2.3 Suitably cover rough surfaces such as wooden benches.

5.2.4 Avoid sliding unprotected plastic sheet across any surface, no matter how smooth.

5.3 Forming Tools

5.3.1 Thermoplastic sheet forming moulds may be made of wood, plastic, metal, plaster, masonite or similar material suitable for the work to be done.

5.3.2 Use only moulds specified in TS.292.11.00. If practical, use internally heated aluminum moulds (tool type -256).

5.3.3 Forming moulds, for use with Ultem (polyetherimide) material, shall withstand temperatures of 550°F. Bonding or finishing materials, used on forming moulds, shall withstand temperatures up to 400°F.

5.3.4 Ensure that the working surface of the forming tools have a fine smooth finish free of any ripples or other defects that may cause mark-off or will adversely affect the appearance of the finished part. Hand sand vacuum forming moulds used for Lexan with 180 - 220 grit abrasive paper to provide minute air channels for air evacuation.

5.3.5 Wipe all moulds before use with a tack cloth to remove dust or other particles.

5.3.6 To facilitate separation of the formed part from the mould, apply a thin film of silicone-free grease to the mould before forming.

5.4 Tool Proving Vacuum Forming Moulds

5.4.1 Before production use, tool prove each new mould.

5.4.2 Prepare a set-up data card for each part during tool proving of the mould. Ensure set-up data cards show all details of machine settings required to produce acceptable parts. Retain set-up data cards on file for use by the machine operator and other authorized personnel at all times. Refer to Table II for a listing of specific types of thermoplastic sheet and the forming temperatures.

5.5 Preparation of Material for Forming

5.5.1 Prepare thermoplastic sheet for forming as follows:

Step 1. Remove all protective paper or covering from the plastic sheet material.

Step 2. Remove any residual adhesive remaining on the surface of the sheet by dabbing with a piece of the adhesive paper or masking tape.

Step 3. Rack the sheets in the drying oven so that a minimum 1" separation between sheets is maintained.

Step 4. Oven dry the thermoplastic sheet according to Table I.

Step 5. Immediately before forming, wipe the thermoplastic sheet with a clean damp cotton wiper to remove dust from the surface.

TABLE I - DRYING SCHEDULES

SHEET MATERIAL (NOTE 1)	SHEET THICKNESS	DRYING TIME	OVEN SETTING
Lexan (DHMS P1.01)	0.041" - 0.060"	4 - 5 hours	225°F
	0.061" - 0.080"	5 - 6 hours	
	0.081" - 0.100"	6 - 7 hours	
	0.101" - 0.125"	8 - 9 hours	
	0.126" - 0.187"	24 - 25 hours	
	0.188" - 0.250"	72 - 73 hours	
Aerform LHR (DHMS P1.46)	0.045" - 0.085"	16 - 24 hours	160°F ± 5°F
	0.105" - 0.125"		170°F ± 5°F
Ultem (DHMS P1.47)	0.000" - 0.040"	4 - 5 hours	325°F
	0.041" - 0.060"	5 - 6 hours	
	0.061" - 0.080"	8 - 9 hours	
	0.081" - 0.100"	10 - 11 hours	
	0.101" - 0.125"	12 - 13 hours	
Declar (BMS 8-319)	0.061" - 0.080"	13 - 14 hours	260°F

Note 1. Lexan and Ultem sheets which have not been formed within 4 hours of drying shall be re-dried. Declar sheets which have not been formed within 1 hour of drying shall be re-dried.

5.6 Vacuum Forming Thermoplastic Sheet

5.6.1 Vacuum form thermoplastic sheet as follows:

Step 1. Turn on the air pressure, vacuum and electric supply to the forming machine.

Step 2. Ensure that the mould surfaces are free of contamination and dust.

Step 3. Position and clamp the mould and preforming box or plug onto the designated platen as noted on the set-up card. Except where the clamping frame is an integral part of the mould or forming box, ensure that the working face of the mould base plate extends at least 3/4" beyond the gripping faces of the clamping frame when the platen is in the extended position (see Figure 1 and Figure 2). A ring or grid assist may be provided to improve definition of the parts on multiple drape moulds (see Figure 3).

Step 4. When using an internally heated aluminum mould (tool type -256), pre-heat the mould to the temperature specified in Table II.

Step 5. Seal the underside of the mould box, mounting board or bolster with a gasket of soft rubber or plastic material.

Step 6. Place the thermoplastic sheet on mould.

Step 7. Adjust the machine controls according to the set-up data card and form.

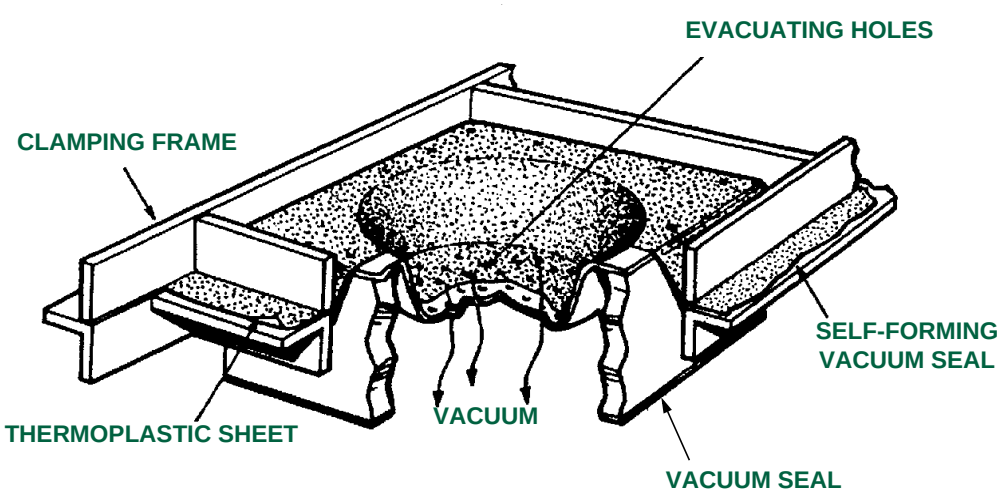

FIGURE 1 - VACUUM FORMING MOULD - CAVITY TYPE

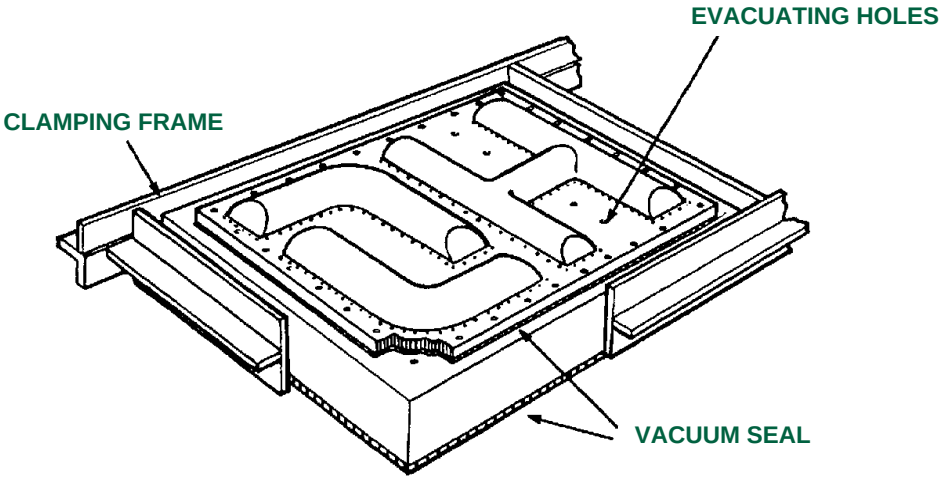

FIGURE 2 - VACUUM FORMING MOULD - DRAPE TYPE

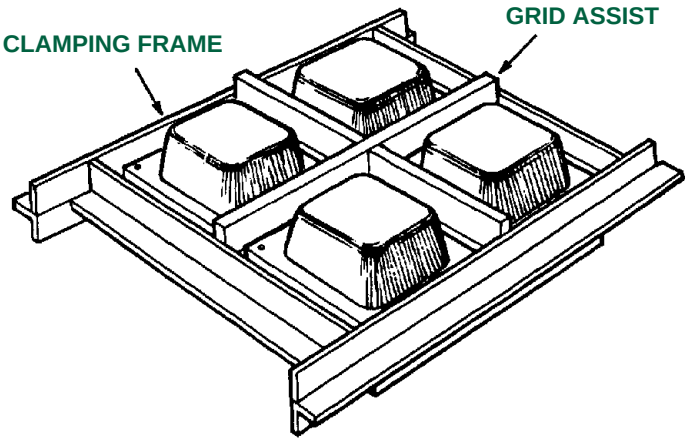

FIGURE 3 - MULTIPLE PART DRAPE FORM MOULD

TABLE II - THERMOPLASTIC SHEET FORMING TEMPERATURES

SHEET MATERIAL	MINIMUM TOOL TEMPERATURE (NOTE 1)	FORMING TEMPERATURE
Plexiglas (Acrylic plastic) to MIL-P-5425 or MIL-P-25690	N/A	320°F
Kydex (Acrylic polyvinyl chloride) to DHMS P1.09	N/A	375°F
Lexan (Polycarbonate) to DHMS P1.01	270°F	375°F
Aerform LHR to DHMS P1.46	140°F ± 10°F	300°F - 350°F (Note 2)
Ultem (Polyetherimide) to DHMS P1.47	315°F	500°F
Declar (Polyetherketoneketone) to BMS 8-319	270°F	360°F

Note 1. The minimum tool temperature applies only when using internally heated aluminum moulds (tool type-256).

Note 2. The heating (dwell) times vary depending on the heat source. For sheet 0.045" to 0.085" thick, the dwell time is 30 to 90 seconds and for sheet 0.105" to 0.125" thick, the dwell time is 60 to 120 seconds. If the part looks shiny, the surface may have been overheated and, therefore, the dwell time should be increased and the percentage of heat applied to the decorative side should be reduced. If blisters occur, the cycle time should be extended and temperatures adjusted accordingly, and/or additional drying may be required.

5.7 Hand Drape Forming

5.7.1 Hand drape form as follows:

Step 1. Heat the thermoplastic sheet in an oven at the temperature specified in Table II. Support the sheet during heating to prevent warpage or distortion. Do not heat Plexiglas sheet longer than 1 hour.

Step 2. When forming transparent plastic sheet (Plexiglas or Lexan), cover the surface of the forming tool with a soft covering such as billiard cloth or rubber sheeting to help minimize internal stresses which could cause warpage of the finished part. The protective cover also helps prevent “mark-off” resulting from dirt, dust particles, or surface irregularities on the surface of the form tool.

Step 3. Since the temperature of the sheet will fall rapidly, set-up the forming mould and equipment as near to the oven as possible.

Step 4. If forming Declar, Lexan or Ultem sheet material, pre-heat the mould to the temperature specified in Table III.

Step 5. When the sheet has been completely heated to the forming temperature, remove the sheet from the oven and immediately place it onto the drape form mould.

Step 6. Drape plastic film over the thermoplastic sheet on the forming tool to prevent fingerprint marking and dust settling onto the hot plastic sheet.

TABLE III - NOMINAL HAND DRAPE FORMING TOOL TEMPERATURES

SHEET MATERIAL	TOOL TEMPERATURE
Lexan (Polycarbonate) to DHMS P1.01	270°F
Ultem (Polyetherimide) to DHMS P1.47	315°F
Declar (Polyetherketoneketone) to BMS 8-319	270°F

5.8 Cold Forming

5.8.1 Thermoplastic materials, except Plexiglas (acrylic plastic), may be bent to form flanges or angles at room temperature using standard forming brakes or presses.

5.8.2 When brake forming thermoplastic material, allowances for springback shall be made by over-forming the parts on the brake press by approximately 30°.

5.8.3 Refer to Table IV for the recommended punch and die radii for cold forming thermoplastic sheet.

TABLE IV - RECOMMENDED COLD FORMING TOOL RADI

MATERIAL THICKNESS	PUNCH RADIUS	DIE RADIUS
0.000" - 0.040"	0.020"	0.060"
0.041" - 0.060"	0.020"	0.080"
0.061" - 0.080"	0.040"	0.100"
0.081" - 0.100"	0.060"	0.120"

5.9 Protective Wrapping and Storage of Formed Parts

5.9.1 Protective wrap transparent plastic parts according to PPS 10.01. Protect non-transparent parts from damage by wrapping or inter-leafing with clean Kraft paper or polyfoam.

5.9.2 Store formed parts to avoid warpage or sagging.

6 REQUIREMENTS

6.1 Reject formed parts showing signs of cracks, punctures, voids, or crazing.

6.2 Surface scratches or blisters are cause for rejection.

6.3 Unless otherwise specified on the engineering drawing, formed parts need not be checked for minimum material thickness.

6.4 Formed parts shall be free of folds, ridges or wrinkles, but a moderate amount of mark-off, drag or chill lines is not cause for rejection.

6.5 Ensure edges on formed parts are clean with no evidence of shattering or splitting.

6.6 Examine Plexiglas panels intended for use in optically critical areas according to the Acceptance Test Procedure.

6.7 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.

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 personnel requirements.

9 MAINTENANCE OF EQUIPMENT

9.1 Store thermoplastic sheet forming moulds in a clean, dry area where they will be protected from damage such as nicks, dents or scratches.

10 STORAGE OF THERMOPLASTIC SHEET MATERIALS

10.1 Store thermoplastic sheets in cool, dry areas. Ideal conditions are 70°F and a maximum of 30% relative humidity. Exposure to high humidity can cause blistering during forming.