BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 1.13

PRODUCTION PROCESS STANDARD

Laser Cutting

Issue 14
- This standard supersedes PPS 1.13, Issue 13.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS related questions to PPS.Group@aero.bombardier.com or (416) 375-4365.
- 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 thermal cutting aluminum, nickel, stainless steel and titanium alloy sheet and tubing material to the finished part profile using laser beam cutting machine.

1.1.1 This PPS complements the engineering drawings that specify its use as an authorized instruction and the procedure specified must 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.

2 Hazardous Materials

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

3 References

3.1 ASTM E466 - Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials

3.2 PPS 1.09 - Drilling and Reaming.

3.3 PPS 13.26 - General Subcontractor Provisions.

3.4 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.5 PPS 27.02 - Edge Finishing Aluminum Alloy Parts.

3.6 PPS 27.04 - Edge Finishing Titanium Alloy Parts.

3.7 PPS 27.10 - Edge Finishing Steel, Nickel and Copper Alloy Parts.

3.8 PPS 31.17 - Solvent Usage.

3.9 LAB-042-B - Sheet Fatigue Test Specimen, Modified (Krouse).

4 Materials, Equipment and Facilities

4.1 Materials

4.1.1 Anti-spatter compound, (e.g., Cantesco Tip Dip).

4.1.2 Argon gas, 99.9% pure minimum (e.g., MIL-A-18455).

4.1.3 Nitrogen gas, 99.9% pure minimum.

4.2 Equipment

4.2.1 Cotton gloves (e.g., DSC 422-1).

4.2.2 CNC controlled laser cutting machine, CO_2 type laser, pulse mode. All laser beam cutting shall be accomplished using a computer controlled laser beam machine. Computer programs for laser cutting titanium parts shall be designed to minimize the heat affected zone generated by the laser beam.

4.2.3 Tatnall-Krouse Model CSS-40, constant speed, fixed deflection, sheet fatigue testing machine.

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 thermal cutting using a laser beam cutting machine according to this PPS.

4.3.2 Bombardier subcontractors must direct requests for approval to Bombardier Aerospace Supplier Quality Management. Bombardier Aerospace facilities must 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 must 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 must be detailed in the facility report. Based upon the facility report, Bombardier Toronto (de Havilland) Materials Technology may identify additional qualification and/or process control test requirements. During the facility survey, the facility requesting qualification must 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 Unless otherwise specified by Bombardier Aerospace Supplier Quality Management, for approval of subcontractor facilities to perform thermal cutting using a laser beam cutting machine according to this PPS completion of a test program and submission of suitable test samples representative of production parts is required. Test samples must meet the requirements specified in section 6.

4.3.3.2 Before producing production titanium alloy parts, subcontract facilities must also prepare test specimens for fatigue testing as follows:

Step 1. Prepare 5 fatigue test specimens conforming to LAB-042-B according to section 5. Cut the test specimens from a single sheet of 0.050" thick titanium alloy to MIL-T-9046 Type I Composition B (i.e., MIL-T-9046 CP-1 or CP-B), with the grain flow in a longitudinal direction.

Step 2. Using a Tatnall-Krouse Model CSS-40 fatigue test machine at an alternating stress of 35 ksi, test each of the titanium test specimens to failure or to a minimum of 5×10^6 cycles. Acceptable laser cutting capability will be demonstrated if all of the fatigue test specimens each reach a minimum of 5×10^6 cycles.

5 Procedure

5.1 General

5.1.1 Laser cutting as specified herein consists of profiling the parts to the finish part contour (net size) and piercing of fastener and tooling holes by thermal means using a CNC laser beam machine.

5.1.2 A process control document must be prepared and maintained for each material thickness, alloy, type and composition combination to be laser cut in production using each particular laser cutting machine. Process control documents must be qualified according to section 6.2. Process control documents must contain at least the following information:

- Material alloy and type
- Sheet thickness
- Machine description (including serial number)
- All machine settings (including feed rate, nozzle to part distance, pulse rate, etc.)
- Anti-spatter compounds used, if any
- Cutting environment (e.g., argon or nitrogen filled)

5.1.2.1 For process control documents for laser cutting materials other than titanium, if it can be demonstrated that identical cutting conditions can be achieved from two or more laser cutting machines, the same process control document may be used on those machines.

5.1.3 Dispose of scrap/unused titanium alloy material as specified by Bombardier Aerospace Procurement.

5.1.4 Refer to Table 1 for recommended material limitations for laser cutting.

Table 1 - Recommended Material Limitations for Laser Cutting

MATERIAL	MAXIMUM THICKNESS	PROCESSING
Aluminum and Aluminum Alloys	0.16"	• Use a laser with a TEM_{00} mode and power output of 500 watts or more. • Use short focal length lenses and high assist gas pressure to eliminate slag blown to the backside of the cut.
Stainless Steel	0.197"	• Use high pressure assist gas to avoid molten material adhering to the bottom of the cut.
Titanium and Titanium Alloys	0.275"	• Use an inactive assist gas such as Argon or Helium to prevent formation of titanium oxides / alpha case.
Nickel and Nickel Alloys	0.125"	• Use high pressure assist gas to avoid molten material adhering to the bottom of the cut.

5.2 Preparation of Material

5.2.1 Immediately before laser cutting, prepare material as follows:

Step 1. Solvent clean both sides of the material to be cut according to PPS 31.17 to remove all traces of grease, oil, shop soil, fingerprints or any other contaminants from the surfaces. After solvent cleaning, wear clean cotton gloves at all times when handling raw material or parts.

Step 2. If specified by the process control document, apply anti-spatter compound to one or both sides of the material to be cut, as specified, ensuring full coverage.

5.3 Laser Beam Cutting

5.3.1 Set-up the laser cutting machine according to the qualified process control document.

5.3.2 Perform laser cutting using a numerical control (NC) computer program validated according to section 6.3.

5.3.3 Except as noted below, to facilitate complete removal of the heat affected zone (HAZ) from around the periphery of holes, laser cut fastener and tooling holes undersize (1/32" undersize for titanium alloys and 0.015" undersize for aluminum, nickel and stainless steel alloys).

- Laser cut tooling holes located in tooling lugs that are to be cropped off during fabrication to the final drawing size.
- Laser cut holes in piccolo tubes manufactured from AMS 4941 titanium tubing to final drawing size.
- For sheet thicknesses greater than 0.040", laser cut fastener and tooling holes sufficiently undersize so that the HAZ remaining after conventional drilling will meet the requirements specified in section 6.2.

5.4 Post Laser Cutting Procedure

5.4.1 Finish laser cut metallographic and fatigue test specimens and production parts as follows:

Step 1. Final drill undersize holes using conventional drilling equipment according to PPS 1.09.

Step 2. Except as noted below, edge finish laser cut edges according to PPS 27.02, PPS 27.04 or PPS 27.10, as applicable.

- For conventionally drilled holes, laser cut piccolo tube holes and tooling holes in lugs that are to be removed, deburr **only** (i.e., do not edge corner relieve or edge face polish).
- For test samples for process control documentation qualification (ref. paragraph 6.2), edge finish the laser cut edges of one of the test specimens according to PPS 27.02, PPS 27.04 or PPS 27.10, as applicable, and leave the other test sample in the “as cut” condition.
- For fatigue test specimens (ref. paragraph 4.3.3.2), edge finish laser cut edges according to PPS 27.02, PPS 27.04 or PPS 27.10, as applicable.

Step 3. Ensure that the edge finish requirements specified by PPS 27.02, PPS 27.04 or PPS 27.10, as applicable, have been met, as applicable. In cases where the applicable requirements have not been met, it is acceptable to repeat edge finishing if the dimensional configuration allows for additional metal removal.

Step 4. Solvent clean parts according to PPS 31.17 to remove all traces of deburring chips and grit. After solvent cleaning, wear clean lint free cotton gloves at all times when handling cleaned parts.

6 Requirements

6.1 General

6.1.1 Fatigue testing and metallographic examination for process control document qualification, as specified herein, shall only be performed by a Bombardier Aerospace laboratory or Bombardier Aerospace approved laboratory.

6.2 Process Control Document Qualification

6.2.1 Before being used to prepare production parts or fatigue test specimens, all process control documents must be qualified according to paragraph 6.2.3.

6.2.2 In the event of re-location, repair or maintenance to a laser cutting machine which could affect machine performance, all process control documents for that machine must be re-qualified. Whenever a qualified process control document is revised, it must be re-qualified. Process control documents must be re-qualified at least every 6 months, or if there is cause to doubt the effectiveness of the process or equipment.

6.2.3 Qualify, and re-qualify, process control documents as follows:

Step 1. Prepare 2 test samples of the sheet thickness and alloy to be qualified to the design of Bombardier Toronto (de Havilland) part number 85410565 according to section 5.

Step 2. Check the edge finished test sample for deviation from the part profile.

Step 3. For both test samples (edge finished and “as-cut”), cut a minimum of 4 test specimens from areas such as corners, finished holes and complex geometrical features where the thermal effects of the laser would be expected to be greatest.

Step 4. Mount the test specimens (8 minimum) for metallographic examination.

Step 5. Metallographically examine each of the mounted test specimens. For qualification, the following requirements must be met by all mounted sections:

- there shall be no evidence of micro-cracks in the HAZ adjacent to the laser cut edge
- the depth of HAZ on test specimens cut from around the perimeter of fastener and tooling holes shall not exceed 0.016" for titanium alloy test specimens or 0.005" for aluminum, nickel or stainless steel test specimens
- the depth of HAZ on test specimens cut from the perimeter of test samples shall not exceed 0.010" for titanium alloy test specimens or 0.005" for aluminum, nickel or stainless steel test specimens

6.2.3.1 If the test specimens fail to meet any of the requirements specified herein, the cause of the failure must be corrected and the revised process control document qualified as specified herein.

6.2.4 Once qualified, a copy of each process control document shall be maintained on file by the processing facility and shall not be modified without re-qualification as specified herein.

6.2.5 Process control documents must be re-qualified every 6 months, or if there is cause to doubt the effectiveness of the process or equipment.

6.3 Numerical Control (NC) Computer Program Validation

6.3.1 Before being used to prepare production parts, numerical control (NC) computer programs must be validated as specified by Bombardier Aerospace.

6.4 Production Parts

6.4.1 All laser cut parts shall be checked for evidence of discrepancies or deviations from the part profile resulting from incorrect tracking, incorrect operation of the laser cutting machine or improper edge finishing.

6.4.2 Except for piccolo tube holes, conventionally drilled holes and holes in tooling lugs that are to be cropped off, the edge finish on laser cut edges shall meet the requirements of PPS 27.02, PPS 27.04 or PPS 27.10, as applicable, and the engineering drawing. Piccolo tube holes are acceptable “as cut” by the laser and deburred. Conventionally drilled holes and holes in tooling lugs that are to be cropped off are acceptable as drilled according to PPS 1.09 and deburred.

7 Safety Precautions

7.1 Safety precautions applicable to the materials and procedures specified herein shall be defined by the subcontractor performing such work for Bombardier Toronto (de Havilland).

8 Personnel Requirements

8.1 This PPS has been categorized as a “Controlled Critical Process” by PPS 13.39. Refer to PPS 13.39 for personnel requirements.