BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 20.04

PRODUCTION PROCESS STANDARD

Ultrasonic Inspection of Metals for Discontinuity Detection and Evaluation

Issue 14 - This standard supersedes PPS 20.04, Issue 13.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS 20.04 related questions to michael.wright@aero.bombardier.com.
- 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.

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1 Scope

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for ultrasonic inspection of metallic aircraft parts and raw materials for detection and evaluation of discontinuities.

1.1.1 This PPS complements the engineering drawings that specify its use as an authorized instruction. The procedure specified in this PPS 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 Alternatively, it is acceptable to perform ultrasonic inspection according to internationally or nationally recognized standards or specifications (e.g., Military, ASTM, AMS, etc.) in place of the procedure specified herein.

1.1.3 For subcontractors performing ultrasonic inspection of metallic aircraft parts only, refer to PPS 13.26 for the subcontractor provisions applicable to this PPS. The subcontractor provisions specified in PPS 13.26 are not applicable to suppliers of raw materials.

1.1.4 Procedure or requirements specified in a Bombardier BAPS, MPS, LES or P. Spec. **do not** supersede the procedure or requirements specified in this PPS.

1.1.5 This PPS may be used where ultrasonic inspection of metallic aircraft parts and raw materials according to QCD/G/C8 or QAP 4.11/15 is specified (ref. QDI-10-SN-1). QCD/G/C8 or QAP 4.11/15 are obsolete cancelled/superseded documents and are no longer available.

1.1.6 This PPS is not applicable to measuring material thickness using an ultrasonic thickness gauge instrument. Perform ultrasonic thickness measurement according to PPS 20.11.

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 General

3.1.1 Unless a specific issue is indicated, the issue of the reference documents specified in this section in effect at the time of manufacture shall form a part of this specification to the extent indicated herein.

3.2 **Bombardier Toronto (de Havilland) Process Specifications**

3.2.1 PPS 13.26 - General Subcontractor Provisions.

3.2.2 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.2.3 PPS 20.11 – Ultrasonic Thickness Measurement.

3.3 **Bombardier Aerospace Engineering Requirements Documents**

3.3.1 BAERD GEN-012 - Non-Destructive Testing - Certification of Personnel.

3.4 **Industry Specifications**

3.4.1 ASTM E127 - Standard Practise for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks.

3.4.2 ASTM E317 - Standard Practise for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Instruments and Systems without the Use of Electronic Measurement Instruments.

3.4.3 ASTM E2375 - Standard Practice for Ultrasonic Testing of Wrought Products.

3.4.4 MIL-STD-2154 - Inspection, Ultrasonic, Wrought Metals, Process for.

3.4.5 SAE-AMS-STD-2154 - Inspection, Ultrasonic, Wrought Metals, Process for.

3.5 **Bombardier Toronto (de Havilland) Internal NDT Written Practice**

3.5.1 WP-001 – Nondestructive Testing Certification of Personnel.

4 **Materials, Equipment and Facilities**

4.1 **Materials**

4.1.1 No materials are specified herein.

4.2 **Equipment**

4.2.1 The ultrasonic testing equipment shall include a test system comprising a basic ultrasonic test instrument, a search unit (transducer), an interconnecting apparatus, a suitable tank containing liquid couplant, a bridge and manipulator. The test system must meet or exceed the requirements of ASTM E2375, MIL-STD-2154 or SAE-AMS-STD-2154.

4.2.2 Flat entry surface reference blocks manufactured and checked according to procedures outlined in ASTM E127.

4.2.3 The test system must be capable of meeting or exceeding the following minimum requirements as determined by the procedures outlined in ASTM E317:

- Any electronic device that produces pulsed longitudinal waves and displays ultrasonic reflections on an A-scan cathode ray tube when used with an appropriate search unit is acceptable provided that the minimum performance characteristics specified in Table 1 are met.
- The instrument must provide stable linear amplification of received pulses of a selected test frequency and required sensitivity levels within the specified performance limits.
- The equipment must be checked every 12 months to ensure it meets the requirements of ASTM E317. All information required for approval must be recorded and available for reference.

Table 1. Equipment Performance Limits

	Test Frequency			
Limits	**2.25 MHz**	**5.0 MHz**	**10.0 MHz**	**15.0 MHz**
Minimum vertical	2.5" tp			
Upper linearity	≥95%			
Lower linearity	10%	10%		
Minimum ultrasonic sensitivity	100% (Note 1)	100% (Note 2)	80% (Note 2)	50% (Note 2)
Minimum signal to noise ratio	65 (Note 1)	100 (Note 2)		
Maximum entry surface resolution	0.7" Al	0.5" Al	0.3" Al	0.2" Al (Note 3)
Maximum back surface resolution	0.3" Al	0.2" Al	0.2" Al	0.1" Al (Note 3)
Minimum horizontal	3.5"			
Minimum horizontal linearity	85%			

Note 1. ASTM reference block 2-0300.

Note 2. ASTM reference block 1-0300.

Note 3. The resolution shall be accomplished if the intercept of the response separating the flaw from the surface is within 40% of the total screen height from the baseline.

4.2.4 An alarm is recommended when inspecting plate, bar stock and forged billets. The alarm should be used along with visual monitoring of the cathode ray tube.

4.2.5 A dual gate system is recommended: one for loss of back reflection and one to monitor received defect signals.

4.2.6 Immersion tank and carrier.

4.2.7 Except as noted, use search units up to 0.75" in diameter. For initial scanning of plates up to 3.0" in thickness, a rectangular (paintbrush) transducer may be used with an active element up to 0.25" by 3.0". For initial scanning of plates over 3.0" in thickness, a rectangular (paintbrush) transducer may be used with an active element up to 1.0" by 3.0". Any discontinuities detected using a rectangular (paintbrush) transducer must be evaluated using search units 0.75" or less in diameter. All search units must be serialized and records maintained for initial qualification and periodic tests.

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 ultrasonic inspection of metallic aircraft parts and raw materials 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, approval of subcontractors to perform ultrasonic inspection of metallic aircraft parts and raw materials according to this PPS does not require completion of a test program or submission of test samples.

5 Procedure

5.1 General

5.1.1 Before performing any acceptance inspection to this specification, all written instructions, procedures and techniques must first be reviewed and approved by a Bombardier Toronto (de Havilland) UT Level 3.

5.1.2 Prepare the water couplant in the immersion tank by adding sodium dichromate or potassium dichromate in the proportion of 1 to 3 lbs per 1,000 gallons of water. Other suitable corrosion inhibitors may be used.

5.1.3 Calibrate the inspection equipment such that the second front reflection from the test material does not appear between the first front and first back reflections. Maintain the distance between the crystal and the test material thus determined within 0.5" for initial scanning and flaw evaluation.

5.1.4 Inspection of cylindrical parts or areas containing fillets may be performed using shear waves.

5.1.5 Compare discontinuities to the test blocks.

5.2 Definitions

5.2.1 Class A areas are defined as areas in which:

- Indications from a single discontinuity do not exceed the response from a 5/64" diameter flat-bottomed hole at the estimated discontinuity depth.
- Indications from a single discontinuity equal to or greater than the response from a 3/64" diameter flat-bottomed hole at the estimated discontinuity depth are not more than 1" in length.
- Multiple indications in excess of the response from a 3/64" diameter flat bottomed hole at the estimated discontinuity depth do not have their indicated centres closer than 1" apart.
- Multiple discontinuities are not of such a size or frequency as to reduce the back reflection pattern to 50% or less of the back reflection pattern of normal material of the same geometry. This is measured with the crystal parallel to the front and back surfaces to ensure that the loss of back reflection is not caused by surface roughness or part geometry variation.

5.2.2 Class B areas are defined as areas in which:

- Indications from a single discontinuity do not exceed the response from an 8/64" diameter flat-bottomed hole at the estimated discontinuity depth.

- Indications from a single discontinuity equal to or greater than the response from a 5/64" diameter flat-bottomed hole at the estimated discontinuity depth are not more than 1" in length.
- Multiple indications in excess of the response from a 5/64" diameter flat-bottomed hole at the estimated discontinuity depth do not have their indicated centres closer than 1" apart.
- Multiple discontinuities are not of such a size or frequency as to reduce the back reflection pattern to 50% or less of the back reflection pattern of normal material of the same geometry. This is measured with the crystal parallel to the front and back surfaces to ensure that the loss of back reflection is not caused by surface roughness or part geometry variation.

5.2.3 Class C areas are defined as areas in which the indications from a single discontinuity do not exceed the response from an 8/64" diameter flat-bottomed hole at the estimated discontinuity depth.

5.3 **Inspection Method**

5.3.1 Unless otherwise specified, perform inspection via the immersion method using pulsed longitudinal waves.

5.3.2 Except for die forgings, perform initial scanning perpendicular to the inspection surface. For die forgings, if possible perform initial scanning perpendicular to the parting plane.

5.3.3 Use angular manipulation to obtain maximum response from individual discontinuities.

5.3.4 The amount of scanning overlap will be determined at the time of inspection to ensure that all areas are effectively covered.

5.3.5 The test frequency and sensitivity standardization used for this inspection shall be selected to ensure the most effective detection and evaluation of discontinuities in the parts being inspected. Any differences in the finish of the surface being inspected and the finish of the standard reference blocks must not be of sufficient magnitude that the calibrated test sensitivity is significantly affected.

5.3.6 Clearly stamp each ultrasonically inspected item to identify the means of inspection and the inspectors' stamp number. Place the stamp on the lower left edge (viewed from the side where the ultrasonic receiver is located). Apply a roll stamp to one surface to indicate the direction of grain flow in non-machined stock material.

6 Requirements

6.1 Class Limits

6.1.1 Unless otherwise specified on the engineering drawing, discontinuities shall not exceed the class limits specified in Table 2 unless they will be removed by subsequent machining to finish dimensions.

Table 2. Ultrasonic Discontinuity Limits

Product	Alloy	Size			Discontinuity Class
		Thickness	Maximum Weight per Piece	Maximum Width to Thickness Ratio	
Plate	2014, 2024, 2124, 2219, 7075, 7079, 7178 & 7050	0.500" - 1.499"	2,000 lbs.	---	B
		1.500" - 3.000"			A
		3.001" - 4.500"			B
Extruded Bar and Shapes	2014, 2024 & 2219	0.500" and over	600 lbs.	10 to 1	B
	7075, 7079 & 7178	0.500" - 1.499"			B
		1.500" and over			A
Rolled or Cold Finished Bar and Shapes	2014, 2219, 2024, 7075, 7079 & 7178	0.500" - 1.499"	600 lbs.	---	B
		1.500" - 3.000"			A
		3.001" - 6.000"	1,000 lbs.		B
Die Forgings and Rolled Rings	2014, 2219, 7075 & 7079	0.375" - 4.000"	300 lbs.		B
Hand Forgings	2014, 2219, 7075, 7079 & 7050	1.000" - 8.000"	600 lbs.		A

Note 1. Defect classification shall be according to the engineering drawing and not necessarily as shown in this table.

6.2 Documentation

6.2.1 Subcontractors or raw material suppliers performing ultrasonic inspection for Bombardier Toronto (de Havilland) must provide certified reports of results along with a grid of defects found, if any.

7 Safety Precautions

7.1 **The safety precautions specified herein are specific to Bombardier Toronto (de Havilland) to meet Canadian Federal and Provincial government environmental, health and safety regulations. It is recommended that other facilities consider these safety precautions; however, suppliers, subcontractors and partners are responsible for ensuring that their own environmental, health and safety precautions satisfy the appropriate local government regulations.**

7.2 **Observe general shop safety precautions when performing the procedure specified herein.**

8 Personnel Requirements

8.1 Personnel responsible for performing ultrasonic inspection must be certified according to BAERD GEN-012. At Bombardier Toronto (de Havilland) only, certification according to WP-001 constitutes certification to BAERD GEN-012.

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