BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 20.11

PRODUCTION PROCESS STANDARD

ULTRASONIC THICKNESS MEASUREMENT

Issue 1 - This is a new standard.
- Direct PPS 20.11 related questions to michael.wright@aero.bombardier.com.
- 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 measuring the thickness of metallic material using ultrasonic thickness gages utilizing the straight-beam, manual contact pulse-echo method.

1.2 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.

1.2.1 Refer to PPS 13.26 for the subcontractor provisions applicable to this PPS.

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

1.3 Refer to PPS 20.04 for the procedure and requirements for ultrasonic inspection of metallic aircraft parts and raw materials for detection and evaluation of discontinuities.

2 Hazardous Materials

2.1 Before receipt at Bombardier (Toronto Site), all materials must be approved and assigned Material Safety Data Sheet (MSDS) numbers by the Bombardier (Toronto Site) 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 Site) 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 Site) 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 20.04 – Ultrasonic Inspection of Metals for Discontinuity Detection and Evaluation.

3.2.4 PPS 31.07 – Cleaning and Stripping of Painted Surfaces.

3.2.5 PPS 31.17 – Solvent Usage.

3.3 Bombardier Aerospace Specifications

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

3.4 Bombardier (Toronto Site) Internal NDT Written Practice

3.4.1 WP-001 – Nondestructive Testing Certification of Personnel.

4 Materials, Equipment and Facilities

4.1 Materials

4.1.1 Unless otherwise specified in this section, use only the materials specified; use of superseding or alternative materials is not allowed.

4.1.2 Ultrasonic couplant (e.g., Ultragel II) compatible with the material to be inspected. The couplant must not contain chlorine, lead or graphite.

4.2 Equipment

4.2.1 Digital ultrasonic thickness gauge (e.g., Olympus 38DL PLUS, see Figure 1) utilizing the straight-beam, manual contact pulse-echo method.

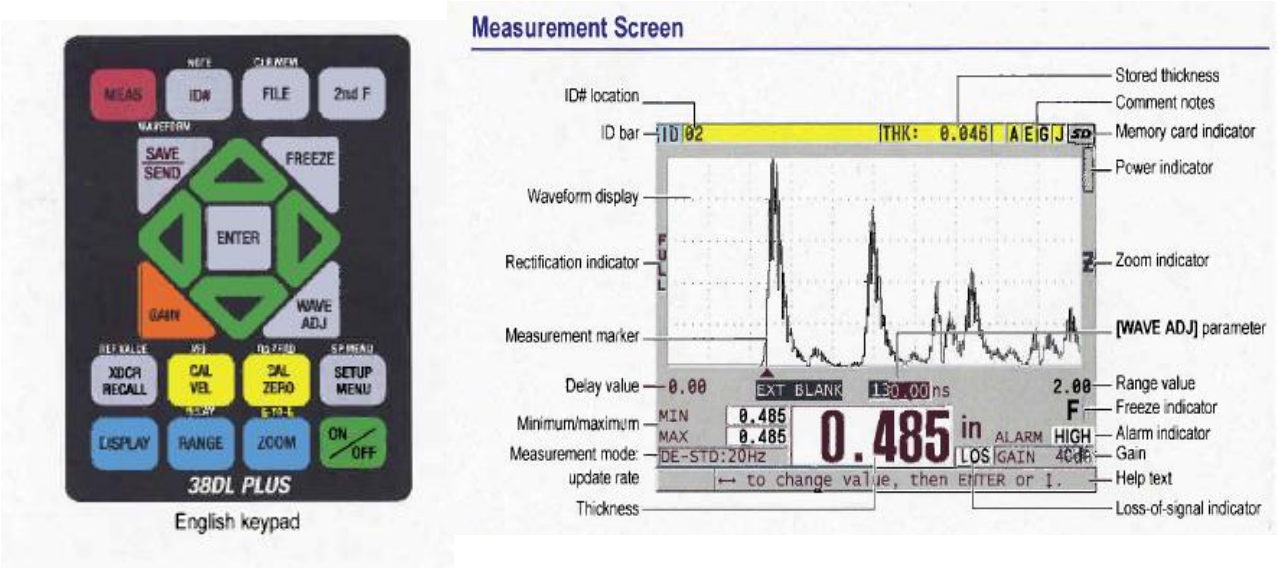


Figure 1. Olympus Model 38DL PLUS Keypad & Display

4.2.2 Transducer (e.g., Panametrics Model M116, M202, M208, V260, etc.) in the frequency range of 2.25 - 30.0 MHz; must be compatible with the ultrasonic thickness gauge.

4.2.3 Transducer cable (e.g., Lemo FFA.00 single pin to micro-dot cable).

4.2.4 Reference standards, used to adjust the parameters of the ultrasonic thickness gauge.

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 ultrasonic thickness measurement 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 subcontractor facilities to perform ultrasonic thickness measurement 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 For ultrasonic thickness gauge instruments other than the Olympus 38DL PLUS refer to the manufacturer's instructions for instrument operating modes, initial set-up, etc.

5.1.2 The Olympus 38DL PLUS instructions include the necessary initial set-up, calibrations and inspection details to permit an accurate thickness measurement, but does not include all the Gaging features such as Statistical and Data Logging (DL). If required, information on these additional features can be obtained from the Instrument User's Manual.

5.2 Olympus 38DL PLUS Operating Modes

5.2.1 DEFM1 = Mode 1: Is used with contact transducers. In this mode, measurement is made from the initial excitation pulse to the first returning echo from the back wall of the test piece. It is normally recommended for use unless one of the conditions described under modes 2 or 3 is present.

5.2.2 DEFM2 = Mode 2: Is used with delay line transducers. In this mode, measurement is made between an interface echo, representing the near surface of the piece, marking the time the sound wave enters the test piece and the first back wall echo. This mode is usually used with thin material where the excitation pulse and the first back echo would be confused during Mode 1 (e.g., see Figure 2).

5.2.3 DEFM3 = Mode 3: Is used with delay line transducers. In this mode, measurement is made between two successive back wall echoes that follow an interface echo. This mode is usually used with thin material (0.050" or less) where excitation pulse and the first back echo are confused. Mode 3 offers the highest measurement accuracy and the best minimum thickness resolution in a given application, at the expense of penetration, and is used when accuracy and/or resolution requirements cannot be met in Mode 1 or Mode 2 (e.g., see Figure 3).

5.3 Surface Preparation of the Thickness Measurement Area

5.3.1 The surface in the area where the transducer and couplant is to be applied must be free of paint. If there is paint on the transducer contact surface of the part, strip the paint according to PPS 31.07 before thickness measurement; reapply stripped coatings after thickness measurement according to the applicable PPS's.

5.3.2 Ensure that the front and back surfaces of the thickness measurement area are smooth, as a rough contact surface will reduce the minimum thickness that can be accurately measured. Both surfaces should be smooth or the returning echo may be distorted and measurement inaccuracies will result. Engineering approval must be granted prior to any blending operations, if needed.

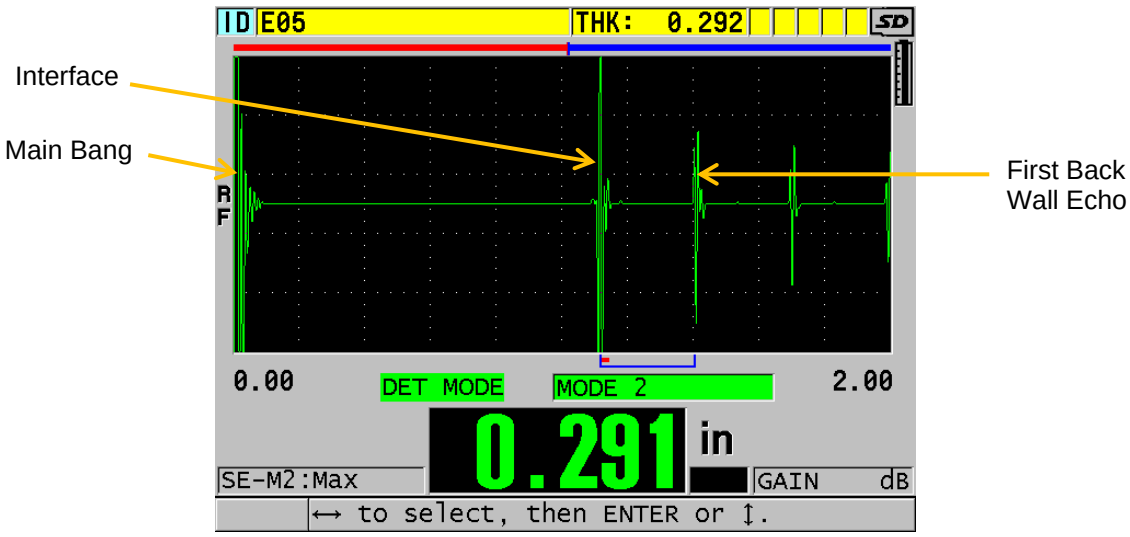
5.3.3 The surface to be tested shall be free of any loose scale, surface corrosion, particles or any foreign substances otherwise a blending operation must be performed prior to taking any measurements.

5.3.4 The surface temperature of the component must be below 50^{o}C.

5.3.5 Immediately before performing ultrasonic thickness measurement, solvent clean the area where the thickness measurements will be performed according to PPS 31.17.

The following parameters are set as an example only, different parameters might have to be set while using different transducer or measurement is performed on a different area.

1. Using Single Element transducer
2. Frequency – 10 MHz
3. Def Mode – Mode 2
4. Meas Type – Standard
5. Probe type – select probe (M202 or V206)
6. Pulser power – Indicates the voltage used to drive the transducer that is selected – 110 Volts
7. Max gain – Max Gain is used to amplify echoes that are further out in time (65 dB)
8. Init gain – Amplifies echoes close to the Main Bang or Interface Echoes, set initial gain (40 dB)
9. TDG – Starts to slope at the end of the Interface Blank (set above 20 dB)
10. MB blank – Set just before the Interface Echo
11. Echo window – at the end of interface echo, Indicates the selected period of time in which the receiver will search for echoes
12. Echo 1 detect – detect polarity of 1st echo (1st If echo) as '+' Slope
13. Echo 2 detect – detect polarity of 1st BW echo as '-' Slope
14. IF Blank – Move pass ringing, if required
15. Range – at least 2 BW for selected range
16. Delay – move delay so that 1st interface echo is left side of screen (select 2nd function + delay and move screen as required)
17. IF blank – set pass 1st if echo away from NZ ringing

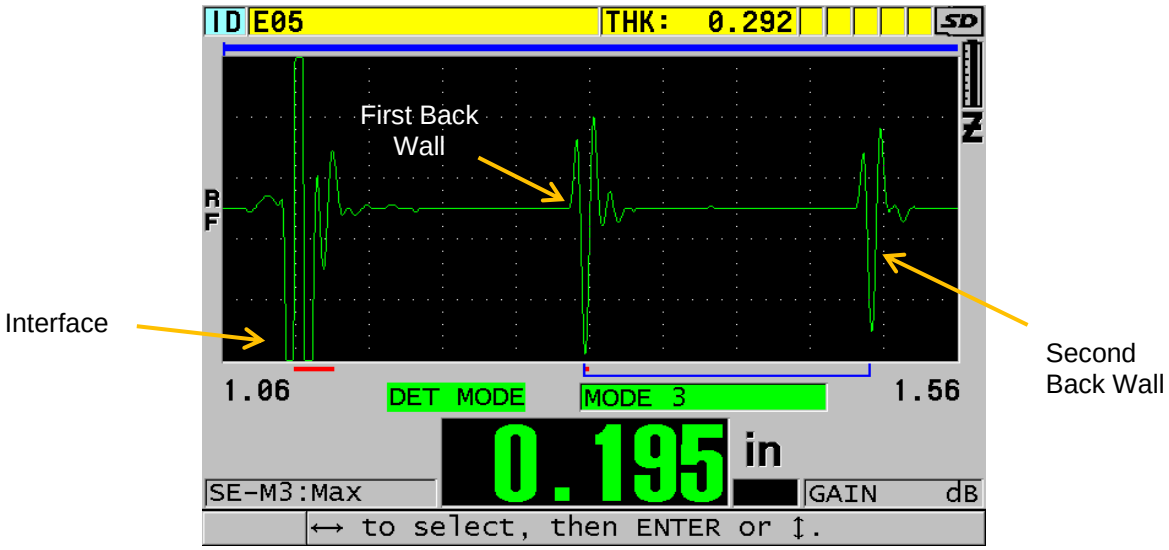


Mode 2 measures the time of flight between the interface (or delay line) echo and the first back wall echo, using delay line

Figure 2. Olympus 38DL PLUS Mode 2, Wave Setting for Single Element Transducers

The following parameters are set as an example only, different parameters might have to be set while using different transducer or measurement is performed on a different area.

1. Single Element transducer
2. Frequency – 10 MHz
3. Def Mode – Mode 3
4. Meas Type – Standard
5. Probe type – select probe (M202 or V206)
6. Pulser power – Indicates the voltage used to drive the transducer that is selected - 110 Volts
7. Max gain – Max Gain is used to amplify echoes that are further out in time (65 dB)
8. Init gain – set initial gain (40 dB)
9. TDG – set above 30 dB
10. MB blank – Set just before the Interface Echo
11. Echo window – at the end of interface echo, Indicates the selected period of time in which the receiver will search for echoes
12. Echo 1 detect – detect polarity of 1st echo (1st If echo) as '+' Slope
13. Echo 2 detect - detect polarity of 1st BW echo as '-' Slope
14. IF Blank – Move pass ringing, if required
15. Range – at least 2 BW for selected range
16. Delay – move delay so that 1st interface echo is left side of screen (2nd function + delay)
17. IF blank – set past 1st IF echo away from NZ ringing
18. M3 blank – set past 1st backwall echo away from NZ ringing



Mode 3 measures the time of flight between one back wall echo to the next back wall echo, using delay line or immersion transducers.

Figure 3. Olympus 38DL PLUS Mode 3, Wave Setting for Single Element Transducers

5.4 Reference Standards

5.4.1 Reference standards used must have the following characteristics:

a) The reference standard shall have the same sound velocity as the part area to be measured. For aluminum alloy, the first digit of the aluminum series shall be the same (e.g., a part made of 2024 alloy shall use a reference standard made of 2XXX series aluminum alloy, whereas a part made of 7075 alloy shall use a reference standard made of 7XXX series aluminum alloy). When measuring stainless steel material, a reference standard of the same stainless steel series shall be used. The same is applicable for titanium material or other types of metallic materials.

b) The reference standard shall contain at least two different known thicknesses within the measurement range of the transducer and set-up in use; one thickness shall be greater than or equal to the maximum thickness of the part to be measured (but no more than twice of its thickness) and the other shall be less than or equal to the minimum thickness to be measured (but not less than half of its thickness).

c) All thicknesses on the reference standard shall have flat, smooth and parallel front and back surfaces and shall be verified and certified by the Metrology department and/or a recognized linear laboratory who will attach an MTI identification label.

5.4.1.1 For parts to be measured which do not have a reference standard with certified thicknesses as described in para 5.4.1, a reference standard shall be made of the same material representing the thickness to be measured and then certified and approved by the Metrology department and/or a recognized linear laboratory. Reference standards must conform to the requirements of para 5.4.1.

5.5 Olympus 38DL PLUS Initial Setup

5.5.1 Set-up the Olympus 38DL PLUS as follows:

Step 1. Select the appropriate transducer and operating mode for the thickness to be measured.

Step 2. Verify the condition of the equipment: the calibration dates of the instrument, the validity of the reference standard, the cable, the transducer and the delay line lens (if applicable) are proper and in good working order. The reference standard must be free of contamination, excessive damage and representative of the material to be evaluated (as specified in section 5.4). Broken or cracked transducer wear plates, worn delay line lenses, and thermal damage will degrade performance and affect measurements.

Step 3. Apply a thin layer of couplant between the transducer's wear plate and the delay line lens and re-assemble the transducer (for Modes 2 or 3 only).

Step 4. Plug the transducer cable into the transducer connector at the top end of the instrument case.

Step 5. Connect the transducer, capable of measuring the thickness range and compatible with the geometry of the part, to the cable.

Step 6. Press ON/OFF to turn on the instrument.

Step 7. Press XDCR RECALL.

Step 8. In the menu, select DEFAULT SINGLE ELEMENT.

Step 9. In the SELECT SETUP list of the DEFAULT SINGLE ELEMENT screen, highlight the setup that corresponds to the transducer you are using and then press ENTER.

Step 10. In the ACTIVE screen, if needed edit the parameters to match the characteristics of the transducer that you are using, and then press MEAS.

5.6 **Olympus 38DL PLUS Velocity and Zero Calibration**

5.6.1 The inspector must know the nominal thickness and material of the area to be measured before commencing measurement; this helps to select the proper range, mode and transducer type.

5.6.1.1 Perform Olympus 38DL PLUS velocity and zero calibration as follows:

Step 1. Ensure that the thickness measurement unit is calibrated with valid calibration sticker.

Step 2. Calibrate the unit using standard Step block as per instruction given in the manufacturer's instruction manual.

Step 3. The calibration of the instrument shall be verified and adjusted whenever the cable, the transducer or the program is changed, before performing a thickness measurement, at every 30 minutes of continuous operation and whenever the precision of the instrument is in doubt.

Step 4. Place couplant on the surface of the thick sample of the test block within the inspection range.

Step 5. Couple the transducer on the thick sample of the calibration block.

Step 6. Press CAL VEL.

Step 7. When the thickness reading is stable, press ENTER.

Step 8. Use the arrow keys to enter the known thickness.

Step 9. Press CAL ZERO.

Step 10. Place couplant on the surface of the thin sample of the test block within the inspection range.

Step 11. Couple the transducer on the thin sample of the calibration block.

Step 12. When the thickness reading is stable, press ENTER.

Step 13. Use the arrow keys to enter the known thickness.

Step 14. Press MEAS.

5.7 Thickness Measurement Procedure

5.7.1 After initial set-up (e.g., according to section 5.5) and calibration (e.g., according to section 5.6) the unit is ready for inspection on material with the same velocity as the reference standard.

5.7.2 When the ultrasonic probe is above a structural configuration that has nonparallel surfaces (e.g., the radius of a machined or chemically milled pocket, a disbonded structure with corrosion, etc.) no readings, or incorrect readings, will be given by the instrument.

5.7.3 Bonded multi-layer structures and/or topcoat, dynatrol, etc. on the parts opposite surface may diffuse the sound into the sub-layers or coating resulting in unreliable readings (no readings or inflated results). Ensure the cross sectional configuration of the structure is known prior to taking measurements, especially the nominal thickness of the metal layer of interest to verify validity of results.

5.7.4 Temperature variations will affect calibration; the instrument sound velocity setting should be calibrated at the same temperature where the measurement will be taken. At no time should any measurements be taken on a surface that is too hot or too cold to comfortably touch with bare fingers.

5.7.5 When using the Olympus 38DL PLUS in Mode 3 on a very thin area and measurement cannot be performed between first and second backwall echoes, move the Gate by changing IF Blank, and perform the measurement between second and third or third and fourth backwall echoes.

5.7.6 Perform thickness measurement as follows:

Step 1. Apply a thin layer of couplant on the area of interest.

Step 2. Place the transducer on the area of interest and press moderately against the surface to obtain a stable reading on the display.

Step 3. Make sure that the pressure applied to the probe during the measurement of the thickness is the same as the pressure applied to the probe during the calibration procedure. Make sure that the amplitude of the first back reflection on the area of interest is at 80% FSH. If the signal amplitude is not at 80%, adjust the gain to bring the signal to 80% FSH.

Step 4. Verify the repeatability of the measurement by measuring two to three times at the same location in order to obtain the same thickness measurement. It is also recommended to take readings at other points close to and around the area of interest, to verify thickness uniformity and to determine changes in thicknesses of the material.

Step 5. During inspection at difference locations, check the calibration of the equipment against the reference block when any of these conditions apply:

a) At least every 30 minutes.

b) When a critical component of the equipment or a set-up parameter changes.

c) Upon completion of the inspection.

6 Requirements

6.1 Record and report all thickness measurements on the appropriate documentation. If required, submit results to the applicable authority for review and disposition. Reports shall contain the following information:

a) The sound velocity used for the measurement

b) The part number of the reference standard used for adjusting the performance of the instrument.

c) The name and badge number of the inspector.

d) The date of inspection.

e) When specifically mentioned, the report must also include a sketch of the location where each measurement was taken.

7 Safety Precautions

7.1 **The safety precautions specified herein are specific to Bombardier (Toronto Site) 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.**

7.3 **Component must be securely situated and accessible.**

7.4 **When working at heights make sure to wear safety harness.**

8 Personnel Requirements

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

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