BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 20.06

PRODUCTION PROCESS STANDARD

Ultrasonic Inspection of Composite Components

Issue 9
- This standard supersedes PPS 20.06, Issue 8.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS 20.06 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) establishes the minimum requirements for ultrasonic inspection of composite components for detection and evaluation of discontinuities in composite materials, parts and assemblies fabricated according to PPS 10.35, PPS 10.43 or PPS 10.48.

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 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.

1.1.4 Specific procedures and applicable written instructions shall be developed for each component or family of components to supplement this PPS.

1.1.5 This PPS shall be used when mentioned in the relevant process specification, material specification, engineering drawing or specific engineering documents.

1.1.6 The parts and assemblies can be monolithic, laminate bonded to laminate, laminate bonded to honeycomb sandwich, and honeycomb sandwich.

1.1.7 The type of discontinuities to be detected includes but not limited to delaminations, disbonds, crushed core cells, voids, inclusions, porosity, resin rich areas, foreign materials, etc.

1.1.8 Three techniques are considered: pulse echo, through transmission and bond tester. When both sides of the component are accessible the through transmission technique may be used but when only single side access is possible the pulse echo technique is used. Bond test using pitch-catch, resonance or MIA modes can be conducted on the part if the detectable is allowed. The pulse echo technique can be conducted by automated, semi-automated or manual means and for the through transmission technique automation is recommended.

1.1.9 The inspection techniques shall deploy longitudinal waves (straight beam) normal to the part surface either reflected (pulse echo) or transmitted (through transmission). Ultrasound generation and detection can be achieved with conventional ultrasonic (single or dual crystal transducers) or advanced ultrasonic (phased array transducer, laser based ultrasound, air coupled ultrasound, etc.).

1.1.10 The inspection technique for the Bond Tester shall deploy Pitch-Catch, Resonance or MIA modes.

1.1.11 Other ultrasonic techniques not defined in this specification must be approved by a UT Level 3.

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 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 (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) Specifications

3.2.1 PPS 10.35 - Fabrication of 250˚F Cure Epoxy Resin Pre-Impregnated, Fibre Reinforced Composite Parts.

3.2.2 PPS 10.43 - Fabrication of 350˚F Cure Epoxy Resin Pre-Impregnated, Fibre Reinforced Composite Parts.

3.2.3 PPS 10.48 - Fabrication of 280˚F Cure, Phenolic Resin Pre-Impregnated, Fibre Reinforced Composite Parts.

3.2.4 PPS 13.26 - General Subcontractor Provisions.

3.2.5 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.2.6 PPS 31.17 - Solvent Usage.

3.3 Bombardier Aerospace Engineering Requirements Documents

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

3.4 **Bombardier Aerospace Materials and Processes Engineering Procedures**

3.4.1 MPEP-004 - Procedure for Request for Deviation to Bombardier Aerospace Materials and Processes Specifications.

3.5 **Industry Specifications**

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

4 Equipment and Facilities

4.1 Equipment

4.1.1 Emitter-Receiver Equipment

4.1.1.1 The emitter-receiver equipment shall produce and record signals in the frequency bandwidth of the transducer.

4.1.1.2 The ultrasonic instrument shall meet or exceed the requirements as specified in ASTM E317.

4.1.1.3 A voltage regulator shall be used on the power source if a fluctuation in the line voltage causes a variation in the height of a signal set at 50 percent of screen saturation or causes ghost signal varying along the baseline of the A-scan display.

4.1.1.4 The ultrasonic inspection equipment shall be checked for accuracy by MEC (Measurement Equipment Control) at intervals determined by MLOM (Metrology Laboratories Operation Manual) or equivalent national standards and Original Equipment Manufacturers calibration requirement on a minimum of an annual basis or after repair.

4.1.2 Transducers

4.1.2.1 The transducer bandwidth frequency shall be compatible with the Emitter-receiver equipment, with the inspected material and with the anomalies to be detected (location, dimension and type).

4.1.2.2 The transducer in combination with the emitter-receiver equipment shall be capable of detecting the minimum acceptable relevant indication with sufficient reliability, sensitivity and repeatability.

4.1.3 **Scanning System**

4.1.3.1 For automated system (immersion, squirter, bubbler, laser UT, etc.), the scanning equipment shall be able to translate the transducer in three perpendicular directions and shall be able to angulate to correctly align the transducer with the part.

4.1.3.2 The scanning system shall have facilities to properly position and increment the transducer in the scanning and index directions during testing. The minimum scan index increment shall be compatible with the minimum acceptable relevant indication.

4.1.3.3 The scanning equipment shall be rigid so that the transducers do not deflect during the inspection, the displacement is smooth and accurate and backlash is within applicable tolerances. Additionally, the scanning equipment shall have the ability to part contact contour profiling.

4.1.3.4 Automated scanning systems shall have crash protection or shall be adjusted to prevent damages to the parts under test and collisions with tooling.

4.1.3.5 Automated scanning systems shall have the ability to mark or point precisely to the location of indications after testing.

4.1.3.6 For semi-automated inspection, the scanning system consists of a manual scanner with an encoder (wheel encoder type, robot scanning arm type …) for positional information. The encoder resolution and minimum increment shall be compatible

4.1.3.7 For automated, semi-automated and manual inspections, a minimum of 10% of Effective Beam Width overlap between scans is required to ensure 100% inspection coverage. For C-scans, evidence of 100% coverage of scan zone-to-scan zone shall be verified by applying a 0.25” round adhesive foam pads at scan perimeter points. A temporary mark or tape may be used for hand-scanning coverage confirmation.

4.1.4 **Immersion Tank**

4.1.4.1 The immersion tank shall have the required depth to accommodate sufficient water to prevent distortion of the signal due to turbulence when the transducer is moved through the water and to allow the transducer to be adjusted so that the second front reflection does not occur before the first back reflection. Integrated systems shall be required to prevent algae and other organic growth that will affect UT signal consistency, system reliability, and Inspector Health and Safety.

4.1.5 **Squirter, Bubbler**

4.1.5.1 The squirter and bubbler equipment shall supply a coupling medium with minimal

turbulence from the transducers to the part. The water jet shall be a laminar flow of fluid. Daily visual inspection is required for diffuser placements, tube water flow and jet obstructions, etc., as part of the routine setting up procedure.

4.1.6 **Bond Tester**

4.1.6.1 A bond tester is used to inspect and test the soundness of bonds in different structural components manufactured from advanced composites. There are three major modes (methods) of inspection using a bond tester: Pitch-Catch, Resonance and MIA methods. Selection of the best method to use for a particular material and type of defect must be determined by a UT Level 3.

4.1.7 **Composite Calibration Reference Standards (CRS)**

4.1.7.1 The equipment shall be calibrated with CRS in the form of coupons or samples representative of the part to be inspected.

4.1.7.2 CRS shall contain natural or simulated anomalies of known type, size and location for standardization and sensitivity determination purpose approved by UT Level 3.

4.1.7.3 CRS shall be manufactured per section 5.3.

4.1.8 **Couplants**

4.1.8.1 Couplant used must be compatible with the composite part and shall be easily removed from the part according to approved cleaning processes.

4.1.8.2 For modified immersion and immersion testing, a water recovery/re-circulation system shall be used. The water couplant shall be free of air bubbles and foreign matters that may interfere with the inspection. Corrosion inhibitors and wetting agents shall be added to prevent formation of bubbles on the face of the transducer and on the surface of the part. Surface preparation and cleaning shall be completed prior to installing the part in the Inspection System to prevent contamination of the couplant (water supply).

4.1.8.3 For contact techniques, a liquid or semi-liquid couplant such as water base with humectants unharmful to the material being inspected, shall be used to wet the surfaces of the transducer and the test piece, eliminating any air space between the two.

4.1.8.4 The viscosity of the coupling medium shall be appropriate for the surface finish and configuration of the part.

4.1.8.5 When applicable and per Part Specific Technique Sheet or applicable UT Procedure, a sprayed fine mist of water can also be used as a couplant when sufficient to achieve the required coupling.

4.1.8.6 The use of glycerin and glycerin based couplant is forbidden. When couplant can deteriorate the tested part integrity, a protective layer shall be added prior to inspection with couplant. Immersion in water, water jets or water based couplant can change mechanical properties or chemical composition due to penetration of water in unprotected core or fibers.

4.1.9 **Written Instruction**

4.1.9.1 A detailed written instruction, Part Specific Technique Sheet (PSTS) and/or procedure shall be developed meeting the requirements of this specification, Engineering drawings and/or specific engineering documents as applicable for all Non Destructive Inspection.

4.1.9.2 The written instructions and procedures must stipulate all details and steps to prepare, set up, perform, complete and report the Non Destructive Inspection, refer to section 5.1. Before performing any acceptance inspection to this specification, all written instructions and procedures must first be approved by a Bombardier Toronto (de Havilland) UT Level 3.

4.2 **Facilities**

4.2.1 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 composite components according to this PPS.

4.2.2 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.

4.2.3 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.

4.2.3.1 Unless otherwise specified by Bombardier Aerospace Supplier Quality Management, approval of subcontractors to perform ultrasonic inspection of fibre reinforced composite parts 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 The procedure, as a minimum, shall include but not limited to:

- Name and address of inspection facility
- Scope and limitation (including inspection technique)
- Date written, including record of applicable Revision(s)
- Applicable documents including reference to this specification
- Personnel certification requirements
- Surface preparation
- Special parts handling and processing instructions
- Part(s) Identification
- Identification of the required Calibration Reference Standards and part number
- Sketches of the parts with inspection zone identifications
- Identification of equipment and materials
- Emitter-Receiver Unit
- Scanning System (if applicable)
- Software (if applicable)
- Tooling for part positioning
- Transducer including diameter, frequency, element material type, description of any wedges, shoes, stand-off attachments, bubblers or squirters
- Couplant (if applicable)
- Inspection technique
- Calibration procedure
- Pulse repetition rate
- Water path, focal distance (if applicable)
- Determination and application of transfer value (dB correction factor) if required
- Method of establishing scan sensitivity
- Method of determining effective beam width of transducer
- Scan speed, scan direction and scan index
- Gate settings, signal-to-noise level

- Evaluation of indications
- Applicable acceptance requirements
- Post inspection and cleaning
- Date, UT Level 3 name and signature
- Evidence of UT Level 3 approval

5.1.2 Part Specific Technique Sheets (PSTS) as a minimum, shall include but not limited to:

- Part Preparation and Inspection Instruction
- Date and Level 3 signature
- Couplant requirement (if applicable)
- Standardization Procedure
- Set-up instruction (Set Up files, list of ultrasonic equipment and scanning instrument parameters, including freq., transducer type (single, dual and array (number of element)), PRF, gain, delay, gate levels/lengths, scan speed, etc.)
- Calibration Reference Standards (CRS)
- Method of applying transfer value, if required, including maximum allowed value
- Inspection procedure.(min and/or max speed and index).
- Discontinuity evaluation procedure and applicable acceptance criteria
- Cleaning and zone identification • Reference to applicable procedure.
- Specific accessories.
- Rejected indications reporting and marking.
- Post cleaning instructions.
- Inspection report and Data Record instructions.
- Evidence of UT Level 3 approval.

5.2 Process Qualification

5.2.1 The requirements of this specification in its entirety shall apply at Bombardier.

5.2.2 Subcontract processors shall process in strict accordance with this specification and all sub-tier specifications. Any deviation to this specification must be obtained per MPEP-004 RFD process.

5.3 Composite Calibration Reference Standards (CRS)

5.3.1 Ultrasonic inspection of composite components shall be performed with composite CRS for equipment set-up and calibration, and validation of the inspection technique. CRS must have engineering approved technical drawings and UT C-scan images for reference, unless otherwise specified by a UT Level 3.

5.3.2 All CRS must be approved by a Bombardier Toronto (de Havilland) UT Level 3.

5.3.3 The CRS and the tested parts shall have a similar response with the ultrasonic inspection equipment. The CRS shall be of the same material and built with the same process, material specifications, physical configuration and acoustic properties to the part under examination.

5.3.4 The CRS shall possess similar geometries such as surface curvature, radii, core and laminate thicknesses, adhesive type, bevel angle, edge, thickness variations, stringers, and shall be composed of same materials like laminate skin, lightning protection plies, honeycomb core and phenolic core types, foam filled regions, paste adhesive and noodles (also referred to as fillers) regions.

5.3.5 Components with curvature related to radii > 6 inches may utilize a CRS with flat configuration for entry point resolution and scan set up calibration.

5.3.6 For components with various laminate thicknesses, generic CRS shall be designed with typical thicknesses that are the thickest, the intermediate and the thinnest. Laminated stepped CRS are required to cover the entire range of thicknesses.

5.4 Preparation of Parts

5.4.1 Remove all traces of grease, oil, dirt, rubber and/or other substances which may interfere with the transmission of a useable signal by solvent cleaning the part according to PPS 31.17.

5.5 Ultrasonic Inspection

5.5.1 General

5.5.1.1 Before using the ultrasonic inspection equipment, ensure that both the unit itself and the transducer are in good working order and initial equipment calibration has been performed according to the manufacturer's instruction manual.

5.5.1.2 Equipment shall demonstrate capability of detecting Engineering's list of required defects such as voids, disbonds and delaminations, material inclusions and porosity (when required) with respect to geometrical and material tolerances.

5.5.1.3 Equipment shall provide a characterization capability to identify, size, measure and locate defects, with consistent signal response from sourced NDI standards.

5.5.1.4 Equipment shall provide a means to which signal response and system noise can be quantified.

5.5.1.5 Equipment shall provide inspection results that demonstrate acceptable dynamic

range and system signal-to-noise ratio for the material and geometry intended for inspection.

5.5.2 Inspection Techniques

5.5.2.1 The inspection technique shall be chosen as a function of the part geometry, the constituent materials, the surface condition, detectability requirements in terms of sensitivity and resolution, speed and defect characterization requirements.

5.5.2.2 The inspection technique shall be described in the specific procedure. Following the guidance above, the appropriate inspection technique must be selected and approved by a Bombardier Toronto (de Havilland) UT Level 3.

5.5.3 Recording Data

5.5.3.1 The data to be recorded should include as much of the following information as available when submitting a report. Maintain all reports of parts inspected for a minimum of two (2) years.

- Part or Assembly number and name
- Test Date
- Report Number
- Work Order Number
- Serial Number and/or Unit Number
- Aircraft Number
- ISR, EVA and R&D Number (if applicable)
- Operator
- Component sketch illustrating the defects detected
- Calibration reference standards used
- Inspection results
- Disposition of parts (Accept/Reject)

6 Requirements

6.1 Interpretation and Evaluation of Indications

6.1.1 General

6.1.1.1 This specification does not specify the exact acceptance criteria. The acceptance criteria shall be defined by the applicable process specification, material specification, drawing and specific engineering documents.

6.1.1.2 This specification provides a general procedure for characterization and evaluation of indications.

6.1.2 **Detection of Discontinuity**

6.1.2.1 When inspecting a part, any observed signal variation can be classified as an indication.

6.1.2.2 Any indication shall be classified as relevant indication or non relevant indication. Non relevant indications can appear from structural or geometrical configuration of the part like edges, interfaces, change of thickness, non parallel front and back surfaces, holes, etc. Non relevant indications can also result from interaction with external objects to the part like water or excess coupling, clamps, tooling, tape, etc. Non relevant indications shall be determined but not reported. Recurring non relevant indications shall be acknowledged and documented in the specific instructions by the applicable technique sheet and/or procedure.

6.1.2.3 A relevant indication shall exceed the minimum recordable size. Relevant indications shall be sized and located to determine if they exceed the requirements of the applicable acceptance criteria as individual or multiple indications. All indications exceeding the acceptance requirements based on size and characterization shall be reported.

6.1.2.4 Any rejectable indications shall be reported, and classified (i.e., delamination, disbond, unbond, foreign material, porosity, voids, etc.). Also, its specific location on the part with clear references (i.e., position, size and depth) from reference side (t/s or b/s) shall be reported. If the technique employed cannot determine flaw characterization, an alternative technique shall be used at the discretion of the Bombardier Toronto (de Havilland) UT Level 3.

6.1.3 **Acceptance Criteria**

6.1.3.1 Acceptance criteria shall be as specified on the engineering drawing. If not specified on the drawing, then acceptance criteria shall be according to the specific program Stress Engineering Damage Allowable Scenario Reports. If acceptance criteria is not specified on the drawing or by the specific program Stress Engineering Damage Allowable Scenario Reports, then acceptance criteria shall be according to the applicable process or material specification.

6.1.3.2 The acceptance criteria are based on size, location, proximity or density for individual defects.

6.2 Inspection Documentation

6.2.1 General

6.2.1.1 An inspection report or traveller documentation shall be prepared for each part or group of parts and filed in accordance with contractual or Quality Assurance (QA) requirements as appropriate.

6.2.1.2 The report shall include the date of inspection, reference to this specification, the approved written instruction/technique or procedure, part number(s) and serial number(s), reference standard used (including applicable S/N), inspector name, employee number and level of certification, acceptance criteria and indicate whether the part(s) was accepted or rejected, including any Non Conformity Report (NCR) references.

6.2.1.3 Maintain copies of all inspection records, reports and/or traveller documentation on file.

6.2.2 Inspection Results

6.2.2.1 Acceptance criteria for discrepancies requirements are documented in specific program Stress Engineering Damage Allowable Scenario Reports and Process Specifications.

6.2.2.2 Components that do not conform to the acceptance criteria or exceeds the maximum allowable defect size requirements defined in the documentation or Engineering drawings shall be rejected.

6.2.2.3 Non Conformity Report (NCR) shall include the defect's characterization, location (with specific references to aircraft datum lines, EOP, particular geometric reference points, etc.), depth (referencing from t/s or b/s), size (area for porosity, length and width for all others) and specific reference to the applicable specification rejection criteria (including Section, Table and page number).

6.3 Disposition of Rejectable Parts

6.3.1 All rejected components shall be clearly identified as rejected, and quarantined for Engineering disposition. The parts shall be identified and traceable to a Bombardier Aerospace Non Conformity Report (NCR).

6.3.2 All the relevant defect information such as defect type, size, shape and location (traceable to the part, and approximate depth) and relevant calibration C-scans shall be recorded and documented in accordance with Bombardier Aerospace Non Conformity Report (NCR) Procedure. Maintain copies of photographs, hardcopy of C-scans and/or

overlays to ensure accuracy of translating the defect information back to the defective area(s) on the part. Inspection records shall be retained for a retention period outlined per Quality Assurance requirements.

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.**

7.3 **Material covered by this specification may be toxic, flammable and/or irritating to the skin. Consult the Environment, Health and Safety Department for specific handling precautions.**

7.4 **Personnel operating automated systems shall be aware of and responsible for areas of equipment motion and specific danger zones that require placement of warning placards.**

8 Personnel Requirements

8.1 Personnel who are engaged in specifying, reviewing, monitoring or evaluating test methods must be qualified UT Level 3 according to BAERD GEN-012.

8.2 Personnel responsible for performing ultrasonic inspection of fibre reinforced composite parts must be certified according to BAERD GEN-012.

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