BOMBARDIER

Toronto Site

PROPRIETARY INFORMATION

PPS 35.08

PRODUCTION PROCESS STANDARD

REQUIREMENTS FOR ALUMINUM ALLOY FORGINGS

Issue 8
- This standard supersedes PPS 35.08, Issue 7.
- Vertical lines in the left hand margin indicate technical 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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Signed original on file. Validation of paper prints is the responsibility of the user.

Issue 8 - Summary of Changes (over the previous issue)

The following summaries are not detailed and are intended only to assist in alerting PPS users to changes which may affect them; refer to the applicable sections of this PPS for detailed procedure and requirements.

- Specified that this PPS is categorized as a controlled critical process according to PPS 13.39.
- Specified that all testing and evaluation specified herein must only be performed by Bombardier Toronto Materials Laboratory or by laboratories accredited according to BAERD GEN-018.
- Added requirement to refer to PPS 13.39 for additional personnel requirements.

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Tables

1 SCOPE

1.1 This standard specifies the inspection requirements for aluminum alloy hand and die forgings.

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, all materials must 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 BAERD GEN-018 - Engineering Requirements for Laboratories.

3.2 LAB 011 - Test Piece - Standard Round, *Bombardier Toronto Laboratory Drawing*.

3.3 PPS 13.26 - General Subcontractor Provisions.PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.4 PPS 20.03 - Fluorescent Penetrant Inspection.

3.5 PPS 20.04 - Ultrasonic Inspection of Metals.

3.6 PPS 30.01 - Heat Treatment of Aluminum and Aluminum Alloys.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Aluminum alloy forging materials as specified by the engineering drawing (e.g., QQ-A-367, AMS 4149, AMS 4108, etc.).

4.2 Equipment

4.2.1 The equipment used for production of aluminum alloy forgings must be at the discretion of the forge house. It is the responsibility of the forge house to ensure that their equipment is capable of producing satisfactory forgings which meet the requirements of this PPS, the engineering drawing, and the applicable material specification.

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 aluminum alloy hand and die forging 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 must 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 Engineering 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 aluminum alloy hand and die forging 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 All testing and evaluation specified herein must only be performed by Bombardier Toronto Materials Laboratory or by laboratories accredited according to BAERD GEN-018.

5 PROCEDURE

5.1 General

5.1.1 For the purposes of this PPS, the term “MRB” (Material Review Board) must be considered to include Bombardier Toronto MRB and Bombardier Toronto delegated MRB.

5.1.2 For the purposes of this PPS, “LOT” is defined as a batch of parts of the same part number produced in a continuous working period from the same heat of material and heat treated in one furnace load.

5.1.3 For each forging, a Process Control Document (PCD) must be developed and maintained by the forging manufacturer. Once established and approved as specified herein, the PCD must be adhered to.

5.1.3.1 The PCD must define the overall manufacturing process including statistical process control, purchasing and acceptance of raw materials, processing equipment, manufacturing processes, process flow chart, batch/lot acceptance, packaging, shipping and quality control requirements for assuring consistent, uniform and compliant products. All specifications and test procedures employed during the process must also be listed and issue/date controlled on the PCD. All recorded data must be traceable to a batch/lot of material. The PCD must have a unique number relating to this specification and carry an issue/revision status. The PCD must be signed by the manufacturer, Bombardier Engineering and Bombardier Quality and must not be changed without prior written approval. The PCD and all production data must be available to any Bombardier Aerospace auditors when requested.

5.2 Forging

5.2.1 The procedure for the manufacture of forgings is at the discretion of the forge house. It is the responsibility of the forge house to ensure that their practices are capable of producing satisfactory forgings which meet the requirements of this PPS, the engineering drawing, and the applicable material specification. Record the optimum technique, once established, on a PCD. The process must be re-qualified if there is any technical changes (e.g., processing parameter, material, etc.) made to the Bombardier approved PCD. If unclear whether the change in question is technical in nature, contact Bombardier prior to implementing such change on production parts.

5.3 Heat Treatment

5.3.1 Unless otherwise specified by the engineering drawing, heat treatment of forgings must be carried out according to PPS 30.01. The applicable PCD must include heat treatment details. The Bombardier approved PCD must be adhered to.

5.3.2 All forgings must be heat treated to the precipitation hardened temper specified in the final heat treat column on the engineering drawing.

6 REQUIREMENTS

6.1 Inspection Schedule

6.1.1 Except where otherwise specified by the engineering drawing, inspect forgings according to the requirements specified in Table I.

TABLE I - INSPECTION SCHEDULE (NOTE 1)

INSPECTION	APPLICABLE SECTION	QUALIFICATION TESTING (NOTE 2)	PRODUCTION TESTING
Visual	6.2	Yes	100%
Dimensional	6.3	Yes	100%
Fluorescent Penetrant	6.4	Yes	100%
Ultrasonic	6.5	Not applicable	100%
Grain Flow	6.6	Yes	Not applicable
Mechanical Properties	6.7.1	Yes	Not applicable
	6.7.2	Not applicable	Two forged test coupons (Note 3) to be supplied with each lot of forgings when specified on the engineering drawing or purchase order or when the forgings are heat treated by a facility other than the supplier.
Hardness and Conductivity	6.8	Not applicable	100%

Note 1. Special inspection schedule requirements specified by the engineering drawing, if any, take precedence over the inspection schedule requirements specified herein.
Note 2. Qualification testing must be carried out for each new die or significantly reworked die. The supplier must submit one die forging sample to Bombardier Toronto for qualification and die approval.
Note 3. Forged test coupons must be of the same heat as the lot of forgings they represent and must be forged and heat treated together with the represented parts.

6.2 Visual Inspection

6.2.1 All forgings must be of uniform quality and condition, free from blisters, fins, folds, seams, laps, cracks, segregation, spongy areas or other defects.

6.2.2 The surface finish of forgings must be a maximum of 125 RMS. Deep scratches, gouges or tool marks are not acceptable.

6.2.3 Blended flash areas which are not to be subsequently machined must be reasonably straight. Undercutting of the actual forging is not acceptable.

6.3 Dimensional Inspection

6.3.1 Ensure that forgings conform to the dimensional requirements of the engineering drawing. First article forgings must be inspected for all the dimensions specified by the engineering drawing (i.e., 100% dimensional inspection) with all measurement results recorded and maintained on file. All production parts produced after the first article forging must be checked (e.g., using a suitable checking fixture) to ensure compliance with the engineering drawing limits. Refer parts which do not meet the engineering drawing limits to MRB for disposition.

6.4 Fluorescent Penetrant Inspection

6.4.1 Forgings must be fluorescent penetrant inspected according to PPS 20.03. Evidence of any defects specified in paragraph 6.2.1 must be cause for rejection.

6.5 Ultrasonic Inspection

6.5.1 Ultrasonically inspect forgings according to PPS 20.04. The requirements of the engineering drawing and PPS 20.04 must be met.

6.6 Grain Flow

6.6.1 The sample forging must be sectioned and etched and the grain flow pattern must be examined by a laboratory as specified in paragraph 4.3.3.2. The location of the cross-section must be as specified on the engineering drawing or must be as such to represent the principal sections of the forgings. The grain flow pattern must not show any sharp re-entry flow lines or any discontinuities in the grain flow, other than at the forging parting line. If the grain flow is found to be satisfactory, the sample forging or photograph must be retained as a quality standard.

6.7 Mechanical Properties

6.7.1 Qualification Testing

6.7.1.1 Where possible, two tensile test specimens must be prepared according to paragraph 6.7.1.2 from the qualification sample sectioned according to section 6.6. If it is not possible to prepare the tensile test specimens from the sectioned forging, one additional forging may be requested from the supplier.

6.7.1.2 Tensile test specimens must conform to the dimensions of the largest possible LAB 011 test specimen and must be selected as follows:

- Unless otherwise specified, test specimens must be selected at random, with one specimen having its axis parallel to the direction of forging grain flow lines and the other having its axis transverse to the forging flow lines.
- If the forging drawing shows cross-hatched areas, with minimum mechanical properties referenced to such areas, the tensile test specimens must be cut from the cross-hatched areas.
- Mechanical properties of the test specimens must meet the requirements specified in Table II or the minimum requirements specified on the engineering drawing.

6.7.2 Production Testing

6.7.2.1 One of the forged test coupons specified in Table I must be machined to dimensions of the largest possible LAB 011 test specimen.

6.7.2.2 Mechanical properties of the machined test coupon must meet the requirements specified in Table II or the minimum requirements specified on the engineering drawing.

TABLE II - MECHANICAL PROPERTIES OF DIE FORGINGS (NOTE 1)

ALLOY AND TEMPER	MAXIMUM HEAT TREAT SECTION THICKNESS (INCHES)	MINIMUM TENSILE STRENGTH (PSI)	MINIMUM YIELD STRENGTH AT 0.2% OFFSET (PSI)	MINIMUM % ELONGATION IN 2 INCHES OR 4D	
				FORGING	TEST COUPON
TEST SPECIMENS PARALLEL TO FORGING FLOW LINES					
2014-T6	Up to 1.0	65000	56000	6	8
	Over 1.0 to 2.0	65000	56000	6	Note 2
	Over 2.0 to 3.0	65000	55000	6	Note 2
	Over 3.0 to 4.0	63000	55000	6	Note 2
6061-T6	Up to 4.0	38000	35000	7	10
7075-T73	Up to 3.0	66000	56000	7	10
	Over 3.0 to 4.0	64000	55000	7	10
7175-T736	Up to 3.0	76000	66000	7	—
7175-T74					
TEST SPECIMENS NOT PARALLEL TO FORGING FLOW LINES					
2014-T6	Up to 1.0	64000	55000	3	—
	Over 1.0 to 2.0	64000	55000	2	—
	Over 2.0 to 3.0	63000	54000	2	—
	Over 3.0 to 4.0	63000	54000	2	—
6061-T6	Up to 4.0	38000	35000	5	—
7075-T73	Up to 3.0	62000	53000	3	—
	Over 3.0 to 4.0	61000	52000	2	—
7175-T736	Up to 3.0	71000	62000	4	—
7175-T74					

Note 1. For hand forgings, refer to the applicable material specification for the required mechanical properties.
Note 2. When separately forged test coupons are used to verify acceptability of forgings in the indicated thicknesses, the properties specified for thicknesses up to 1.0" including test coupon elongation, apply.

6.8 Hardness and Conductivity

6.8.1 Hardness and conductivity testing of heat treated forgings must be carried out according to PPS 30.01.

6.9 Rejections

6.9.1 Qualification Testing

6.9.1.1 Failure of the qualification sample forging to meet all of the requirements of the inspection methods specified in Table I must be cause for rejection of the die.

6.9.1.2 Where a die sample has been rejected, Bombardier Quality may request a further sample for qualification testing or, if deemed necessary, may request rework of the die with a subsequent qualification test.

6.9.2 Production Testing

6.9.2.1 Failure of any forging to meet all the requirements of this standard must be cause for rejection of the forging. If a rejected forging is part of a sample representing a lot, each forging in the lot must be submitted for applicable inspection and any forging in the represented lot that do not meet the requirements must also be rejected.

6.9.2.2 Failure of a test coupon to meet all of the requirements specified in section 6.7.2 must be cause for rejection of the represented lot of forgings. If a lot of forgings rejected on the basis of a failed test coupon is to be re-heat treated, the second test coupon provided with the lot must be re-heat treated with the forgings and must be re-submitted for mechanical property testing. Failure of the second test coupon to meet all of the requirements specified in section 6.7.2 must be cause to reject and submit the lot of forgings to MRB.

7 SAFETY PRECAUTIONS

7.1 Safety precautions applicable to the materials and procedures specified herein must be defined by the subcontractor performing such 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 ADDITIONAL INFORMATION

9.1 Reports must be furnished by the supplier with each shipment of forgings, certifying the physical properties and chemical composition of each lot, together with other pertinent data as required by the purchase order and the applicable drawings.

9.2 Depending on size, each forging, or bag or bundle of forgings, must be rubber stamped with the applicable receiving slip number.