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BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 35.04

PRODUCTION PROCESS STANDARD

REQUIREMENTS FOR STEEL FORGINGS

Issue 7
- This standard supersedes PPS 35.04, Issue 6.
- 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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1 SCOPE

1.1 This Production Process Standard (PPS) specifies the requirements for steel forgings.

1.1.1 This PPS complements the engineering drawings that specify its use as an authorized instruction. The procedure specified in this PPS shall 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. Similarly, the procedure and requirements specified in this PPS are not applicable when use of a BAPS, MPS, LES or P. Spec. is specified.

2 HAZARDOUS MATERIALS

2.1 Before receipt at Bombardier Toronto, all materials shall 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 Bombardier Toronto Laboratory Drawing - LAB 011.

3.3 PPS 13.26 - General Subcontractor Provisions.

3.4 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.5 PPS 15.01 - Part Marking.

3.6 PPS 20.01 - Magnetic Particle Inspection.

3.7 PPS 20.03 - Fluorescent Penetrant Inspection.

3.8 PPS 30.04 - Steel Heat Treatment - Carbon and Low Alloy Steels.

3.9 PPS 31.03 - Cleaning of Carbon and Low Alloy Steels.

3.10 Federal Test Method, Standard No. 151 - Metals, Test Methods.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Not applicable to this PPS.

4.2 Equipment

4.2.1 Not applicable to this PPS.

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 utilize this PPS.

4.3.2 Bombardier subcontractors shall direct requests for approval to Bombardier Supplier Quality Management. Bombardier facilities shall 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. The facility report shall 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 shall 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 shall be prepared to demonstrate their capability. Once approved, no changes to subcontractor facilities may be made without prior written approval from Bombardier Toronto Engineering.

4.3.3.1 For approval of subcontractor facilities to utilize this PPS, completion of a test program and submission of suitable test samples representative of production parts is required. Test samples shall meet the requirements specified in section 6.

4.3.3.2 All testing and evaluation specified herein shall only be performed by Bombardier Toronto Materials Laboratory or by laboratories accredited according to BAERD GEN-018.

4.3.4 Each specific facility shall demonstrate its ability to repeatedly produce forgings which meet the requirements of this PPS, the engineering drawing, and the applicable materials specifications by providing batch release data for the past 10 consecutive batches of production forgings of similar configuration as the parts to be supplied to Bombardier Toronto.

4.3.5 The procedure for the manufacture of forgings is at the discretion of the foundry. It is the responsibility of the foundry to ensure that the foundry practices are capable of producing satisfactory forgings which meet the requirements of this specification, the engineering drawing, and the applicable material specification.

5 PROCEDURE

5.1 Not applicable to this PPS.

6 REQUIREMENTS

6.1 General

6.1.1 All testing and evaluation specified herein shall only be performed by Bombardier Toronto Materials Laboratory or by laboratories accredited according to BAERD GEN-018.

6.1.2 For the purposes of this standard, a “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.

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

6.1.4 Unless otherwise specified on the engineering drawing, furnish steel forgings in the form of die forgings.

6.1.5 Produce forgings from suitable forging stock of the composition and alloy specified on the engineering drawing.

6.1.6 Clean all forgings according to PPS 31.03 before delivery.

6.2 Heat Treatment

6.2.1 Perform heat treatment of forgings according to PPS 30.04.

6.2.2 If the final heat treatment or condition is not specified on the engineering drawing, refer to Bombardier Toronto Engineering to designate the condition required for the applicable forging.

6.2.3 If a forging is to have a final strength range of a normalized condition, the forging shall be hardened and tempered back to 95 to 110 ksi in place of normalizing and tempering except as noted below:

- Normalize and temper parts forged from AMS 6418 (Hy Tuf) that are welded into an assembly according to PPS 30.04 after forging.

TABLE I - INSPECTION SCHEDULE

INSPECTION METHOD	APPLICABLE SECTION	QUALIFICATION TESTING (NOTE 1)	PRODUCTION TESTING (NOTE 3)
Visual	section 6.4	Yes	100%
Dimensional	section 6.5	Yes	100%
Magnetic Particle or Fluorescent Penetrant	section 6.6	Yes	100% as follows: • Before machining • After machining • After all heat treatments
Grain Size	section 6.7	Yes	One per LOT
Grain Flow	section 6.8	Yes	N/A
Flash Removal	section 6.9	Yes	100%
Mechanical Properties	section 6.10	N/A	One test coupon (Note 2) to be supplied with each LOT of forgings: a) When forgings are hardened and tempered. b) Forgings heat treated to 180 ksi and higher. c) Forgings heat treated by Bombardier.
Hardness	section 6.11	N/A	According to Table II
Ultrasonic	section 6.13	N/A	100%

Note 1. Carry out qualification testing for each new die or significantly reworked die. The supplier shall submit one die sample forging to Bombardier for qualification and die approval.
Note 2. Forged test coupons shall be of the same heat as the LOT of forgings they are to represent and shall be forged and heat treated together with the represented forgings.
Note 3. If any failed forging is determined within the sample size, 100% inspect the LOT and disposition the LOT according to section 7.

TABLE II - SAMPLING FOR HARDNESS TESTING

LOT SIZE	SAMPLE SIZE (NOTE 1)
2 - 44	All
45 - 64	44
65 - 110	60
111 - 180	67
181 - 300	73
301 - 780	78
Over 780	78

Note 1. If any failed forging is determined within the sample size, 100% inspect the LOT and disposition the LOT according to section 7.

6.3 Inspection Schedule

6.3.1 Inspect forgings according to the requirements of Table I.

6.4 Visual Inspection

6.4.1 All forgings shall be of uniform quality and condition, free from blisters, fins, folds, seams, laps, cracks, segregation, spongy areas, or other defects, and within the drawing dimensions.

6.5 Dimensional Inspection

6.5.1 Ensure that forgings conform to the dimensional requirements of the engineering drawing.

6.6 Magnetic Particle and Fluorescent Penetrant Inspection

6.6.1 All forgings shall be magnetic particle inspected according to PPS 20.01, or if necessary fluorescent penetrant inspected according to PPS 20.03. This shall be performed before and after machining and after all heat treatments.

6.6.2 Forgings shall be free from laps, seams, splits, cracks, nicks, pits and voids.

6.7 Grain Size

6.7.1 With the first order of forgings, submit one additional forging to Bombardier Toronto Materials Laboratory for examination.

6.7.2 Select one forging from the initial order at random for sectioning, etching followed by examination of the grain size.

6.7.3 When requested by Bombardier, or after any major change in the forging technique, or dies, the grain size shall be re-examined.

6.7.4 Bombardier may waive the above requirements where the size and shape of the forgings make sectioning impossible.

6.8 Grain Flow

6.8.1 The sample die forging shall be sectioned, etched and the grain flow pattern examined by the Bombardier Toronto Materials Laboratory.

6.8.2 Location of the cross-section shall be such as to represent principal sections of the forging or as required by the engineering drawing.

6.8.3 The grain flow pattern in the principal components of the forging shall be generally in the direction indicated on the engineering drawing.

6.8.4 The grain flow pattern shall be so called closed flow (i.e., where the grain flow generally follows the part surface contour, except at forging parting line). Open flow (i.e., where the grain flow lines break out at forging surface contours) is not acceptable, except at the forging parting lines.

6.8.5 The grain flow pattern shall not show any sharply re-entrant flow lines or any discontinuity in the grain flow other than at the forging parting line.

6.9 Flash Removal

6.9.1 Remove flash to within 0.030 inches of the surface. If possible, grinding or filing shall be done across the parting plane.

6.9.2 The surface finish shall not exceed 200 micro inches. Deep scratches, gauge or tool marks are not acceptable.

6.9.3 Blended flash areas that are not subject to subsequent machining shall be reasonably straight. Undercutting of the forging proper is not acceptable.

6.10 Mechanical Properties

6.10.1 If forgings are hardened and tempered by the supplier, the latter shall conduct suitable tests to establish that the mechanical properties meet the requirements of the engineering drawing and this PPS.

6.10.2 In addition, if the forgings are heat treated by the supplier to a strength of 180 ksi and higher, submit two test coupons fabricated according to paragraph 6.10.2.1, paragraph 6.10.2.2 or paragraph 6.10.2.3 to Bombardier Toronto with each LOT (see section 7.1) for testing by the Bombardier Toronto Materials Laboratory.

6.10.2.1 Each test coupon shall be taken from one forging of the LOT from a location as defined on the drawing.

6.10.2.1.1 If the drawing does not specify the location of the test piece, it shall be taken from the ruling section in such a way that wherever possible the axis of the specimen is substantially parallel to the grain flow.

6.10.2.1.2 Reports certifying the mechanical properties of the forgings shall indicate the location from where the test specimen was taken.

6.10.2.2 If it is not possible to obtain test specimen as in paragraph 6.10.2.1, specimens may be taken from a prolongation of the forging, in the direction of maximum reduction, of sufficient size to obtain a tensile test bar.

6.10.2.3 If neither paragraph 6.10.2.1 nor paragraph 6.10.2.2 is possible, a separate test coupon may be forged from the same bar, billet or bloom as the forgings it represents. The percentage reduction given to this test piece shall not be greater than the minimum amount of reduction given to the forging.

6.10.3 Forgings heat treated by Bombardier to a strength of 180 ksi and higher, shall have a test specimen machined from bar stock of the same alloy as the forgings represented included with each heat treat LOT.

6.10.3.1 Submit this specimen to an approved laboratory as specified in paragraph 6.1.1 for mechanical testing.

6.10.4 Test specimens shall conform in dimension and tolerance to LAB 011 or Federal Test Method, Standard No. 151, selecting the largest size of specimen obtainable from the forging.

6.10.5 The mechanical properties of the forgings shall meet the values specified in Table III unless otherwise specified on the engineering drawing.

6.10.6 If only the minimum or maximum UTS values are specified for a heat treated part, the range of acceptable tensile strength shall be 20 ksi above the minimum or below the maximum as applicable.

TABLE III - MECHANICAL PROPERTIES OF CARBON AND LOW ALLOY STEELS

UTS ksi	Yield Strength ksi at 0.002" Elongation	Round Specimens		Sheet Specimens		
		Minimum Elongation in 4D (%)	Minimum Reduction of Area (%)	Minimum Elongation in 2" (%)		
				Sheet < 0.032" thick	Sheet 0.032" - 0.060" thick	Sheet > 0.060" thick
125	103	17	55	5	7	10
150	132	14	52	4	6	9
180	163	12	47	3	5	7
200	176	10	43	3	4	6
260	217	Refer to the engineering drawing for the mechanical properties above 200 UTS value.				

6.11 Hardness Testing

6.11.1 Hardness test all forgings below 180 ksi except as noted below:

- Forgings that do not receive a specific hardening treatment, namely, forgings acceptable in the as forged or normalized condition.

6.11.2 The minimum and maximum hardness values on any one part shall not differ more than 4 Rockwell C points or equivalent. The values shall be within the range specified on the engineering drawing.

6.11.3 Table IV lists the approximate conversion figures from ultimate tensile strength (UTS) values to Rockwell Hardness values, and is applicable to carbon and low alloy steels only.

6.11.4 If only the minimum or maximum UTS values are specified for a heat treated part, the range of acceptable hardness values shall be the equivalent of 20 ksi above the minimum or below the maximum as applicable.

TABLE IV - UTS TO ROCKWELL HARDNESS

UTS ksi	Rockwell No.
90	B91
100	B96
110	C21
120	C25
125	C27
140	C31
150	C34

UTS ksi	Rockwell No.
160	C36
175	C39
180	C40
200	C43
220	C46
240	C48
260	C51

6.12 Welding

6.12.1 Welding is prohibited unless specifically indicated on the engineering drawing or unless written approval has been obtained from Bombardier Toronto Engineering prior to welding.

6.13 Other Inspection Methods

6.13.1 Additional examination such as ultrasonic testing is to be carried out if specified on the drawing.

6.13.2 If ultrasonic inspection is performed by the subcontractor, or by an outside facility for the subcontractor, the results are to be submitted with each forging so inspected.

7 DISPOSITION

7.1 Qualification Testing

7.1.1 Failure of the qualification sample forging to meet any of the requirements of the inspection methods specified in Table I, shall be cause for rejection of the die.

7.1.2 If a die sample has been rejected, Bombardier may request a further sample for qualification testing or, if deemed necessary, any request rework of the dies with a subsequent qualification re-test.

7.2 Production Testing

7.2.1 Failure of any forging to meet the requirements of this standard shall be cause for rejection of the forging.

7.2.2 If a rejected forging is part of a sample representing a LOT, submit each forging of the LOT to the appropriate inspection method for which the subject forging was rejected. Accept the forgings that meet the requirements. For forgings that do not meet the requirements, refer the part to MRB for disposition. Determine the cause of failure and take corrective action prior to commencing processing production parts.

7.2.3 Failure of a test coupon to meet the mechanical property requirements as specified in paragraph 6.10.5 shall be cause for rejection of the represented LOT of forgings. Determine the cause of failure and take corrective action prior to commencing processing production parts.

7.2.3.1 If a LOT of forgings which have been rejected on the basis of a failed test coupon, is to be re-heat treated, the second test coupon provided with the LOT shall be re-heat treated together with the forgings and shall be re-submitted for mechanical property testing.

7.2.3.2 Failure of the second test coupon to meet the mechanical property requirement shall be cause for rejection of the LOT pending MRB disposition.

8 SAFETY PRECAUTIONS

8.1 Not applicable to this PPS.

9 PERSONNEL REQUIREMENTS

9.1 Not applicable to this PPS.

10 ADDITIONAL INFORMATION

10.1 Chemical and Physical Properties

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

10.2 Masking

10.2.1 Mark each forging by rubber stamping according to PPS 15.01. The marking shall state the following:

- Part Number
- LOT Number
- Magnetic Particle or Penetrant Inspection, as applicable
- Trademark or name of Vendor (optional)

10.2.2 Box or place forgings which are too small for individual marking in suitable plastic bags and tag as above.