BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 30.11

PRODUCTION PROCESS STANDARD

STEEL CASE HARDENING (CARBURIZING)

Issue 12
- This standard supersedes PPS 30.11, Issue 11.
- 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 procedure and requirements for case hardening carbon and low alloy steels by gas carburizing.

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 AMS 2762 - Carburizing Carbon and Low Alloy Steel Parts.

3.2 BAERD GEN-018 - Engineering Requirements for Laboratories.

3.3 Bombardier Toronto Laboratory Drawings - LAB 045.

3.4 Bombardier Toronto form DH #3772A/3772B - Steel Heat Treatment Quality Control and Inspection Record.

3.5 PPS 13.26 - General Subcontractor Provisions.

3.6 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.7 PPS 16.20 - Temporary Corrosion Protection of Carbon and Low Alloy Steel Parts.

3.8 PPS 20.01 - Magnetic Particle Inspection.

3.9 PPS 20.08 - Hardness Testing of Metals.

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

3.11 PPS 31.04 - Degreasing Processes.

3.12 PPS 31.17 - Solvent Usage.

3.13 QDI-09-02 - Process Control - *Bombardier Toronto internal Quality procedure*.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 No materials specified herein.

4.2 Equipment

4.2.1 Protective gloves (e.g., DSC 422-3).

4.2.2 Aluminized fire-proof jacket and hood.

4.2.3 All equipment and facilities shall be approved by Bombardier as meeting the requirements of this PPS and applicable facility Quality Instructions (e.g., QDI-09-02).

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 case hardening carbon and low alloy steels by gas carburizing according to this PPS.

4.3.2 Bombardier subcontractors shall direct requests for approval to Bombardier Aerospace Supplier Quality Management. Bombardier Aerospace 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, if required. 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 Aerospace Supplier Quality Management.

4.3.3.1 For approval of subcontractor facilities to perform case hardening carbon and low alloy steels by gas carburizing according to 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.

5 PROCEDURE

5.1 General

5.1.1 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.

5.1.2 Gas carburizing is a method of case hardening during which carbon or low alloy steel parts are heated to a suitable temperature in a closed furnace containing a hydrocarbon gas atmosphere. The parts are held at this temperature for a sufficient length of time to allow a specific amount of carbon to diffuse into their surfaces.

5.1.3 If carburizing is specified on the engineering drawing, parts shall be gas carburized.

5.1.4 Include one LAB 045-1 or LAB 045-2 test piece, as specified in Table I, with each batch of parts being carburized. This test piece shall accompany the parts through all subsequent heat treatment operations. It is the responsibility of the facility processing work according to this PPS to include the test piece in the production batch.

TABLE I - TEST PIECE

REPRESENTED MATERIAL	TEST PIECE
1010	LAB 045-1
1020	
3310	LAB 045-2
9310 or SUPER IMPACTO	

5.1.5 Do not straighten, bend or rework case hardened surfaces unless authorized by MRB.

5.2 Heat Treat Records

5.2.1 All facilities processing work according to this PPS shall enter all records of heat treatment data on form DH #3772A/3772B or equivalent (see Figure 1 and Figure 2).

5.2.2 Records shall be stamped by the inspector responsible.

PART NO: _____
ISSUE: _____
NAME: _____
CONTRACT: _____

BOMBARDIER Inc.
de Havilland

STEEL HEAT TREATMENT
QUALITY CONTROL AND
INSPECTION RECORD

MATERIAL SPEC: _____ H.T. SPEC.
APPLICABLE SWG/DESIGN REQUIREMENTS
TENSILE: T.S. Y.S. E.
METALLOGRAPHIC: CARB. DECARB. OXID.
HARDNESS:
MISC.:

	RECORDING DATE	HEAT TREAT NO.	MATERIAL SOURCE REF.	WORK ORDER/JOB CARD NO.	QUANTITY MATERIAL OR PARTS	THICKNESS OR RULING SECTION	HEAT TREATMENT TEST RESULTS	INSPECTION REPORT	INSPECTION STAMP
1					A N S/R H/T		T.S. Y.S. E REPORT # HARDNESS - METALLO - MISC. -	DATE - ACCEPTED - REJECTED - RE H.T'D -	
2					A N S/R H/T		T.S. Y.S. E REPORT # HARDNESS - METALLO - MISC. -	DATE - ACCEPTED - REJECTED - RE H.T'D -	
3					A N S/R H/T		T.S. Y.S. E REPORT # HARDNESS - METALLO - MISC. -	DATE - ACCEPTED - REJECTED - RE H.T'D -	
4					A N S/R H/T		T.S. Y.S. E REPORT # HARDNESS - METALLO - MISC. -	DATE - ACCEPTED - REJECTED - RE H.T'D -	
5					A N S/R H/T		T.S. Y.S. E REPORT # HARDNESS - METALLO - MISC. -	DATE - ACCEPTED - REJECTED - RE H.T'D -	
6					A N S/R H/T		T.S. Y.S. E REPORT # HARDNESS - METALLO - MISC. -	DATE - ACCEPTED - REJECTED - RE H.T'D -	
7					A N S/R H/T		T.S. Y.S. E REPORT # HARDNESS - METALLO - MISC. -	DATE - ACCEPTED - REJECTED - RE H.T'D -	

NOTE: 1. MAKE ENTRIES IN INK.
2. RETAIN RECORD FOR 3 YEARS (MIN).
3. DO NOT DEFACE OR DESTROY
4. DO NOT REMOVE FROM H.T. AREA

DH3772A

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FIGURE 1 - DH FORM #3772A SAMPLE

BOMBARDIER INC.
de Havilland
STEEL HEAT TREATMENT RECORD

PART NO. _____ NAME: _____ SHEET NO._____

	HEAT TREAT REF. NO.	NORMALIZE F	STRESS RELIEVE F	AUSTENIZE F	DEW POINT	QUENCH MEDIUM	TEMPER F	MISCELLANEOUS (ANNEAL ETC.)
1		TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	1- 2- 3- 4- 5-	OIL WATER SALT F	TEMP - SOAK - FURNACE # - CHART - DATE -	HEAT TREATER # -
2		TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	1- 2- 3- 4- 5-	OIL WATER SALT F	TEMP - SOAK - FURNACE # - CHART - DATE -	HEAT TREATER # -
3		TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	1- 2- 3- 4- 5-	OIL WATER SALT F	TEMP - SOAK - FURNACE # - CHART - DATE -	HEAT TREATER # -
4		TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	1- 2- 3- 4- 5-	OIL WATER SALT F	TEMP - SOAK - FURNACE # - CHART - DATE -	HEAT TREATER # -
5		TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	1- 2- 3- 4- 5-	OIL WATER SALT F	TEMP - SOAK - FURNACE # - CHART - DATE -	HEAT TREATER # -
6		TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	TEMP - SOAK - FURNACE # - CHART - DATE -	1- 2- 3- 4- 5-	OIL WATER SALT F	TEMP - SOAK - FURNACE # - CHART - DATE -	HEAT TREATER # -

DH3772B PAGE 2 I:\data\sf\3772.xls

FIGURE 2 - DH FORM #3772B SAMPLE

5.3 Heat Treatment Handling

5.3.1 Place or hang parts in suitable racks or supports to allow free circulation of the heating and quenching media and to prevent distortion and warpage during heating and quenching.

5.3.2 Parts shall be separated from one another by suitable means to prevent surface contact and masking of adjacent parts during heat treatment and carburizing.

5.3.3 During loading and unloading, take care to avoid nicks or other damage to the surfaces of finished parts.

5.3.4 Ensure furnaces are operating within the specified temperature range before loading parts. Set temperature control instruments at the middle of the specified temperature range.

5.4 Case Hardening Procedure

5.4.1 Perform case hardening as follows:

Step 1. If the manufacturing document (e.g., Process Sheet) specifies finish machining after carburizing, rough machine parts before carburizing to leave a maximum oversize of 20% of the specified minimum case depth (e.g., leave a maximum of 0.002" oversize if the specified case depth is 0.010" - 0.020"). Otherwise, finish machine parts to final size before carburizing.

Step 2. Stress relieve parts at the temperature specified in Table II for the time specified in Table III.

Step 3. Remove all traces of oil, grease or other surface contamination from parts by solvent cleaning according to PPS 31.17 or degreasing according to PPS 31.04.

Step 4. If the engineering drawing indicates areas which are not to be carburized, copper plate those areas to a thickness of 0.001" - 0.002" according to PPS 33.05.

Step 5. If contamination has occurred during the copper plating, clean parts by solvent cleaning according to PPS 31.17 or degreasing according to PPS 31.04.

Step 6. Perform carburization at the temperature specified in Table II for the time required to produce the case depth specified on the engineering drawing.

Step 7. Cool parts in a protective atmosphere to below 900°F. Further cooling to room temperature may be performed in air.

Step 8. Remove all traces of oil, grease or other surface contamination from parts by solvent cleaning according to PPS 31.17 or degreasing according to PPS 31.04.

Step 9. Pre-heat large or intricately shaped parts at the temperature specified in Table II for the time specified in Table III.

Step 10. Perform austenitizing at the temperature specified in Table II for the time specified in Table III. Use either a protective atmosphere or same atmospheric conditions employed for the carburizing diffusion cycle when austenitizing. Parts should not be exposed to oxygen at temperatures above 900°F. Soaking time commences when, after loading the furnace, all furnace control instruments have returned to the minimum of the specified austenitizing temperature range.

Step 11. Quench parts according to Table II. Agitate the quench bath and parts during quenching. Do not use air as a means of agitating the quench bath.

Step 12. If necessary, in order to meet the residual austenite requirements (i.e., complete transformation and provide desired microstructure), sub-zero quench parts according to PPS 30.02. For low alloy steel intricate shapes or if part design and thermal stresses may result in cracking, "snap temper" at 300°F ± 10°F for 1 to 2 hours before the sub-zero quench. Allow parts to cool to room temperature after quenching or quenching followed by "snap tempering", as applicable, before sub-zero quenching.

Step 13. Temper parts at the temperature specified in Table II for the time specified in Table III. If parts were sub-zero quenched, allow the parts to warm to room temperature before tempering operations.

TABLE II - HEAT TREATMENT TEMPERATURES

<table>
<tr><th>MATERIAL</th><th>STRESS RELIEF</th><th>CARBURIZING</th><th>PREHEAT</th><th>AUSTENITIZING</th><th>QUENCHING (Note 2)</th><th>TEMPERING</th></tr>
<tr><td>SAE 1010</td><td rowspan="4">1150 ± 25°F</td><td rowspan="4">1675 ± 25°F</td><td rowspan="4">1125 ± 25°F</td><td rowspan="2">1425 ± 25°F</td><td rowspan="2">in 60 to 80°F water</td><td rowspan="4">375 ± 25°F</td></tr>
<tr><td>SAE 1020</td></tr>
<tr><td>SAE 3310</td><td rowspan="2">1500 ± 25°F</td><td rowspan="2">in 70 to 150°F oil</td></tr>
<tr><td>SAE 9310 (Note 1)</td></tr>
<tr><td colspan="7">Notes: 1. If necessary, Atlas SUPER IMPACTO tool steel may be used as an alternate material for 9310.
2. Allow parts to cool to at least 150°F before removal from the quench bath.</td></tr>
</table>

TABLE III - MINIMUM SOAKING TIMES

HEAT TREATMENT	THICKNESS (Note 1)	MINIMUM SOAKING TIME (Note 2)
Preheating Austenitizing Stress Relieving	less than 0.100"	20 minutes
	0.100" - 0.249"	25 minutes
	0.250" - 0.500"	45 minutes
	0.501" - 1.000"	1 hour
	1.001" - 1.500"	1 hour 15 minutes
	1.501" - 2.000"	1 hour 30 minutes
	2.001" - 2.500"	1 hour 45 minutes
	2.501" - 3.000"	2 hours
	3.001" - 3.500"	2 hours 15 minutes
	3.501" - 4.000"	2 hours 30 minutes
Tempering	One hour per inch of thickness or fraction thereof (Note 1).	

Notes: 1. Thickness is the minimum dimension of the heaviest section of a part or the minimum dimension of a multi-layer load, whichever is greater.
2. Soaking time commences when, after loading the furnace, the temperature returns to the mid-range specified in Table II.

Step 14. Allow parts to cool in still air to room temperature.

Step 15. Finish machine any parts which were left oversized. Do not remove more than 20% of the minimum effective case depth by finish grinding after case hardening.

Step 16. Re-temper parts at the temperature specified in Table II for the time specified in Table III after any grinding or machining.

Step 17. Perform magnetic particle inspection according to PPS 20.01 on any parts which have been ground after case hardening.

Step 18. If the 0.001" thickness of copper plate on a close tolerance surface would cause fouling or interference with adjacent parts, strip the copper plate according to PPS 30.02 and then embrittlement relieve according to PPS 30.04. Otherwise, leave any copper plate used for masking on the finished part surface.

5.5 Protection of Parts for Shipping

5.5.1 Before shipping parts (either before or after carburizing), oil coat parts according to PPS 16.20.

6 REQUIREMENTS

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

6.2 Do not straighten, bend or rework case hardened surfaces unless authorized by MRB.

6.3 One LAB 045-1 or LAB 045-2 test piece, as specified in Table I, shall be included with each batch of parts being carburized. This test piece shall accompany the parts through all subsequent heat treatment operations.

6.4 Submit the test piece for microscopic examination and microhardness traverse according to PPS 20.08.

6.5 Any test piece failing to meet the case hardness, case depth and core hardness requirements specified in Table IV shall be cause for rejection of the represented batch of parts.

6.6 Any test piece showing evidence of carbide networks or retained austenite in the carburized case in excess of the limits specified in AMS 2762 shall be cause for rejection of the represented batch of parts.

TABLE IV - HARDNESS REQUIREMENTS

TEST PIECE	CORE HARDNESS (Note 1)	EFFECTIVE CASE DEPTH (Note 2)		CASE HARDNESS
LAB 045-1	157 - 240 VPN (50.5 - 61.5 R_A)	0.003" - 0.010"	0.010" - 0.020"	670 - 855 Knoop (57-65 R_C)
LAB 045-2	342 - 420 VPN (35 - 42.5 R_C)			

Notes: 1. Core hardness is representative of the test piece only and does not necessarily reflect actual core hardness of represented parts.
2. As determined by microhardness traverse to a minimum hardness of 576 Knoop (52 R_C).

7 SAFETY PRECAUTIONS

7.1 Safety precautions applicable to the materials and procedures specified herein shall be defined by the subcontractor performing the 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.