BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 30.05

PRODUCTION PROCESS STANDARD

STEEL CASE HARDENING - GAS NITRIDING

Issue 10
- This standard supersedes PPS 30.05, Issue 9.
- Vertical lines in the left hand margin indicate 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 heat treating and subsequent case hardening carbon and low alloy steels by gas nitriding.

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 2759/6 - Gas Nitriding and Heat Treatment of Steel Parts.

3.2 BAERD GEN-007 - Quality Control of Heat Treating Equipment and Hot Forming Equipment.

3.3 BAERD GEN-018 - Engineering Requirements for Laboratories.

3.4 DH Form #3772 - Steel Heat Treatment Record - Bombardier Toronto internal Quality procedure.

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 17.02 - Abrasive Blasting.

3.9 PPS 20.01 - Magnetic Particle Inspection.

3.10 PPS 20.08 - Hardness Testing of Metals.

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

3.12 PPS 31.04 - Degreasing Processes.

3.13 PPS 31.17 - Solvent Usage.

3.14 PPS 33.02 - Removal of Metallic Coatings.

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

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Nitriding grade steel alloys: MIL-S-6709, SAE 7140, AMS 6470.

4.2 Equipment

4.2.1 Air furnaces and salt baths used for heat treatment shall be equipped with pyrometric control, and chart recorder controlled according to BAERD GEN-007.

4.2.2 All equipment and facilities used in this process shall be approved by Bombardier Quality as meeting the requirements of PPS 30.04 and QDI-09-02.

4.2.3 Instrumentation and equipment shall be qualified according to BAERD GEN-007.

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 heat treating and subsequent case hardening carbon and low alloy steels by gas nitriding 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 heat treating and subsequent case hardening carbon and low alloy steels by gas nitriding 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 Gas nitriding is a method of case hardening during which specific nitridable grade steel alloys are heated at a suitable temperature in contact with a nitrogeneous gas (normally dissociated ammonia) for a sufficient length of time to form a hard, nitride-compound layer on the material to a specified case depth.

5.1.2 Perform gas nitriding (according to Flow Chart 1) only if specified by the engineering drawing.

5.1.3 Do not bend or straighten case hardened parts unless authorized by Bombardier Aerospace Toronto MRB or Bombardier Aerospace Toronto delegated MRB.

5.1.4 Take care to ensure test pieces remain with their respective batches of parts throughout the entire processing cycle.

5.1.5 The ability of a part to nitride properly is dependent upon its surface finish. A burnished or highly polished surface will not nitride satisfactorily.

5.1.6 Throughout this PPS, the term “thickness” is defined as the minimum dimension of the heaviest section of the part.

5.1.7 All facilities processing work according to this PPS shall complete DH Form #3772 for all heat treat operations. Each form shall be stamped by the responsible inspector and shall be kept in the heat treat records.

5.2 Hardening and Tempering

5.2.1 Preparation of Parts

5.2.1.1 Before hardening and tempering, remove all traces of oil, grease or other surface contamination from all parts by solvent cleaning according to PPS 31.17 or degreasing according to PPS 31.04.

5.2.2 Heat Treatment Handling

5.2.2.1 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.

5.2.2.2 Take care to ensure that parts being case hardened and heat treated are separated from one another by suitable means to prevent contact and masking of adjacent parts. Multi-layer loads (i.e., flat parts in contact) are prohibited.

5.2.2.3 Take care during loading and unloading to avoid nicks or other damage to the surfaces of finished parts.

5.2.2.4 Ensure that furnaces and baths are operating within the specified temperature range before being loaded. Set temperature control instruments at the middle of the specified temperature range.

5.2.3 Pre-Heating

5.2.3.1 Pre-heat large parts and parts of intricate shape at 1100°F to 1150°F for 15 minutes per inch of thickness or fraction thereof before transfer to the austenitizing furnace.

5.2.4 Austenitizing

5.2.4.1 Load parts into the furnace as quickly as possible.

5.2.4.2 Soak parts at 1700°F to 1750°F for 1 hour per inch of thickness or fraction thereof.

5.2.4.3 Use controlled atmosphere furnaces or other suitable heating medium employing a neutral or slightly oxidizing atmosphere.

5.2.4.4 After loading the furnace, the soaking time commences when the temperature has returned to the middle of the specified range or, when using a salt bath, the temperature has reached the minimum of the specified range.

5.2.5 Quenching

5.2.5.1 After soaking, quench parts in 70°F to 150°F oil within 15 seconds of removal from the furnace or salt bath.

5.2.5.2 Agitate the quench bath and the parts during quenching. Do not use air as a means of agitating the quench bath.

5.2.5.3 Allow parts to cool to 150° F or lower before removal from the quench bath.

5.2.6 Tempering

5.2.6.1 Perform tempering immediately after quenching.

5.2.6.2 Temper parts by soaking for the time and temperature specified in Table I, followed by cooling in still air to room temperature.

TABLE I - TEMPERING DATA

ULTIMATE TENSILE STRENGTH	TEMPERING TEMPERATURE	TEMPERING TIME	CRITICAL CROSS SECTION (Note 1)
130 - 150 ksi	1275 ± 25°F	1 hour per inch of thickness or fraction thereof	2.5"
170 - 190 ksi	1100 ± 25°F		1.0"

Note 1. Critical cross section size is the minimum dimension of the heaviest section of a part that will attain the specified tensile strength range when the part is hardened and tempered.

5.3 Rough Machining

5.3.1 After hardening and tempering, rough machine all parts to within 0.002" - 0.003" over the finished part dimensions on all surfaces to be nitrided.

5.3.2 Surfaces not to be nitrided, as specified on the engineering drawing, may be machined to finish dimensions before nitriding.

5.3.3 During manufacturing and heat treating, the steel alloy may be subjected to surface decarburization to the depth specified in Table II. Therefore, it is important to remove an amount of stock at least equal to the depth of decarburization from all surfaces to be nitrided.

TABLE II - DECARBURIZED SURFACE LAYER REMOVAL

NOMINAL STOCK DIAMETER OR DISTANCE A/F	MINIMUM DEPTH OF SURFACE LAYER REMOVAL
0.500" and under	0.030"
0.501" - 1.000"	0.035"
1.001" - 1.500"	0.040"
1.051" - 2.000"	0.050"
2.001" - 2.500"	0.060"
2.501" - 3.000"	0.070"

5.4 Protection of Parts for Shipping

5.4.1 Before shipping to a subcontractor for nitriding, ensure that parts are oil coated according to PPS 16.20 and suitably wrapped and packaged to prevent damage.

5.4.2 Subcontractors shall re-oil and re-wrap all nitrided parts as above before returning the parts to Bombardier Toronto or shipping them to another subcontractor.

5.5 Masking

5.5.1 Mask areas not to be case hardened, as specified on the engineering drawing, with a minimum thickness of 0.001" of copper, brass, tin or nickel plating.

5.6 Nitriding

5.6.1 Before nitriding, remove all traces of oil, grease or other surface contaminants from all parts by solvent cleaning according to PPS 31.17 or degreasing according to PPS 31.04. If necessary, grit blast parts using aluminum oxide according to PPS 17.02 to increase surface roughness.

5.6.2 Nitride parts to meet the requirements of this PPS and AMS 2759/6.

5.6.3 The Two-Stage (Floe) process, which produces a thinner white layer, is preferred to the Single-Stage Process.

5.7 Stripping of Plating

5.7.1 Strip the plating from masked parts according to PPS 33.02 after nitriding.

5.8 Embrittlement Relief

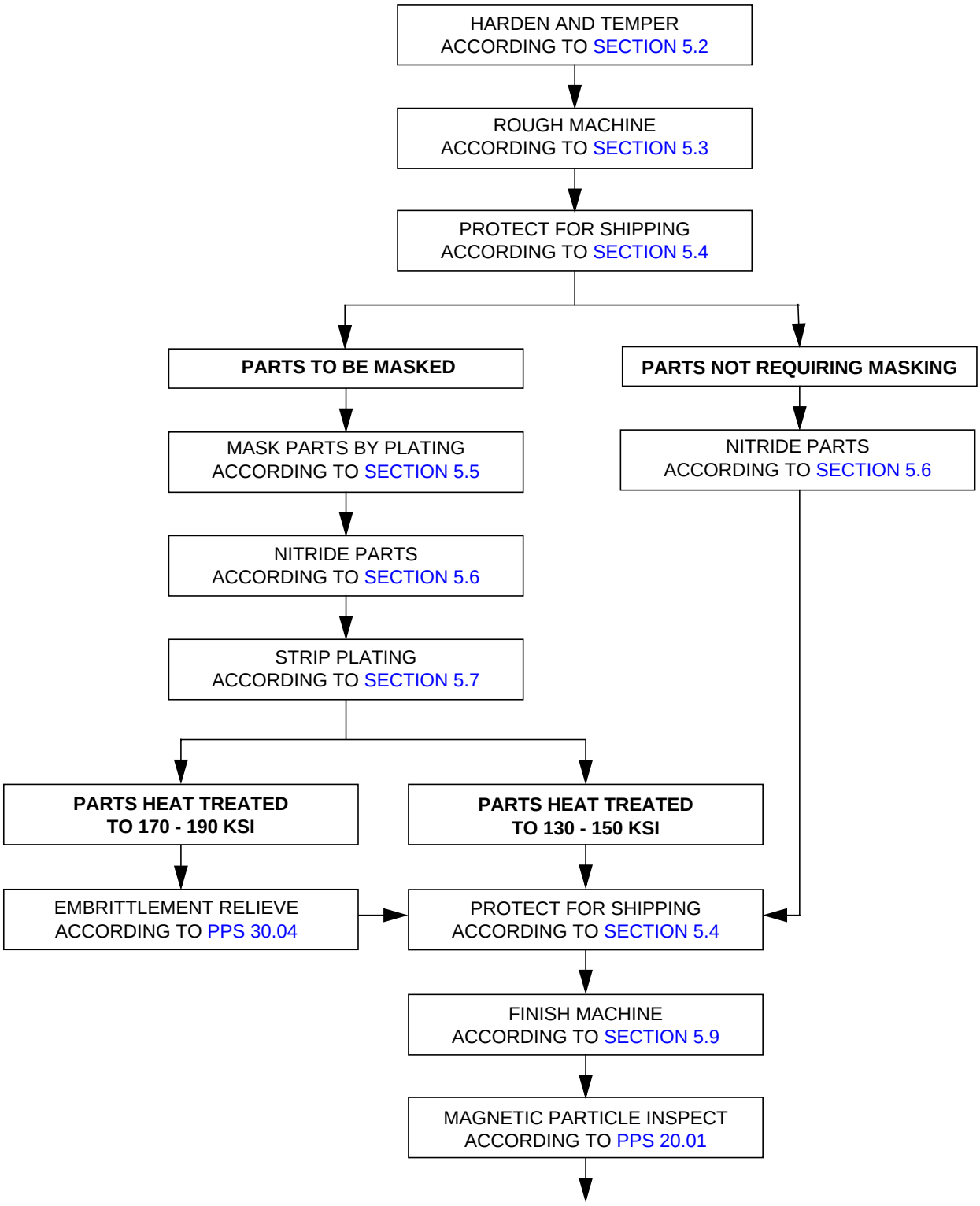
5.8.1 Within 4 hours of plating removal, embrittlement relieve all parts having a final heat treat temper of 170 to 190 ksi or greater according to PPS 30.04.

5.9 Finish Machining

5.9.1 After nitriding, finish machine all nitrided surfaces to size, removing a maximum of 0.003" of material per surface. Take care during finish grinding to prevent cracking of case hardened surfaces.

5.9.2 Magnetic particle inspect all finish ground parts according to PPS 20.01.

FLOW CHART 1 - GAS NITRIDING



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.

6.2 Test Piece

6.2.1 One test piece, having minimum dimensions of 1/2" diameter x 1/4" thickness and of the same material, condition and thermal history as the parts being treated, shall be included with each batch of parts being nitrided.

6.2.2 Submit the test piece to the Bombardier Toronto Materials Laboratory for metallographic examination to determine the total case depth, case quality, depth of white layer and case and core hardness.

6.2.3 Cut the test piece in half, through the diameter, and examine the cut face as specified in paragraph 6.2.4 through paragraph 6.2.8. Take care to prevent overheating when cutting the test piece. If the test piece has been machined smooth on one face only, examine the smooth surface.

6.2.4 Unless otherwise specified on the engineering drawing, the minimum total case depth shall be 0.015". Determine the total case depth by micro-hardness traverse to a point where the Vickers hardness is 700 VPN.

6.2.5 The finished case shall show a uniform distribution of nitrides, diminishing gradually from the surface to the core.

6.2.6 The case hardness, as measured using a suitable microhardness tester at a distance of 0.003" - 0.005" from the surface, shall be as specified in Table III.

6.2.7 The core hardness, as measured according to PPS 20.08 at the approximate centre of the test piece, shall be as specified in Table III.

6.2.8 The white layer on the surface of the test piece shall be 0.002" thick maximum.

6.2.9 Failure of the test piece to meet all of the above requirements shall be cause to reject the batch of represented parts.

6.3 Production Parts

6.3.1 Core Hardness

6.3.1.1 After hardening and tempering and before nitriding, one or more parts, as necessary, shall be hardness tested according to PPS 20.08.

6.3.1.2 If it is necessary to obtain hardness readings from a surface to be nitrided, the Rockwell 15N superficial hardness scale shall be used according to PPS 20.08.

6.3.1.3 A minimum of 3 hardness readings shall be taken on each part.

6.3.1.4 The minimum and maximum hardness readings obtained on each part shall differ no more than 3 Rockwell C points, or equivalent, and all values shall be within the range specified in Table III for the tensile strength range specified on the engineering drawing.

6.3.1.5 If a material or temper not listed in Table III is processed according to this PPS, core hardness shall be as specified in PPS 20.08.

6.3.2 Case Hardness

6.3.2.1 After finish grinding, one part from each batch shall be hardness tested on a suitable nitrided surface using a Vickers or Knoop microhardness tester.

6.3.2.2 The minimum acceptable case hardness shall be as specified in Table III.

TABLE III - CASE AND CORE HARDNESS LIMITS

FINAL HEAT TREAT TEMPER	CORE HARDNESS (Note 1)			MINIMUM CASE HARDNESS (Note 2)	
	Rockwell C	Rockwell 15N	Vickers (10 kg)	Vickers	Knoop
130 - 150 ksi	28.3 - 34.0	74.1 - 77.2	288 - 335	800 VPN (5 Kg)	830 (200 g)
170 - 190 ksi	38.0 - 41.3	79.4 - 81.1	372 - 406		

Note1. As hardened and tempered.
Note 2. Measured on part surface after grinding to finish size or on test piece at 0.003" - 0.005" from outer surface.

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.