BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 30.08

PRODUCTION PROCESS STANDARD

HEAT TREATMENT OF MARTENSITIC STAINLESS STEELS

Issue 16
- This standard supersedes PPS 30.08, Issue 15.
- 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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Figures, Tables and Flow Charts

1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for heat treatment of Types 410 and 431 martensitic corrosion resistant steel.

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-H-6875 - Heat Treatment of Steel Raw Materials.

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

3.5 Bombardier Toronto Laboratory Drawings - LAB 009, LAB 011, LAB 027 and LAB 045.

3.6 PPS 13.26 - General Subcontractor Provisions.

3.7 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.8 PPS 15.01 - Part Marking.

3.9 PPS 20.01 - Magnetic Particle Inspection.

3.10 PPS 20.08 - Hardness Testing of Metals.

3.11 PPS 30.02 - Sub-Zero Treatment of Steel Parts.

3.12 PPS 31.04 - Degreasing Processes.

3.13 PPS 31.05 - Surface Treatment of Corrosion Resistant Steels.

3.14 PPS 35.07 - Requirements for Investment and Sand Castings.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Argon, Compressed Gas Association (CGA) specification G-11.1, Grade C (dewpoint of -76°F or below, 5 ppm oxygen maximum).

4.1.2 Nitrogen, CGA specification G-10.1, Grade L (dewpoint of -90°F or below, 10 ppm oxygen maximum).

4.1.3 Ferric chloride in hydrochloric acid.

4.2 Equipment

4.2.1 General

4.2.1.1 Furnaces used for heat treatment shall be equipped with pyrometric control, and chart recorder controlled according to BAERD GEN-007.

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

4.2.2 Heating Equipment

4.2.2.1 Except as noted below, perform homogenizing, full annealing or austenitizing in air, vacuum, endothermic or inert atmosphere furnaces.

- Do not heat treat Type 431 steel in an endothermic or nitrogen-based atmosphere.

4.2.2.2 Perform sub-critical annealing, tempering, embrittlement relief and stress relief in air, neutral salt, vacuum furnaces or inert atmosphere furnaces. In salt baths, use salt that will not react adversely with the metals being heat treated. Do not use salt baths to heat treat parts in which salt is likely to become entrapped, such as tubes of intricate shapes and welded parts.

4.2.2.3 The design and construction of the heating equipment shall be such that the temperature at any point in the working zone, with any charge, does not exceed the heat treat temperature range during heating to temperature. Also, for operations other than tempering, the temperature shall not vary more than ± 25°F from the desired temperature after the charge has been brought up to temperature. For tempering operations, the temperature shall not vary more than ± 10°F from the desired temperature after the charge has been brought up to temperature.

4.2.2.4 Use automatic controlling and recording temperature measuring instruments, preferably of the potentiometric type. Adequately protect thermocouples located in the working zone.

4.2.2.5 Equip endothermic atmosphere furnaces with a dew point analyser, preferably of the fog chamber type (e.g., Alnor Dew Pointer or equivalent), used to set the appropriate dew point temperature according to the manufacturer's instructions.

4.2.2.6 The furnace atmospheres shall be such as to prevent carburization or decarburization of the surfaces of the parts. For parts heat treated to an ultimate tensile strength of 200 - 220 ksi or greater, control carburization/decarburization according to section 6.5.

4.2.2.7 The heating media in furnaces used to heat treat parts to temperatures of 1250°F and greater shall be controlled to prevent excess intergranular attack. Control intergranular attack according to section 6.6.

4.2.3 Quenching and Rinsing Equipment

4.2.3.1 Within the quenching tanks, provide adequate circulation of the quenching media and means for cooling or heating, as applicable. Do not use compressed air for agitation. Ensure the tanks are large enough for the work load involved and equip the tanks with temperature gauges.

4.2.3.2 At the start of the quenching operation, check that the oil temperature is 75 to 140°F. Unless otherwise specified, the oil temperature shall not exceed 200°F at any time during the quenching operation.

4.2.3.3 If heat treating in a vacuum furnace not equipped for drop bottom quenching, parts shall be quenched as follows:

- Flush Type 410 steel with either dry argon or nitrogen.
- Flush Type 431 steel with dry argon.

4.2.3.4 If salt baths are used, provide hot water rinse tanks to remove salt from the part surfaces. Equip the tanks with suitable heating coils to maintain the water at the boiling point.

4.2.4 Approval of Equipment

4.2.4.1 All equipment and facilities employed in carrying out the procedure specified herein shall be approved by Bombardier as meeting the requirements of this PPS and applicable facility Quality Instructions.

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 treatment of Types 410 and 431 martensitic corrosion resistant steel 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 treatment of Types 410 and 431 martensitic corrosion resistant steel 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 Heat Treat Records

5.1.1 Keep records of all heat treat operations, including information regarding Job Card number, part number, material type, furnace or bath, quantity of parts, heating time, soaking time and temperature, cooling time (if furnace cooled) and average Rockwell hardness.

5.1.2 Enter all records of heat treatment data on form DH #3772A/3772B or equivalent (see Figure 1 and Figure 2).

5.1.3 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

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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 -	TEMP -	TEMP -	1-	OIL	TEMP -	HEAT TREATER # -
		SOAK -	SOAK -	SOAK -	2-	WATER	SOAK -	
		FURNACE # -	FURNACE # -	FURNACE # -	3-	SALT	FURNACE # -	
		CHART -	CHART -	CHART -	4-	F	CHART -	
		DATE -	DATE -	DATE -	5-		DATE -	
2		TEMP -	TEMP -	TEMP -	1-	OIL	TEMP -	HEAT TREATER # -
		SOAK -	SOAK -	SOAK -	2-	WATER	SOAK -	
		FURNACE # -	FURNACE # -	FURNACE # -	3-	SALT	FURNACE # -	
		CHART -	CHART -	CHART -	4-	F	CHART -	
		DATE -	DATE -	DATE -	5-		DATE -	
3		TEMP -	TEMP -	TEMP -	1-	OIL	TEMP -	HEAT TREATER # -
		SOAK -	SOAK -	SOAK -	2-	WATER	SOAK -	
		FURNACE # -	FURNACE # -	FURNACE # -	3-	SALT	FURNACE # -	
		CHART -	CHART -	CHART -	4-	F	CHART -	
		DATE -	DATE -	DATE -	5-		DATE -	
4		TEMP -	TEMP -	TEMP -	1-	OIL	TEMP -	HEAT TREATER # -
		SOAK -	SOAK -	SOAK -	2-	WATER	SOAK -	
		FURNACE # -	FURNACE # -	FURNACE # -	3-	SALT	FURNACE # -	
		CHART -	CHART -	CHART -	4-	F	CHART -	
		DATE -	DATE -	DATE -	5-		DATE -	
5		TEMP -	TEMP -	TEMP -	1-	OIL	TEMP -	HEAT TREATER # -
		SOAK -	SOAK -	SOAK -	2-	WATER	SOAK -	
		FURNACE # -	FURNACE # -	FURNACE # -	3-	SALT	FURNACE # -	
		CHART -	CHART -	CHART -	4-	F	CHART -	
		DATE -	DATE -	DATE -	5-		DATE -	
6		TEMP -	TEMP -	TEMP -	1-	OIL	TEMP -	HEAT TREATER # -
		SOAK -	SOAK -	SOAK -	2-	WATER	SOAK -	
		FURNACE # -	FURNACE # -	FURNACE # -	3-	SALT	FURNACE # -	
		CHART -	CHART -	CHART -	4-	F	CHART -	
		DATE -	DATE -	DATE -	5-		DATE -	

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FIGURE 2 - DH FORM #3772B SAMPLE

5.2 Preparation of Material

5.2.1 Before heat treatment, identify all parts according to PPS 15.01.

5.2.2 Before heat treatment, clean all parts according to PPS 31.05.

5.2.3 Type 431 steel parts to be hardened and tempered to 125-145 ksi shall be heat treated as raw material before machining.

5.3 Heat Treatment Handling

5.3.1 Examine and clean heat treatment fixtures before processing parts. Ensure that any areas of the fixtures that come into contact with the parts are free of loose scale, dirt, oil, water, or any materials that are volatile or that may spall at the heat treatment temperature.

5.3.2 Place or hang parts in suitable racks or supports in a manner that allows free circulation of the heating and quenching media and minimizes distortion and warpage during heating or quenching.

5.3.3 Except when using a vacuum furnace, load parts by opening the furnace door, inserting the parts and closing the furnace door as rapidly as possible. When loading and unloading parts, avoid causing nicks or other damage to the surface of finished parts.

5.3.4 Except as noted below, set temperature control instruments at the correct soaking temperature and ensure that the furnace is operating at the specified temperature before loading parts.

- If parts are being pre-heated according to section 5.4 or if a vacuum furnace is being used, parts may be loaded at room temperature.

5.4 Pre-heating of Parts

5.4.1 Before annealing, homogenizing or austenitizing, pre-heat parts by heating the furnace to 1400°F to 1450°F and holding until all parts in the charge have reached that temperature. If pre-heating large parts, perform a preliminary pre-heat to 1000°F to 1050°F before pre-heating as above.

5.5 Heating and Soaking Time

5.5.1 Soak parts at the required temperature for not less than the specified time. The soaking time, as specified in Tables I through IV, commences when, after loading the furnace, 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.

TABLE I - SOAK TIMES

PROCESS	MINIMUM SOAK TIME	
	GAS/AIR	SALT BATH
TEMPER	Note 1	—
AUSTENITIZING AND ANNEALING THICKNESS	MINIMUM SOAK TIME (NOTE 4)	
	GAS/AIR	SALT BATH
under 0.250"	25	18
0.250" - 0.499"	45	35
0.500" - 0.999"	60	40
1.00" and over	Note 2	Note 3

Note 1. Soaking time shall be not less than two hours plus one hour additional for each inch of thickness or fraction thereof greater than one inch. Multiple tempering is permitted to reduce hardness. When multiple tempering is used, parts shall be cooled to ambient temperature or below between tempering treatments.
Note 2. 60 plus 15 minutes for every 0.5 inch or fraction thereof over 1.00 inch.
Note 3. 40 plus 5 minutes for every 0.5 inch or fraction thereof over 1.00 inch.
Note 4. The maximum soak time shall be the minimum + 15 minutes.

5.6 Annealing

5.6.1 If specified on the engineering drawing, perform full annealing and/or sub-critical annealing of parts according to Table II.

TABLE II - ANNEALING

ALLOY	FORM	SUBCRITICAL ANNEAL		FULL ANNEAL	
		HEATING	COOLING	HEATING	COOLING
410	Castings	Soak at 1250°F - 1400°F (Note 2)	Air cool to room temperature	Soak at 1500°F - 1600°F (Note 2)	See Note 1
431	Bar	Soak at 1150°F - 1300°F (Note 2)		Do not Full Anneal	

Note 1. Furnace cool at a rate of 50°F per hour to 1100°F and then air cool to room temperature.
Note 2. Soak time as specified in Table I.

5.7 Homogenizing

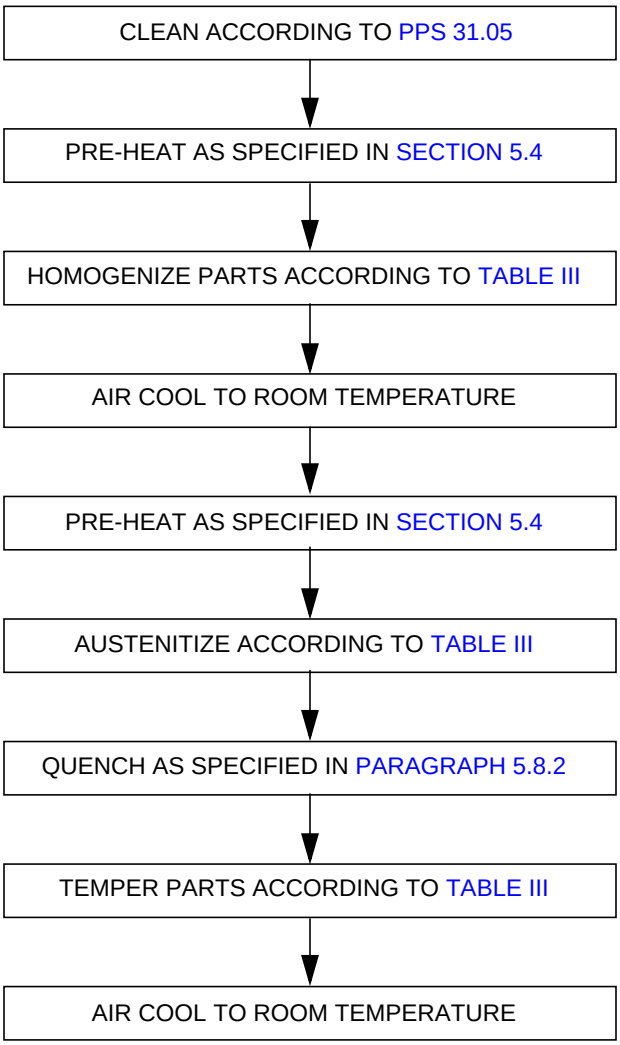
5.7.1 Before austenitizing, homogenize Type 410 steel parts according to Flow Chart 1.

5.8 Hardening (Austenitizing and Quenching) & Tempering

5.8.1 If specified on the engineering drawing, perform hardening and tempering according to Flow Chart 1 or Flow Chart 2, as applicable.

5.8.2 Quench parts as rapidly as possible. Degrease oil quenched parts according to PPS 31.04. If oil quenching is not possible, Type 410 steel parts that are 0.250" and less in thickness may be air quenched provided that the air circulates freely around the parts.

FLOW CHART 1 - HARDENING & TEMPERING TYPE 410 STEEL



FLOW CHART 2 - HARDENING & TEMPERING TYPE 431 STEEL

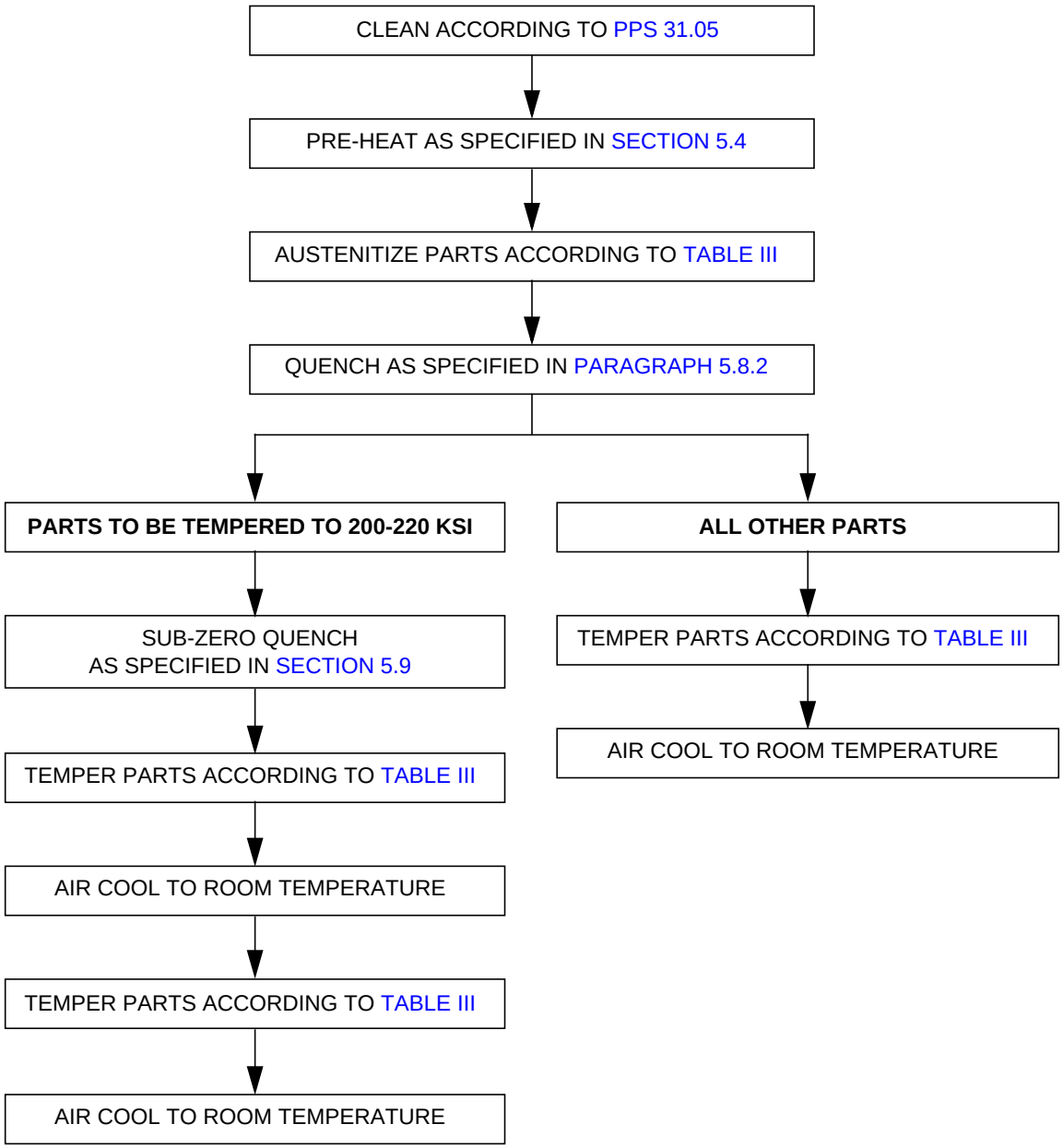


TABLE III - HARDENING & TEMPERING

ALLOY	FORM	HOMOGENIZING	AUSTENITIZING	SUGGESTED TEMPERING TEMPERATURES (Note 2)				
				ULTIMATE TENSILE STRENGTH (ksi)				
				95 - 115	125 - 145	125 - 160	180 - 215	200 - 220
410	Investment castings (AMS 5350)	1900 ± 25°F (Note 1)	1775 ± 25°F (Note 2)	1100°F min.	—	1050°F min.	575 to 700°F	—
431	Bar (MIL-S-18732)	N/A	1875 ± 25°F (Note 2)	—	1200 ± 10°F	—	—	500 ± 10°F

Notes:
1. Soak for 90 minutes for the first inch of thickness or fraction thereof and 30 minutes for each additional inch of thickness or fraction thereof.
2. Soak time as specified in Table I.
3. Thickness is defined as the minimum dimension of the heaviest section of a part, or the minimum dimension of a multi-layer load, whichever is greater.

5.9 Sub-Zero Quench/Tempering of Type 431 Steel

5.9.1 After hardening and before final tempering, Type 431 steel parts to be tempered to 200 - 220 ksi shall undergo a sub-zero quench/temper treatment as follows:

Step 1. Immerse parts in a refrigerant bath according to PPS 30.02.

Step 2. Allow the parts to soak for 2 hours.

Step 3. Immediately temper parts to the final heat treat temper.

5.10 Stress Relief

5.10.1 All parts having a final heat treat temper of 160 - 180 ksi or greater, which have been machined, cold formed or ground in the finish temper condition and are to undergo a pickling or plating operation, shall be stress relieved according to Table IV as soon as possible after such operations and before pickling or plating.

5.10.2 All parts having a final heat treat temper of 200 - 220 ksi or greater, which have been machined, cold formed or ground in the finish temper condition, shall be stress relieved according to Table IV as soon as possible after such operations.

TABLE IV - STRESS RELIEF

ALLOY	FORM	TEMPERATURE & TIME	COOLING
410	Castings	395 ± 25°F for 3 - 4 hours	Air cool to room temperature
431	Bar	450 ± 25°F for 4 - 5 hours	

5.11 Embrittlement Relief

5.11.1 If specified by the applicable cleaning or plating PPS, within 4 hours of cleaning or plating, perform embrittlement relief at 395 ± 25°F for 4 - 5 hours. Air cool to room temperature.

5.12 Salt Removal

5.12.1 If parts have been heated in a salt bath, use a rinse tank to remove all salt residue from parts before any further heating or machining operations as follows:

Step 1. Immerse parts in agitated hot water (over 130°F).

Step 2. Thoroughly rinse tube bores and similar parts by flushing through with clean water.

Step 3. Visually inspect for entrapped salt.

Step 4. If necessary, repeat this procedure until the salt is completely removed.

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 Magnetic Particle Inspection

6.2.1 If specified on the engineering drawing, magnetic particle inspect parts according to PPS 20.01.

6.3 Hardness Testing

6.3.1 Perform hardness testing as specified in this section on one part (or more parts, if necessary) from each batch of parts heat treated to a tensile strength of 125-145 ksi or greater that are to be machined after heat treatment.

6.3.2 Perform hardness testing as specified in this section on all parts heat treated to a tensile strength of 125 - 145 ksi or greater that are not to be machined after heat treatment.

6.3.3 After hardening and tempering, perform hardness testing as specified in this section on one casting from each lot.

6.3.4 On each part to be checked, take 3 hardness readings minimum.

6.3.5 Perform hardness testing on a suitable surface of the part according to PPS 20.08.

6.3.6 After hardening and tempering bar and rod stock material, cut a test piece from one bar from each furnace load of a length equal of the diameter or minimum thickness of the largest section. Hardness test at the approximate centre of the cut surface.

6.3.7 After hardening and tempering castings, perform hardness testing on a surface from which 0.010" minimum of material has been removed or, if this is not possible, on the sectioned surface of a scrap casting of the same lot and heat treat batch.

6.3.8 Minimum and maximum hardness values obtained on any one part shall not differ by more than 3 Rc points or equivalent and all values shall be within the range specified on the engineering drawing or in this PPS.

6.3.9 Refer to Table V for the specified Rockwell hardness range for each alloy and condition. If an alloy or temper is not specified in Table V, refer to PPS 20.08 for the acceptable hardness range.

TABLE V - MECHANICAL PROPERTIES (NOTE 1) & HARDNESS REQUIREMENTS

ALLOY	FORM	CONDITION	U.T.S. (ksi)	MIN. 0.2% YIELD STRENGTH (ksi)	MIN. % ELONGATION (Note 2)	MIN. % REDUCTION IN AREA	ROCKWELL HARDNESS
410	Investment castings (AMS 5350)	95 - 115 ksi	See PPS 35.07				B-94 - B-100
		125 - 160 ksi					C-27 - C-32
		180 - 215 ksi					C-40 - C-43
431	Bar (MIL-S-18732)	125 - 145 ksi	125 - 145	90	15.0	40.0	C-27 - C-32
		200 - 220 ksi	200 - 220	150	10.0	40.0	C-43 - C-46

Notes: 1. Mechanical property requirements apply to the longitudinal direction.
2. % elongation in 4D (round test bars) or 4.5A (rectangular test bars).

6.4 Tensile Testing

6.4.1 Wrought Alloys

6.4.1.1 If specified by the engineering drawing, for each furnace load of parts heat treated to a tensile strength of 200 - 220 ksi or greater, cut one tensile test specimen from the same material batch as that of the production parts.

6.4.1.2 Ensure that tensile test specimens conform to the Laboratory drawings specified in Table VI.

6.4.1.3 Submit test specimens for tensile testing.

6.4.1.4 Submitted test specimens shall meet the tensile strength requirements specified by the engineering drawing or in Table V. If only the minimum or maximum tensile strength values are specified, the acceptable range is 20 ksi above the minimum or below the maximum, as applicable.

6.4.1.5 If a tensile test specimen fails to meet the specified tensile strength requirements, reject the represented batch of parts.

TABLE VI - TENSILE TEST SPECIMEN RAW MATERIAL DIMENSIONS

LABORATORY DRAWING	BAR	
	Diameter	Length (Note 1)
None (Note 2)	under 0.250"	2"
LAB 027-1	0.250" - 0.374"	2"
LAB 011-9	0.375" - 0.499"	5"
LAB 011-7	0.500" - 0.561"	5"
LAB 011-5	0.562" - 0.749"	5"
LAB 011-3	0.750" - 0.874"	5.5"
LAB 009-1	0.875" and over	7"

Notes:
1. Dimensions given are finished part dimensions. For bar test specimens, unless the material is called up to be issued in length, it will be necessary to increase the length to accommodate chucking.
2. Cut to Bombardier Toronto Materials Laboratory instructions.

6.4.2 Castings

6.4.2.1 Tensile test castings according to PPS 35.07.

6.5 Carburization/Decarburization Control

6.5.1 Each batch of Type 431 steel parts to be heat treated to a final temper of 200 - 220 ksi shall have one LAB 045-7 carb/decarb control test specimen processed with the batch. It is the responsibility of the facility processing work according to this PPS to include the test piece with the production batch.

6.5.2 Anneal or austenitize the test piece along with the represented parts. Do not subject test specimens to sub-zero quenching, stress relief, embrittlement relief or tempering to final heat treat temper.

6.5.3 Submit the test specimen for examination according to paragraph 6.5.5.

6.5.4 If parts require re-heat treatment other than re-tempering, the carb/decarb control test specimen or remnants thereof, shall accompany the parts through such heat treat cycles.

6.5.5 Check for carb/decarb as follows:

Step 1. Cut the carb/decarb test specimen approximately in half through the 0.250" dimension.

Step 2. Perform a micro-hardness traverse at 0.001" intervals on the cut face.

Step 3. Take care during cutting to prevent tempering caused by heat generation.

Step 4. Retain the test specimen for examination according to section 6.6.

6.5.6 If there is evidence of an increase in hardness (due to carburization) at the surface of the sample, reject the represented batch of parts.

6.5.7 The depth of decarburization is defined as the perpendicular distance from the surface to the non-decarburized zone below which there is no increase in hardness.

6.5.8 There shall be no full decarburization and the depth of partial decarburization shall not exceed 0.003". Excessive decarburization shall not be cause for rejection of represented parts if subsequent metal removal operations will reduce the depth of decarburization to 0.003" maximum.

6.6 Intergranular Attack Control

6.6.1 The depth of intergranular attack shall be determined by lightly etching the sectioned carb/decarb control test specimen in a solution of ferric chloride in hydrochloric acid and examining the surface metallographically.

6.6.2 Intergranular attack shall not exceed a depth of 0.0007" on parts heat treated to a tensile strength below 200 ksi and shall not exceed a depth of 0.0005" on parts heat treated to a tensile strength of 200 ksi or greater.

6.6.3 Excessive intergranular attack shall not be cause for rejection of the represented batch of parts if subsequent metal removal operations remove material from all surfaces and reduce the depth of attack to the limits specified in paragraph 6.6.2.

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 The procedure specified herein has been categorized as a Controlled Critical Process according to PPS 13.39. Refer to PPS 13.39 for additional personnel requirements. Certified and/or qualified personnel shall have a good working knowledge of the following, as applicable:

- engineering drawings, work order instructions and PPS sections regarding the heat treatment of precipitation hardenable stainless steels
- how to set up and operate steel heat treat furnaces, thermocouples, dew point analyser, quenching equipment, rinsing equipment and hardness testing machines
- physical and mechanical properties of corrosion resistant steels
- definitions, significance and application of alloying elements, transformation temperature and range, solution heat treatment, precipitation hardening, annealing, homogenizing, normalizing, cold working, stress relieving, austenite conditioning, sub-zero treating, embrittlement relief, cooling and quenching
- breakdown and relevance of the AISI designation system and temper codes