BOMBARDIER

Toronto Site

PROPRIETARY INFORMATION

PPS 30.12

PRODUCTION PROCESS STANDARD

GENERAL STEEL HEAT TREATMENT

Issue 7

- This standard supersedes PPS 30.12, 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.

Prepared By:	(Christie Chung)	May 5, 2017
	Core Methods, PPS Group	
Approved By:	(K. Quon, for Bruce Campbell)	May 9, 2017
	Materials Technology	
	(Stephen Pitt)	May 10, 2017
	Quality	

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1 SCOPE

1.1 This Production Process Standard (PPS) may be used as an index and as general information on the heat treatment of wrought steels. Refer to the PPS's listed in section 3 for information on a particular heat treatment operation.

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.

1.2 Alloy designation and condition codes are shown in PPS 23.03.

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 PPS 13.26 - General Subcontractor Provisions.

3.3 PPS 23.03 - Designation of Steel Alloys.

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

3.5 PPS 30.05 - Steel Case Hardening - Gas Nitriding.

3.6 PPS 30.06 - Heat Treatment of Precipitation Hardenable (PH) Stainless Steels.

3.7 PPS 30.08 - Heat Treatment of Martensitic Stainless Steels.

3.8 PPS 30.10 - Heat Treatment of Austenitic (Strain Hardenable) Stainless Steel.

3.9 PPS 30.11 - Steel Case Hardening (Carburizing).

3.10 PPS 30.16 - Steel Case Hardening - Liquid Nitriding.

3.11 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 All equipment and facilities processing parts for Bombardier Toronto shall be approved by Bombardier as meeting the requirements of the applicable heat treatment PPS's 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 heat treatment of wrought steels 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 wrought steels 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 - Technical Term Definitions

5.1.1 *Austenite* - A solid solution of one or more elements in gamma iron, normally carbon in iron.

5.1.2 *Austenitizing* - Forming of austenite by heating the steel above the transformation temperature.

5.1.3 *Carbide Precipitation Range* - The temperature range of 800 to 1500°F within which strain hardenable corrosion resistant (CRES) steels are susceptible to chromium carbide formation.

5.1.4 *Cementite* - A compound of iron and carbon, also known as iron carbide (Fe_3C).

5.1.5 *Chromium Carbide Precipitation* - The combining of carbon and chromium atoms within a solid solution. In the case of CRES steels, this reduces the effective chromium content of the steel with a resultant loss of corrosion resistance.

5.1.6 *Ferrite* - A solid solution of one or more elements in alpha iron, normally carbon in iron.

5.1.7 *Homogenizing* - Holding a steel at a high temperature to allow atoms of alloying elements, which have become segregated as a result of casting, welding or previous heat treatment, to redistribute evenly throughout the steel.

5.1.8 *Hydrogen Embrittlement* - A condition of low ductility caused by diffused hydrogen resulting in static and dynamic (fatigue) failure at considerably lower loads than the calculated failure load.

5.1.9 *Martensite* - A highly stressed structure which most alloys will form when quenched from above the transformation temperature. It is a supersaturated solution of carbon in iron.

5.1.10 *Pearlite* - An unstressed structure which most alloys will form when slowly cooled from above the transformation temperature. It is a lamellar structure consisting of alternate plates of ferrite and cementite.

5.1.11 *Titanium Carbide* - A compound of carbon and titanium preferentially formed in titanium stabilized 321 CRES steel instead of chromium carbide, thereby retaining the desired corrosion resistant properties.

5.1.12 *Transformation Temperature* - The temperature at which, during heating, the structure of the steel starts to transform to austenite or the temperature at which, during cooling, the austenitic structure of the steel starts to transform to pearlite, martensite or intermediate transformation products.

5.1.13 *Transformation Range* - The transformation of steel to austenite or of austenite to pearlite or martensite occurs over a temperature range rather than at one specific temperature.

5.2 Heat Treatment Standards

5.2.1 The heat treatment standards for the various types of steel are shown in Table I.

TABLE I - STEEL HEAT TREATMENT PPS's

STEEL TYPE	ALLOY	PPS
Carbon and low alloy (heat treatment)	1010, 1020, 1095, 4130, 4330V, 4340, 6150, 7140 (135M), 8630, 52100, 300M, HY-TUF, H-11 MOD, QQ-W-470	30.04
Carbon and low alloy (carburizing)	1010, 1020, 3310, 9310	30.11
Nitriding	7140 (135M)	30.05
Strain hardenable CRES	301, 302, 303, 304, 310, 316, 321, 347, 19-9DL, 21-6-9	30.10
Quench & temper hardenable CRES	410, 431	30.08
Precipitation hardenable CRES	17-4 PH, 17-7 PH, Custom 455	30.06
Liquid nitriding of carbon, low alloy and 410 CRES		30.16

5.3 Heat Treatment Operations

5.3.1 Pre-Heating

5.3.1.1 Pre-heating is used to reduce thermal shock and stressing of the parts during heating, thereby reducing the possibility of cracking. It consists of heating parts, before charging into a heat treating furnace or salt bath operating above the transformation temperature, by soaking at a temperature approximately 300°F below the transformation temperature until the parts are heated through.

5.3.2 Full Annealing

5.3.2.1 Full annealing is a softening process performed to improve cold working and cold forming properties and, in some cases, to improve machinability. It consists of heating the steel to above the transformation temperature, soaking and slow cooling (usually furnace cooling) to a temperature below the transformation range.

5.3.3 Sub-Critical Annealing

5.3.3.1 Sub-critical annealing is used as a stress relieving and softening process producing a softened condition almost equal to full annealing, but with much less possibility of distortion or cracking. It consists of heating the steel to a temperature below the lower limit of the transformation range, soaking and cooling in still air.

5.3.4 Stabilization Anneal

5.3.4.1 Stabilization annealing is applied to 321 CRES steel to promote titanium carbide formation, thereby reducing the possibility of chromium carbide formation if the alloy is exposed to service temperatures in the carbide precipitation range. Stabilization annealing consists of heating the steel to a temperature above the carbide precipitation range, soaking and cooling in still air.

5.3.5 Normalizing

5.3.5.1 Normalizing is a grain refining and homogenizing process used to improve response to subsequent hardening operations. It consists of heating to above the transformation temperature, soaking and cooling in still air.

5.3.6 Stress Relieving Non-Hardened Parts

5.3.6.1 Stress relieving reduces the residual stresses caused by welding or cold forming, thereby reducing the possibility of cracking. Stress relieving non-hardened parts consists of heating to a temperature below the lower limit of the transformation range, soaking and cooling in still air.

5.3.7 Stress Relieving Hardened Parts

5.3.7.1 Stress relieving hardened parts relieves stresses in high strength parts which have been cold formed or machined after hardening. It consists of heating the steel to approximately 100 to 200°F below the tempering temperature, soaking and cooling in still air.

5.3.8 Hardening

5.3.8.1 Hardening is performed to improved strength or wear resistance and is always followed by tempering to improve ductility and toughness. It consists of heating the steel to above the transformation range, soaking and quenching to form martensite. The majority of alloys require rapid cooling by oil or water quench to form martensite while some alloys will transform while cooling in still air.

5.3.9 Sub-Zero Quenching

5.3.9.1 Sub-zero quenching is used to promote complete martensite formation in some high carbon alloys and martensitic CRES steels which do not completely transform when quenched to room temperature. It usually involves immersing the part in a mixture of dry ice and alcohol at approximately -90°F.

5.3.10 Tempering

5.3.10.1 Tempering reduces the hardness of a hardened alloy and increases ductility and toughness. The resultant strength range or hardness is dependant on the temperature used (i.e., the higher the tempering temperature, the softer the part becomes). Tempering consists of heating a hardened part to a specific temperature (applicable to the tensile strength or hardness required) below the transformation range, soaking and cooling in still air.

5.3.11 Embrittlement Relief

5.3.11.1 Embrittlement relief is performed on high strength steel parts to reduce hydrogen embrittlement caused by acid pickling or plating operations. It consists of heating the steel to a specific temperature, soaking to allow dissolved hydrogen to diffuse out of the structure of the steel and cooling in still air.

5.3.12 Homogenizing

5.3.12.1 Homogenizing is used to ensure even distribution of alloying elements throughout the structure. It involves heating of the steel to a very high temperature, soaking and air cooling.

5.3.13 Solution Heat Treatment

5.3.13.1 Solution heat treatment consists of heating the steel to a sufficiently high temperature to allow one or more constituents of the alloy to enter into solid solution, soaking and quenching to hold the constituents in solution.

5.3.14 Austenite Conditioning

5.3.14.1 Austenite conditioning is a treatment that transforms soft, stable austenite to an unstable condition that permits further transformation to hard martensite upon cooling to below 60°F. It consists of heating the steel to the transformation temperature, air cooling and immersing in water below 60°F.

5.3.15 Precipitation Heat Treatment

5.3.15.1 Precipitation heat treatment is a treatment whereby compounds of alloying elements precipitate within the structure of precipitation hardenable steels to increase the strength and hardness. It consists of heating the steel to below the transformation range, soaking and cooling in air.

5.3.16 Case Hardening

5.3.16.1 Case hardening of steels produces a hard, wear resistant surface over a strong ductile core. It is accomplished by diffusing either carbon or nitrogen or both into the surface of a steel alloy (by means of gas nitriding, liquid nitriding, carbonitriding, carburizing or cyaniding) to increase the surface hardness of a previously hardened part or to provide a hard surface as the result of subsequent heat treatment.

5.3.17 Unintentional Carburization

5.3.17.1 Unintentional carburization occurs when carbon diffuses into the surface of an alloy steel during heat treatment. This condition causes increased notch sensitivity, case hardening of carbon and low alloy steel parts and a reduction in the corrosion resistance of corrosion resistant steels. It is the result of heating an alloy in a carbonaceous (high carbon potential) heating medium.

5.3.18 Decarburization

5.3.18.1 Decarburization occurs when carbon diffuses out of the surface of an alloy during heat treatment, thereby lowering surface hardness and fatigue life. Nitriding of a decarburized part will cause spalling of the nitrided case. Decarburization results from heating an alloy in an oxidizing (low carbon potential) heating medium.

6 REQUIREMENTS

6.1 Tensile and hardness testing, carburization/decarburization control and metallographic examination of heat treated parts or test specimens shall be carried out as specified in the applicable PPS.

7 SAFETY PRECAUTIONS

7.1 As specified in the applicable heat treatment PPS listed in section 3.

8 PERSONNEL REQUIREMENTS

8.1 As specified in the applicable heat treatment PPS listed in section 3.