BOMBARDIER
Toronto Site
PROPRIETARY INFORMATION

PPS 30.10

PRODUCTION PROCESS STANDARD

HEAT TREATMENT OF AUSTENITIC (STRAIN HARDENABLE) STAINLESS STEEL

Issue 11
- This standard supersedes PPS 30.10, Issue 10.
- 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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TABLE OF CONTENTS

Sections **Page**

Tables

1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for heat treatment of austenitic stainless steels when specified by the engineering drawing.

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

3.2 PPS 13.26 - General Subcontractor Provisions.

3.3 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.4 PPS 15.01 - Part Marking.

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

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

3.7 PPS 30.12 - General Steel Heat Treatment.

3.8 PPS 31.05 - Surface Treatment of Corrosion Resistant Steel.

3.9 Steel heat treatment record (e.g., form DH3772 - *Bombardier Toronto internal Quality procedure*).

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

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

4.2 Equipment

4.2.1 Equipment as specified in PPS 30.04.

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

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

4.2.4 Furnaces used for annealing of austenitic stainless steels shall be electrically heated, capable of maintaining a temperature within ± 25°F of the set point and be monitored by an independent temperature controller/recorder.

4.2.5 When annealing austenitic stainless steels, use a natural air, argon or vacuum (pressure of 10^{-3} mm Hg or lower) atmosphere.

4.2.6 Finished machined parts may be annealed in natural air provided that they remain within drawing tolerances upon removal of heat treat scale. Otherwise, parts shall either be heat treated in argon or a vacuum or be coated with scale inhibiting compound according to paragraph 5.2.3 before being heat treated in natural air.

4.2.7 Protective leather gloves (e.g. DSC 422-3).

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 austenitic stainless steels when specified by the engineering drawing 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 Supplier Quality Management.

4.3.3.1 For approval of subcontractor facilities to perform heat treatment of austenitic stainless steels when specified by the engineering drawing 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 by Bombardier Toronto Engineering.

5 PROCEDURE

5.1 General

5.1.1 Refer to PPS 30.12 for general information and heat treatment terminology.

5.1.2 All facilities processing work according to this PPS shall complete a steel heat treatment record (e.g., DH Form #3772) for all heat treat operations. Maintain a copy of each form in the heat treat records.

5.2 Preparation of Parts

5.2.1 Before heat treatment, ensure that all parts are identified according to PPS 15.01.

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

5.2.3 Refer to PPS 30.06 for the procedure for application of scale inhibiting compound.

5.3 Loading of Parts

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

5.3.2 Ensure that the furnace is operating at the middle of the specified temperature range before being loaded. Set temperature control instruments at the correct operating temperature.

5.3.3 When loading parts, open the furnace door, insert the parts and close the furnace door, as quickly as possible. Take care while loading parts to avoid nicks or other damage to the surfaces of finished parts.

5.4 Heating and Soaking

5.4.1 Soak parts at the temperature and time specified in Table I. The soaking time commences when, after loading the furnace, the temperature has returned to the middle of the specified range.

5.5 Heat Treatment

5.5.1 If interstage annealing for formability is required or to restore corrosion resistance to materials which have been heated in the range of 800 to 1650°F, anneal unstabilized material grades (301, 302, 303, 304, 310 and 316) according to Table I.

5.5.2 If the engineering drawing specifies annealing or includes the note “Anneal for Stress Relief” (or similar) or if interstage annealing for formability is required, anneal stabilized grades of material (321, 347, 19-9Dl and 21-6-9) according to Table I.

TABLE I - ANNEALING

<table>
<tr><th>MATERIAL TYPE</th><th>TEMPERATURE</th><th>MINIMUM TIME</th><th>COOLING</th></tr>
<tr><td>301</td><td rowspan="3">1900°F to 2000°F</td><td rowspan="10">5 minutes per 0.1" of thickness or 15 minutes, whichever is greater</td><td rowspan="5">Water quench (Note 1)</td></tr>
<tr><td>302</td></tr>
<tr><td>303</td></tr>
<tr><td>304</td><td>1900°F to 2100°F</td></tr>
<tr><td>310</td><td>2000°F to 2150°F</td></tr>
<tr><td>316</td><td>1900°F to 2100°F</td><td rowspan="4">Air cool</td></tr>
<tr><td>321</td><td>1700°F to 1950°F</td></tr>
<tr><td>347</td><td>1800°F to 2050°F</td></tr>
<tr><td>19-9DL</td><td>1800°F to 2050°F</td></tr>
<tr><td>21-6-9</td><td>1900°F to 2000°F</td><td>Water quench (Note 1)</td></tr>
<tr><td colspan="4">Note 1. Parts having a thickness of less than 0.041" may be quenched in an air blast to avoid excessive warpage.</td></tr>
</table>

5.5.3 After annealing according to paragraph 5.5.2 or welding, ensure that 321 material receives a stabilizing anneal (1650 to 1700°F for 30 minutes minimum followed by cooling in still air) if it is to be exposed to service temperatures above 800°F.

5.5.4 Stress relieve welded 21-6-9 parts at 1250 ± 25°F for 1 hour after welding.

6 REQUIREMENTS

6.1 Parts shall be soaked within the applicable temperature range for the time specified in Table I.

6.2 Parts of non-stabilized material (301, 302, 303, 304, 310 and 316) shall not be heat treated in the temperature range of 800 - 1650°F unless followed by a full anneal according to paragraph 5.5.1

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 additional personnel requirements. Certified and/or qualified personnel shall have a good working knowledge of the following, as applicable:

- be familiar with the engineering drawings, work order instructions and PPS sections regarding the heat treatment of austenitic stainless steels
- know how to set up and operate steel heat treat furnaces, thermocouples, dew point analyser, quenching equipment, rinsing equipment and hardness testing machines
- know the physical and mechanical properties of corrosion resistant steels
- know the 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
- know the breakdown and relevance of the AISI designation system and temper codes