BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 37.07

PRODUCTION PROCESS STANDARD

Brazing Processes

Issue 15 - This standard supersedes PPS 37.07, Issue 14.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- 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 furnace, dip and torch brazing of aluminum and aluminum alloys, carbon and low alloy steels, corrosion resistant steels, copper and copper alloys and nickel and nickel alloys as listed in Table 3.

1.1.1 This PPS complements the engineering drawings that specify its use as an authorized instruction. The procedure specified in this PPS must 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.

2 Hazardous Materials

2.1 Before receipt at Bombardier Toronto (de Havilland), all materials must be approved and assigned Material Safety Data Sheet (MSDS) numbers by the Bombardier Toronto (de Havilland) 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 (de Havilland) Environment, Health and Safety Department.

3 References

3.1 General

3.1.1 Unless a specific issue is indicated, the issue of the reference documents specified in this section in effect at the time of manufacture shall form a part of this specification to the extent indicated herein.

3.2 Bombardier Toronto (de Havilland) Specifications

3.2.1 PPS 6.01 - Fabrication of Rigid Fluid Lines.

3.2.2 PPS 6.10 - Cleaning of Fluid System Components.

3.2.3 PPS 13.04 - De-Fuming of Aircraft Fuel Tanks and Fuel Containers.

3.2.4 PPS 13.26 - General Subcontractor Provisions.

3.2.5 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.2.6 PPS 16.01 - Application of Hard and Soft Film Corrosion Preventative Compound.

3.2.7 PPS 20.10 - Radiographic Inspection.

3.2.8 PPS 24.01 - Aluminum Wire Spray Coating.

3.2.9 PPS 30.01 - Heat Treatment of Aluminum Alloys.

3.2.10 PPS 31.02 - Cleaning Processes for Aluminum and Aluminum Alloys.

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

3.2.12 PPS 31.05 - Surface Treatment of Corrosion Resistant Steel.

3.2.13 PPS 31.06 - Cleaning of Copper and Copper Alloys.

3.2.14 PPS 31.07 - Cleaning and Stripping of Painted Surfaces.

3.2.15 PPS 33.02 - Removal of Plating.

4 Materials, Equipment and Facilities

4.1 Materials

4.1.1 Unless otherwise specified in this section, use only the materials specified; use of superseding or alternative materials is not allowed.

4.1.2 Filler alloys and fluxes as listed in Table 3.

4.2 Equipment

4.2.1 Furnaces used in furnace brazing must be equipped with suitable temperature controlling and recording equipment capable of maintaining the temperature in the working zone within ± 25°F (± 14°C). Furnace atmospheres must prevent decarburization or scaling of parts.

4.2.2 Air circulating ovens used for preheating must be capable of maintaining work zone temperatures within ± 50°F (± 28°C).

4.2.3 Dip brazing baths must be equipped with suitable temperature controlling and recording equipment capable of maintaining the solution temperature within ± 10°F (± 6°C). Molten salt and flux constituents for dip brazing must be free of chemicals harmful to the braze alloys and details being brazed.

4.2.4 Leather gloves (e.g., DSC 422-3).

4.3 Facilities

4.3.1 This PPS has been categorized as a “Controlled Special Process” according to PPS 13.39 and as such only facilities specifically approved according to PPS 13.39 are authorized to perform furnace, dip and torch brazing of aluminum and aluminum alloys, carbon and low alloy steels, corrosion resistant steels, copper and copper alloys and nickel and nickel alloys according to this PPS.

4.3.2 Bombardier subcontractors must direct requests for approval to Bombardier Aerospace Supplier Quality Management. Bombardier Aerospace facilities must 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 must 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 must be detailed in the facility report. Based upon the facility report, Bombardier Toronto (de Havilland) Materials Technology may identify additional qualification and/or process control test requirements. During the facility survey, the facility requesting qualification must 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 Unless otherwise specified by Bombardier Aerospace Supplier Quality Management, for approval of subcontractor facilities to perform furnace, dip and torch brazing of aluminum and aluminum alloys, carbon and low alloy steels, corrosion resistant steels, copper and copper alloys and nickel and nickel alloys according to this PPS, completion of a test program and submission of suitable test samples representative of production assemblies is required. Test assemblies must be examined visually, radiographically and metallographically for conformance to the requirements specified in section 6.

5 Procedure

5.1 General

5.1.1 Brazing is the joining of metals through the use of heat and a filler metal with a melting temperature over 840°F (449°C) but less than the melting point of the metals being joined.

5.1.2 Braze welding is a method of welding where a groove, fillet, plug or slot weld is made, using a bronze welding filler metal having a melting point below that of the base metal, which is not distributed in the joint by capillary attraction. Braze welding does not add strength to the joint and is only specified in particular non-critical applications (i.e., a brazement that, upon failure, will not affect the efficiency of the system or endanger personnel).

5.1.3 Brazing is classified on the engineering drawings by the filler metals used and the brazing method employed, as shown in Figure 1. If the drawing does not specify a brazing classification, torch braze weld steels and torch silver braze corrosion resistant steels, and copper and copper alloys.

PROCESS CODE	METHOD CODE
AB - Aluminum Alloy Braze	D - Dip Braze
CB - Copper Braze	F - Furnace Braze
MB - Magnesium Braze	I - Induction Braze
SB - Silver Alloy Braze	R - Resistance Braze
NB - Nickel Braze	T - Torch Braze
BW - Braze Welding	

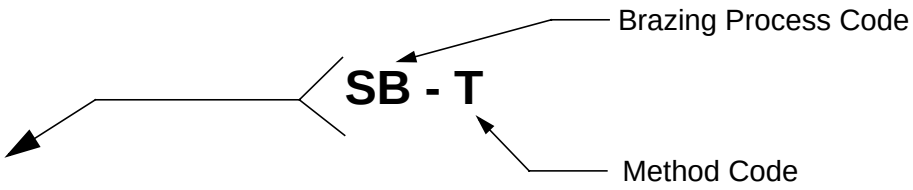

Figure 1 - Engineering Drawing Call-Out

5.2 Cleaning

5.2.1 Ensure that all mechanical operations, such as pre-assembly, fitting and de-burring are complete before cleaning.

5.2.2 Before applying flux, thoroughly clean the faying surfaces and areas adjacent to the braze joint and remove any surface treatment, such as anodizing or plating, according to the PPS specified in Table 1.

5.2.3 Braze parts within 48 hours of cleaning.

5.2.4 Clean pre-formed aluminum alloy filler wire or strip together with the brazing details.

5.2.5 Protect cleaned parts from contamination and do not handle them at the joining surfaces without wearing clean cotton gloves.

Table 1 - Cleaning Processes

CLEANING MATERIAL	PPS		REMOVAL OF SURFACE TREATMENT	PPS
Aluminum and Aluminum Alloys	31.02		Plating	33.02
Carbon and Low Alloy Steels	31.03		Paint and Primer	31.07
Corrosion Resistance Steels	31.05		Metal Spray	24.01
Copper and Copper Alloys	31.06		Alodining and Anodizing	31.02

5.3 Application of Flux

5.3.1 For parts to be torch brazed, apply the flux specified in Table 3, just before assembly and brazing. Apply the flux to the exposed braze joint surfaces and if necessary to the filler metal just before preheating and brazing.

5.3.2 Unless otherwise specified, prepare and apply the flux according to manufacturer's instructions.

5.3.3 Braze within 45 minutes of applying flux.

5.3.4 Parts to be dip brazed do not require flux to be applied, unless the molten salt or brazing paste does not include the flux or wetting agent.

5.4 Application of Filler Material

5.4.1 For torch brazing, introduce the filler metal into the joint by face feeding. For all other brazing operations, pre-place the filler metal during assembly. For the filler metal wire or strip to be pre-placed, cut the filler to the length and shape of the braze joint. On flat face-to-face joints, cover the minor face with the filler strip. The strip may protrude up to 0.010" beyond the edge of the minor face. Ensure that the strip is as thick as the clearance specified in Table 2 and has intimate contact with both faces. For tubular joints, pre-form the filler wire to the ID or the OD of the tube, as applicable.

Table 2 - Joint Clearance

Brazing Process	Clearance (Note 1)		Brazing Process	Clearance (Note 1)
Silver	0.001" - 0.005"		Aluminum	0.005" - 0.015"
Copper	0.0005" - 0.0015"		Aluminum (dip)	0.002" - 0.010"
Copper (furnace)	Interference - 0.001"		Nickel	Interference - 0.002"
Note 1: Joint clearance on diameters is twice the value specified above.				

5.4.2 Unless otherwise specified on the engineering drawing, select the filler material or paste from Table 3.

5.4.3 Prepare filler paste, such as Alumibraze 400, according to the manufacturer's instructions and apply with a brush, syringe or extrusion gun after the parts are assembled. Apply sufficient paste in a uniform fillet so that the brazed joint will be completely filled when brazed.

Table 3 - Filler Alloys and Fluxes

BASE METAL	FILLER METAL		FLUX	BRAZE TEMPERATURE
	SPECIFICATION	DESIGNATION		
BRAZE WELDING (BRONZE) - TORCH				
steels not requiring post brazing heat treatment	MIL-R-19631 or ASTM-B-259-66T Class R (Cu-Zn-C)	Linde Oxweld 25M	Linde Brazo Flux	1660°F ± 40°F (904°C ± 22°C)
steels requiring post brazing heat treatment	ASTM-B-259-66T Class R (Cu-Zn-C)	Eutectic - No. 16 Flux coated		1760°F ± 40°F (960°C ± 22°C)
COPPER BRAZING - FURNACE				
Steels requiring post brazing heat treatment	AMS 4701 AWS B (Cu-1)	---	AWS Atmosphere No. 7 Dew Point -75°F to -100°F (-59°C to -73°C)	2075°F ± 75°F (1135°C ± 42°C)
SILVER BRAZING - TORCH				
Corrosion resistant steel, 4130 steel, copper and copper alloys	BAg-1, AMS 4769	H&H Easy-Flo 45 or Silvaloy 45	H&H Type B-1, 1200 Universal Flux or Englehard Ultra Flux	1303°F ± 97°F (706°C ± 54°C)
	BAg-7, AMS 4763	H&H Braze 560 or Silvaloy 355		
ALUMINUM ALLOYS - TORCH, DIP AND BRAZE				
1100 Al	QQ-B-655 or ASTM-B-260-62T FS-BAlSi 2 (4343)	No. 4343	Torch: Alcoa or Alcan #33 flux or AMS 3412 Furnace: #30 flux or AMS 3412	1125°F ± 25°F (607°C ± 14°C)
3003Al 5052 Al 6061 Al	QQ-B-655 or ASTM-B-260-62T FS-BAlSi 2 (4047) AMS 4185	N0. 4047	Torch: Alcoa or Alcan #33 flux or AMS 3412 Dip: H&H Alumibraze 400	1100°F ± 20°F (593°C ± 11°C)
NICKEL BRAZING - FURNACE				
Carbon and low alloy steels, 300, 400 and PH stainless steels	AMS 4778	B Ni-3	---	2000°F ± 150°F (1093°C ± 83°C)

5.5 Assembly for Brazing

5.5.1 Before brazing, correctly align the parts and set them up securely. Parts may be self-jigging or may be secured by other methods, such as crimping, staking, dimpling, pinning, tack welding, fixturing, clamping or using bench supports. For torch brazing, ensure that any fixtures used provide access for brazing in the down-hand position wherever possible.

5.5.2 If using a preplaced wire or strip, position and assemble the filler metal together with the detail parts.

5.5.3 Ensure that the joint fit and clearance is as specified in Table 2. The brazing process depends upon capillary attraction to draw the filler metal into the joints, and only joint surfaces within the clearance limits specified will fill and hold the braze metal.

5.5.4 If sealing assemblies by brazing, locate and drill vent holes according to the engineering drawing.

5.6 Brazing

5.6.1 General

5.6.1.1 Unless otherwise specified on the engineering drawing, use brazing filler alloys and fluxes specified in Table 3.

5.6.2 Torch Brazing

5.6.2.1 Unless otherwise specified, use a neutral or slightly reducing flame (identified by a slight haze of excess acetylene around the inner cone) for all brazing that requires capillary attraction. Use a slightly oxidizing flame for braze welding.

5.6.2.2 If possible, braze parts in the down-hand position using the fore-hand method.

5.6.2.3 Only apply the outer envelope of the acetylene flame, not the inner cone, to the work. Do not allow the luminous white oxyacetylene flame to touch the work or filler metal at any time during the preheat or brazing operations.

5.6.2.4 Preheat the brazing details to the flux melting temperature. Take care not to overheat the base metal. When preheating, do not allow the flame to directly touch the joint until the flux has melted and the possibility of flaking is eliminated.

5.6.2.5 Once the joint has reached the brazing temperature, flow the filler metal into the joint until the filler metal is observed at the opposite joint face. Complete the brazing quickly to avoid overheating the parts.

5.6.3 Dip Brazing

5.6.3.1 Dip braze parts according to the schedule established for each part number, listing the following information and any other data relevant to the process:

- Preheat oven time and temperature.
- Dip bath temperature and immersion time.
- Proprietary bath material, salt and flux type.
- Filler metal type and form.
- Alignment details including sketch.
- Special instructions and remarks.

5.6.3.2 Perform dip brazing as follows:

Step 1. Assemble and preheat the parts for the specified time and temperature.

Step 2. At the end of the preheat time, remove the parts from the oven and transfer them as quickly as possible to the dip bath.

Step 3. Immerse the parts slowly into the dip bath (before any appreciable cooling takes place) to a depth of at least 1" below the liquid surface and hold for the specified time. Do not immerse the parts in the dip bath if there is moisture on them or if they are not at the preheat temperature.

Step 4. When brazing is complete, remove the assembly from the dip bath and allow the flux and salt drag-out to drain off completely.

5.6.3.3 If the engineering drawing specifies “HEAT TREAT AFTER BRAZING NOT REQUIRED”, allow the assembly to cool sufficiently to ensure that the braze joints are completely set before flushing thoroughly in hot water and de-fluxing according to PPS 31.02.

5.6.3.4 If the engineering drawing specifies “AFTER BRAZING QUENCH AND AGE TO T6”, allow the assembly to cool sufficiently to ensure that the braze joints are completely set, but no lower than 960°F (516°C), and immediately quench in water at below 100°F (38°C). After quenching, flush the assembly thoroughly in hot water, de-flux according to PPS 31.02 and age harden to T6 according to PPS 30.01.

5.6.4 Furnace Brazing

5.6.4.1 Furnace braze parts according to the schedule established for each part number, listing the following information and any other data relevant to the process:

- Furnace temperature and brazing time.
- Furnace atmosphere.
- Filler metal and flux type.
- Filler metal placement requirements.
- Alignment details including sketch.
- Special instructions and remarks.

5.6.4.2 Load the parts into the furnace and heat for the specified time at the specified temperature.

5.6.4.3 Do not remove assemblies from the furnace until they have cooled sufficiently to prevent fracture or distortion of the braze joint.

5.7 Post Brazing Treatment

5.7.1 Remove flux after brazing according to the applicable cleaning PPS shown in Table 1.

5.7.2 Do not passivate or nitric acid pickle silver brazed parts.

5.7.3 Do not weld within 2" of a brazed joint.

5.7.4 Do not re-heat a brazed joint to within 100°F (56°C) of the filler metal melting point, except for rework of a defective joint.

5.7.5 Do not heat corrosion resistant steel parts above 600°F (316°C) after silver brazing.

5.7.6 For parts that have been brazed after surface treatment, retreat after brazing.

5.7.7 Unless otherwise specified, protective treat carbon and low alloy steel parts according to PPS 16.01 after brazing.

6 Requirements

6.1 Ensure that all production parts meet the following visual requirements:

- There must be no flux residue evident on the surfaces of brazed parts.
- The filler metal at the joint edge must be a continuous, unbroken line or ring free of voids or cracks.
- The filler metal surface of a braze weld fillet joint must be concave and must have a uniform feather edge.
- The filler metal edge must be smooth and uniform in appearance and colour and there must be no evidence of cracks.
- External porosity appearing as pin holes is acceptable, provided that the sum of the pin hole diameters does not exceed 0.030" per linear inch of braze fillet and the maximum diameter of any one pin hole does not exceed 0.015".
- There must be no evidence of distortion or misalignment of the brazing details.
- Braze filler in excess of that required for the joint is acceptable, provided that the excess filler metal is not detrimental to the appearance of the completed assembly.
- Blisters resulting from overheating of the parent metal are not acceptable.
- The presence of unmelted brazing alloy in a joint is unacceptable.
- Undercutting of the parent metal adjacent to the brazed joint shall not exceed 5% of the parent metal thickness nor 15% accumulative of the braze length.
- Brazing alloy must be evident at all edges of the joint. Lack of penetration is not acceptable.

6.2 Pressure test all fluid lines with brazed fittings according to PPS 6.01.

6.3 Radiographically examine production lots according to the sampling plan specified in Table 4. Perform radiographic inspection according to PPS 20.10.

- The unbrazed area (including trapped flux, scattered porosity and voids) must not exceed 20% of the faying surface area in any inch of joint length.
- No single unbrazed area may exceed 20% of the overlap distance of the joint.
- Bonded tack welds shall be considered part of the brazed area.

6.3.1 If any of the sample assemblies fails to meet the requirements of para. 6.3, the entire lot must be radiographically examined. If there is any doubt as to the indications obtained radiographically, section and examine one assembly metallographically.

Table 4 - Sampling Plan for Radiographic Examination

LOT SIZE	NUMBER OF ASSEMBLIES TO BE EXAMINED
1	1
2 to 8	2
9 to 15	3
16 to 25	5
26 to 50	8

LOT SIZE	NUMBER OF ASSEMBLIES TO BE EXAMINED
51 to 90	13
91 to 150	20
151 to 280	32
280 to 500	50

Note 1. A lot consists of all parts of the same configuration and alloy, processed in the same manner by an operator and submitted for acceptance at the same time.

7 Safety Precautions

7.1 The safety precautions specified herein are specific to Bombardier Toronto to meet Canadian Federal and Provincial government environmental, health and safety regulations. It is recommended that other facilities consider these safety precautions; however, suppliers, subcontractors and partners are responsible for ensuring that their own environmental, health and safety precautions satisfy the appropriate local government regulations.

7.2 Observe general shop safety precautions when performing the procedure specified herein.

7.3 Do not use grease, oil or lubricant on torch brazing equipment.

7.4 Wear protective respiratory equipment as specified in PPS 13.13 when brazing.

7.5 Wear suitable eye protection, flame resistant aprons and leather gloves during brazing operations.

7.6 Fume extraction equipment must be provided, as necessary, to remove noxious fumes from the work area.

7.7 Tanks in which combustible liquids have been stored must be de-fumed and checked with an explosimeter according to PPS 13.04 before brazing.

8 Personnel Requirements

8.1 This PPS has been categorized as a “Controlled Special Process” by PPS 13.39. Refer to PPS 13.39 for personnel requirements.