DE HAVILLAND AIRCRAFT OF CANADA LIMITED

BOMBARDIER
Toronto Site

PPS 37.03 - FUSION WELDING OF ALUMINUM ALLOYS

Issue 18
- This Production Process Standard (PPS) supersedes PPS 37.03, Issue 17.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS related questions to christie.chung@dehavilland.com.
- This PPS is effective as of the distribution date.

THIS PPS IS CO-OWNED BY DE HAVILLAND AIRCRAFT OF CANADA LIMITED AND BOMBARDIER INC.

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Issue 18 - Summary of Changes (over the previous issue)

The following summaries are not detailed and are intended only to assist in alerting PPS users to changes which may affect them; refer to the applicable sections of this PPS for detailed procedure and requirements.

- Specified this is a jointly owned PPS by both De Havilland Aircraft of Canada Limited and Bombardier Inc.
- Revised Facilities Requirements section.
- Specified all testing must be performed DHC/BA Toronto Materials Laboratory or by laboratories accredited according to DAGER-006 (DASH 8) or BAERD GEN-018 (Lear 45), as applicable.
- In addition to the requirements specified in PPS 13.39, added additional personnel requirements.

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1 SCOPE

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for the fusion welding of aluminum and aluminum alloys.

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.

1.2 This PPS is co-owned by De Havilland Aircraft of Canada Limited (DHC) and Bombardier Inc. (BA) due to its applicability for both the DHC DASH 8 and BA Lear 45 programs. Frozen revisions of Bombardier documents (e.g., BAPS, BAERD GEN, BAMS, etc.) specified herein apply only to the DASH 8 program.

2 HAZARDOUS MATERIALS

2.1 Before receipt at DHC or BA, all materials must be approved and assigned Material Safety Data Sheet (MSDS) numbers by the DHC/BA 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 DHC/BA Environment, Health and Safety Department.

3 REFERENCES

3.1 AWS A2.1-WC - American Welding Society Standard Welding Symbols Wall Chart.

3.2 PPS 13.04 - De-Fuming of Fuel Tanks and Fuel Containers.

3.3 PPS 13.26 - General Subcontractor Provisions.

3.4 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.5 PPS 30.01 - Heat Treatment of Aluminum Alloys.

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

3.7 PPS 31.07 - Cleaning and Stripping of Painted Surfaces.

3.8 PPS 31.17 - Solvent Usage.

3.9 PPS 37.06 - Testing and Certification of Aircraft Fusion Welders.

3.10 PPS 37.10 - Requirements for Fusion Welds.

3.11 BAERD GEN-018 - Engineering Requirements for Laboratories.

3.12 DAGER-006 - Engineering Requirements for Laboratories.

4 MATERIALS, EQUIPMENT AND FACILITIES

4.1 Materials

4.1.1 Welding rods as listed in Table I.

4.1.2 Aluminum welding flux (e.g., Oxweld Aluminum Welding Flux or Saffine Aluminum Flux).

4.1.3 Welding Electrodes - zirconium tungsten, 2% thorium tungsten, or cerium tungsten. Use zirconium tungsten electrodes for AC welding and 2% thorium tungsten or cerium tungsten electrodes for DC welding. Only use DC welding if welding sections greater than 0.250" thick.

4.2 Equipment

4.2.1 Appropriate welding jigs, fixtures and clamps.

4.2.2 Cotton gloves (e.g., DSC 422-1).

4.2.3 Soft stainless steel brush or aluminum oxide abrasive paper.

4.2.4 Tempilstiks, Tempilaq or surface pyrometer.

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 fusion welding of aluminum and aluminum alloys according to this PPS.

4.3.2 Subcontractors must direct requests for approval to DHC or BA Quality.

4.3.3 Facility approval must 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, DHC or BA Engineering 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 DHC or BA Quality.

4.3.3.1 For approval of subcontractor facilities to perform fusion welding of aluminum and aluminum alloys according to this PPS, completion of a test program and submission of suitable test samples representative of production parts is required. Test samples must be inspected as specified in PPS 37.10 (including visual, fluorescent penetrant/magnetic particle inspecting, radiographic inspection **and** metallographic inspection).

4.3.3.2 All testing and evaluation specified herein must only be performed by DHC/BA Toronto Materials Laboratory or by laboratories accredited according to DAGER-006 (DASH 8) or BAERD GEN-018 (Lear 45), as applicable.

5 PROCEDURE

5.1 General

5.1.1 For the purposes of this PPS, the term “MRB” (Material Review Board) is considered to include DHC/BA MRB and DHC/BA delegated MRB.

5.1.2 For any materials with a limited shelf/storage life, before use ensure that the shelf/storage life of such materials has not expired.

5.2 Cleaning

5.2.1 Clean parts according to PPS 31.02 after the completion of all mechanical operations. Welding must be accomplished within 4 hours of cleaning. If welding has not been accomplished within 4 hours of cleaning, abrasive clean the part with a soft stainless steel brush or aluminum oxide abrasive paper immediately before welding. If final fitting and deburring of the assembly is required after assembly, solvent clean the area according to PPS 31.17.

5.2.2 Suitably protect cleaned parts from contamination (e.g., by wrapping them in plastic).

5.2.3 Do not handle cleaned parts at the joining surfaces unless clean cotton gloves are worn.

5.3 Assembly for Welding

5.3.1 Before commencing welding, fit up the parts using the appropriate jigs, fixtures or clamps. Jigs and fixtures are designed to provide easy access for tacking and welding in the down-hand position and provisions are made for dimensional changes during heating and cooling. If a jig or fixture does not facilitate welding, contact Liaison Engineering.

5.3.2 The maximum permissible gap between joint faces is half the thickness of the thinner section. Ensure that any misalignment of butt welds does not exceed 10 percent of the thickness of the thinnest part being joined. When welding flanges to bleed air duct ends, ensure a light press fit of the tube into the end fitting flange along the entire mating surface.

5.3.3 Back-up shielding can be achieved by either applying flux to the back of the weld or by using an inert gas atmosphere at the back and sides of the weld in addition to stainless steel back-up bars.

5.3.4 Do not correct poor fit by building up the weld.

5.4 Preparation of Flux

5.4.1 If flux is needed, mix the flux powder with methanol, if available, or clean water to form a thin paste. Use a clean aluminum, earthenware, or glass container for mixing and storing the flux. At the end of the shift, discard any unused flux. Prepare a fresh mixture of flux for each shift, as required.

5.5 Pre-Heating

5.5.1 Except as noted in paragraph 5.5.1.1, if pre-heating is considered necessary for welding 6061 aluminum assemblies, the pre-heating temperature must not exceed 300°F (149°C). Use suitable controls, such as Tempilstiks, to avoid overheating.

5.5.1.1 Pre-heating at a temperature in excess of 300°F (149°C) is permissible only if the weldment is to receive a post weld full heat treatment (e.g., solution heat treatment and aging).

5.6 Control of Filler Rod or Wire

5.6.1 Ensure that all spools and containers of welding rod material are identified by material type.

5.6.2 When removing welding rod material from spools or containers, remove only the length and type of material necessary to complete the work at hand.

5.6.3 After removing the required welding rod material, affix a suitable length of masking tape, in the form of a flag, to one end of the rod and legibly print the welding rod material type on the flag.

5.6.4 Record the traceability identification of the welding rod material (i.e., RIP (Receipt in Process) or MRV (Material Receipt Voucher) number) on the methods paperwork.

5.6.5 Dispose of unused pieces of welding rod material or, if they are of sufficient length to be used on another job, return them to the designated welding rod storage area with the identification flag attached.

5.7 Welding Process

5.7.1 Weld parts using either the MIG (Metal Inert Gas) or TIG (Tungsten Inert Gas) method.

5.7.2 Before welding, purge the atmosphere around the part to be welded with a “pre-flow” of inert gas.

5.7.3 DC welding may only be used to weld sections greater than 0.250" thick. AC welding may be used on sections of all thicknesses.

5.7.4 Select the appropriate welding rod as listed in Table I.

5.7.5 If possible, weld parts in the down-hand (horizontal) position using the fore-hand method.

5.7.6 For TIG welding, follow the manufacturer's instructions regarding the use of equipment. Select a suitable amperage, voltage, gas cup, gas flow and electrode size to give the proper size and penetration of weld.

5.7.7 If a joint is welded from both sides, clean the back of the weld on the first side and remove excess drop through before welding the second side.

5.7.8 Unless otherwise specified, do not remove weld bead metal and drop through on single welds after welding.

5.7.9 For welded tubes intended to carry fluids, ensure that the drop through does not restrict the free flow through the bore.

5.7.10 If tubular joints intersect at other than right angles, weld the tubes from the angle of greatest restriction to the angle of least restriction (see Figure 1).

5.7.11 If the entire seam joining a flange to a bleed air duct cannot be welded while the assembly is located in a fixture, the flange may be tack welded as follows and the welding completed after removal from the fixture. Complete welding on one flange end at a time to prevent excessive shrinkage.

- Up to 2" diameter tube - 4 tack welds.
- Over 2" diameter tube - 8 tack welds.

5.7.12 Identify completed weldments according to PPS 37.10.

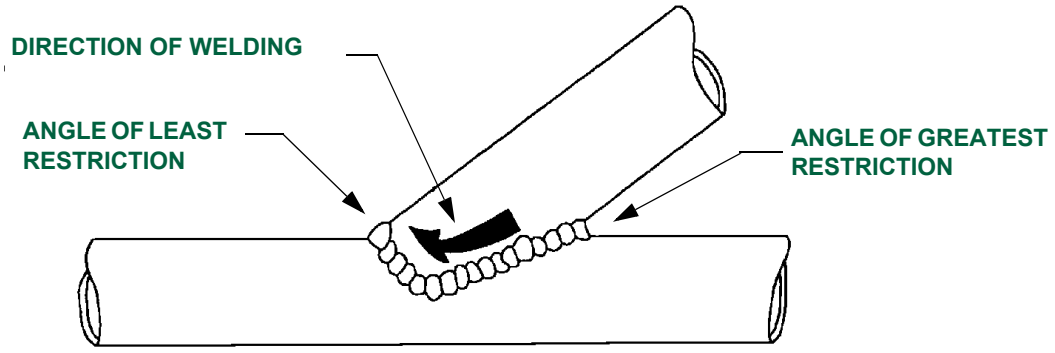

FIGURE 1 - WELDING AT TUBE INTERSECTIONS

TABLE I - WELDING FILLER ROD SELECTION

ALUMINUM ALLOY		FILLER ROD			WELD METHOD
METAL 1	METAL 2	FEDERAL SPECIFICATION	COMMERCIAL DESIGNATION	AWS SPECIFICATION	
1100	1100	QQ-R-566-1100	2S	AWS A5.10 ER1100	TIG
	3003	QQ-R-566-1100	2S	AWS A5.10 ER1100	TIG
2219	2219	QQ-R-566-2319	---	AWS A5.10 ER2319	TIG
3003	1100	QQ-R-566-1100	2S	AWS A5.10 ER1100	TIG
	3003	QQ-R-566-1100	2S	AWS A5.10 ER1100	TIG
5052	5052	QQ-R-566-5356 (Note 1)	56S	AWS A5.10 ER5356 (Note 1)	TIG or MIG
	6061	QQ-R-566-5554 (Note 2)	---	AWS A5.10 ER5554 (Note 2)	TIG or MIG
5083	5083	QQ-R-566-5356 or QQ-R-566-5556	56S	AWS A5.10 ER5356 or AWS A5.10 ER5556	TIG or MIG
6061	5052	QQ-R-566-5554 (Note 2)	---	AWS A5.10 ER5554 (Note 2)	TIG or MIG
	6061	QQ-R-566-4043	33S	AWS A5.10 ER4043 (Note 3)	TIG or MIG

Note 1. QQ-R-566-4043/AWS A5.10 ER4043 filler rod may be used if authorized by the Welding Specialist or Welding Engineer.
Note 2. QQ-R-566-4043/AWS A5.10 ER4043 or QQ-R-566-5356/AWS A5.10 ER5356 filler rod may be used if authorized by the Welding Specialist or Welding Engineer.
Note 3. It is acceptable to use a BS2901 Part 4 Type 4043A British Standard filler rod as an alternate to a AWS A5.10 ER4043 filler rod.

5.8 Repairing Defective Parts

5.8.1 Except for Class C welds, do not repair unacceptable weldments without prior MRB approval. For repair of Class C welds, MRB authorization is not necessary.

5.8.2 Do not cover up a defect in a weld with an additional weld. Completely remove all weld defects by grinding or filing. Do not use a welding or cutting torch to remove such defects.

5.8.3 Except for Class C welds, do not repair weld parts that have been heat treated after welding unless re-heat treatment is permitted by MRB. For Class C welds, MRB authorization is not necessary for repair after heat treatment.

5.8.4 Do not build up or repair improperly nibbled or machined parts or sections by welding.

5.8.5 Inspect all repaired welds for cracks and other defects according to PPS 37.10.

5.8.6 For repair welding of A356 castings use A356 welding filler rods to AMS4181 and for repair welding A357 castings use A357 welding fillers rods to AMS4246.

5.9 Post Weld Treatment

5.9.1 Heat Treatment

5.9.1.1 Only carry out post weld heat treatment if specified on the engineering drawing.

5.9.1.2 Refer assemblies of 6061 or 2219 alloys for which the final heat treat condition after welding is not specified on the engineering drawing to Liaison Engineering.

5.9.2 Defluxing

5.9.2.1 If flux was used, remove all flux according to PPS 31.02 after welding.

5.9.3 Clean-Up

5.9.3.1 If necessary, remove weld spatter and scale by mechanical means according to PPS 31.02.

5.9.4 Protective Treatment

5.9.5 Apply any specified protective treatments, such as anodizing, chemical conversion coating, etc., after completing all welding, heat treatment and checking the weld.

6 REQUIREMENTS

6.1 Quality requirements must be as specified in PPS 37.10.

6.2 Welders must be certified as specified in section 8.

6.3 Except as noted in paragraph 6.3.1, weld all detail parts in the condition specified on the engineering drawing.

6.3.1 6061 alloy details (made from bar, rod, plate, sheet or tube) which are called up in the -T4 condition may be welded in the T6 condition instead of the T4 condition only when the engineering drawing specifies:

“AFTER WELDING AGE ONLY TO -T6”

7 DHC/BA SAFETY PRECAUTIONS

7.1 The safety precautions specified herein are specific to DHC/BA to meet Canadian Federal and Provincial government environmental, health and safety regulations. It is strongly 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 standard plant safety precautions when performing the procedure specified herein.

7.3 Refer to PPS 31.17 for the safety precautions for handling and using solvents.

7.4 Do not use grease, oil or any other lubricant on welding equipment.

7.5 Operators shall wear suitable safety equipment (i.e. goggles, gloves, apron, etc.).

7.6 Fume extraction equipment shall be provided and be in use when welding is in progress.

7.7 Tanks or containers in which combustible liquids have been stored shall be de-fumed according to PPS 13.04 before welding.

8 PERSONNEL REQUIREMENTS

8.1 Fusion welding of aluminum shall only be performed by operators who have been certified according to PPS 37.06.

8.2 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 must have a good working knowledge of the following, as applicable:

- be familiar with the engineering drawing and work order notes regarding the fusion welding of aluminum alloys
- be familiar with the process specifications regarding the fusion welding of aluminum alloys
- be familiar with the Engineering and Quality Assurance requirements in the process specifications regarding the fusion welding of metals
- be familiar with equipment used for the fusion welding of metals
- be familiar with the fusion welding processes
- know the definitions of standard welding terms
- be able to interpret AWS standard welding symbols
- be familiar with the types of fusion welded joints in different material forms
- be familiar with the various fusion welding positions
- be familiar with the different classes of fusion welds and how they are determined
- know the function of filler rods and wire
- know the importance of pre-weld cleaning of parts
- know the importance of pre-heating and inter-pass temperatures
- know the importance of post-weld heat treatment
- know how to use the argon gas flow regulator and the settings for various thickness of aluminum alloys
- know the type of current to use for fusion welding aluminum alloys
- know the high frequency control settings to use for fusion welding aluminum alloys
- know ho to select the amperage range based on part thickness
- know how to use the remote foot pedal to control amperage within a fixed range
- know how to install and dress tungsten electrodes
- know how to use fusion welding equipment to produce acceptable weld joints
- know why a pre-flow of inert gas is required

9 MAINTENANCE OF EQUIPMENT

9.1 Keep all welding equipment, including lines and gauges, in good working order.

9.2 Repair or replace defective welding equipment.

10 ADDITIONAL INFORMATION

10.1 It is recommended that a copy of the AWS Welding Symbols Wall Chart be posted wherever welding is being carried out.