BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 37.16

PRODUCTION PROCESS STANDARD

Orbital Fusion Welding of Fittings to Titanium Tubing

Issue 5
- This standard supersedes PPS 37.16, Issue 4.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS 37.16 related questions to michael.wright@aero.bombardier.com.
- This PPS is effective as of the distribution date.

Signed original on file. Validation of paper prints is the responsibility of the user.

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	Quality	

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1 Scope

1.1 This PPS (Production Process Standard) specifies the procedure and requirements for the orbital fusion welding of titanium fittings to titanium tubing.

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 DH Form #4894 - Certified Orbital Fusion Welding Schedule - *Bombardier Toronto (de Havilland) internal Quality form*.

3.2 PPS 6.05 - Closure of Fluid Lines and Fluid System Components.

3.3 PPS 6.12 - Pressure Testing Hydraulic Components, Fuel and Bleed Air Lines.

3.4 PPS 13.26 - General Subcontractor Provisions.

3.5 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.6 PPS 31.04 - Degreasing Processes.

3.7 PPS 31.09 - Cleaning of Titanium and Titanium Alloys.

3.8 PPS 31.17 - Solvent Cleaning.

3.9 PPS 37.05 - Fusion Welding of Titanium.

3.10 PPS 37.10 - Requirements for Fusion Welding.

4 Materials, Equipment and Facilities

4.1 Materials

4.1.1 Titanium fittings as specified on the relevant Engineering drawing.

4.1.2 Argon gas, minimum 99.99% pure (e.g., MIL-A-18455).

4.1.3 Cotton wipers (e.g., DSC 378-2).

4.1.4 Abrasive paper, aluminum oxide, 180 - 240 grit (e.g., 3M Co.).

4.1.5 Tungsten electrodes, 2% thoriated tungsten, to AWS A5.12.

4.2 Equipment

4.2.1 Orbital fusion welding equipment equipped to automatically control and monitor voltage, amperage and head rotation speed during a complete weld cycle (i.e., prepurge, arc initiation, weld sequence, downslope and post purge). The equipment must be capable of pulsing the welding current between low and high current settings with a minimum of 3 adjustable high current levels and producing welds meeting the requirements specified in PPS 37.10. Qualify equipment according to section 5.3.

4.2.2 Power supply (e.g., Dimetrics, Inc. Centaur 150 PTW TIG with a B2A weld head).

4.2.3 Tube and fitting collets as specified in Table 1.

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 orbital fusion welding of titanium fittings to titanium tubing 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 orbital fusion welding of titanium fittings to titanium tubing according to this PPS, completion of a test program and submission of suitable test samples representative of production parts is required. Test samples must meet the requirements specified in section 6.

5 Procedure

5.1 General

5.1.1 Orbital fusion welding of fittings to titanium tubing consists of using an in-place weld head that clamps over the joint and provides the essential elements for Gas Tungsten Arc (GTA) welding.

5.1.2 Machined fittings welded to titanium tubing at Bombardier Toronto (de Havilland) have machined overlaps (extended lips), 0.020 to 0.040" in length. The extended overlaps fit over the ends of the tubing and are consumed during welding, resulting in machined overlap butt welds.

5.1.3 Establish a certified welding schedule for each joint design and combination of fitting, tube wall thickness and tube outside diameter welded in production. A certified welding schedule is a record of all machine set-up and material variables required to duplicate welding conditions that previously produced acceptable welds. The outside diameter of the machined overlap on the fitting must be considered for applicable set-up parameters. Certify welding schedules according to section 5.4.

5.2 Set-Up of Equipment

5.2.1 General

5.2.1.1 The B2A weld head consists of a rotor that holds the tungsten electrode and rotates it around the joint held stationary in the weld head by removeable collets (see Figure 1). The rotor provides centered and offset positions for the tungsten electrode. Depending on the tube and fitting combination being welded, select the proper collet set and tungsten electrode length, diameter and offset. Refer to Table 1 for the collet set to use for the particular tube diameter and fitting being welded. Calculate tungsten electrode dimensions, when required, according to section 5.2.3. The certified welding schedule must specify the electrode offset position, if applicable.

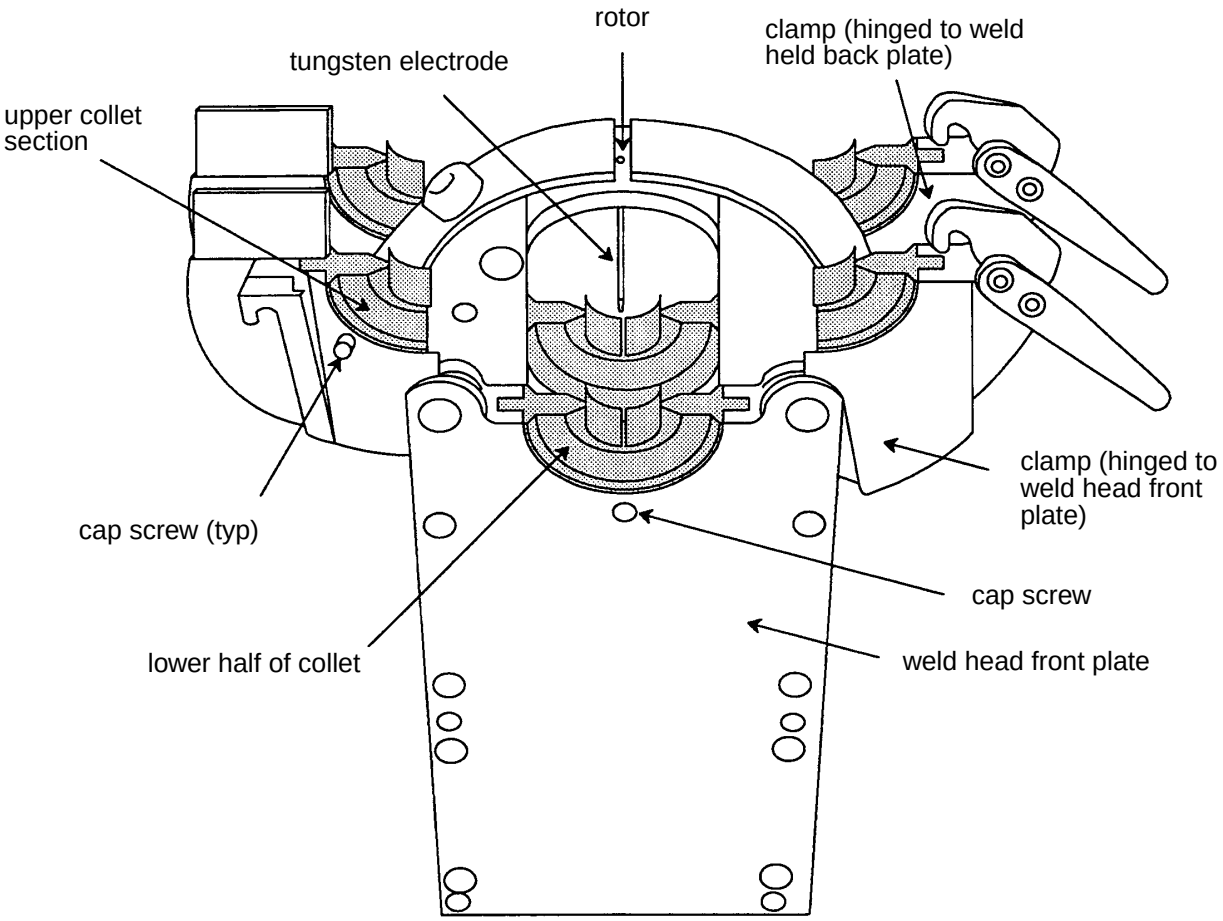


Figure 1 - General Description of B2A Weld Head

5.2.2 Installation of Collet Sets

5.2.2.1 Select the collet set specified in Table 1 for the joint being welded. A collet set consists of a fitting collet and a tube collet. If welding an end fitting, one collet supports the fitting and the other supports the tube. Tube collets are split in 3 sections. The bottom half of the tube collet seats in either the front or back plate of the weld head. The top half of each tube collet is split in 2 sections and each section fits in one of two clamps hinged to both the front and back plates of the weld head (see Figure 1).

5.2.2.2 Install the fitting collet in the weld head plate closest to the tungsten electrode and close the clamps hinged to the plate. Install the bottom of the tube collet in the other weld head plate and install the 2 top sections of the tube collet in the clamps hinged to the plate. Secure tube collet sections in place by tightening the socket head screws. If welding tube-to-tube, use tube collets in both weld head plates.

5.2.2.3 With the clamps closed and locked, the tube collet sections close together to provide support around the entire diameter of the assembly in the weld area.

Table 1 - Collet Sets

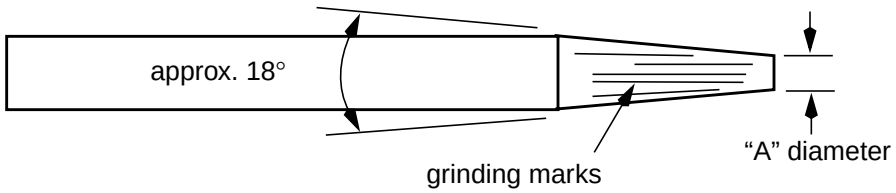
FITTING/TUBE COMBINATION		COLLET SET PART NUMBERS	
FITTING PART NUMBER	TUBING OUTSIDE DIAMETER	FITTING COLLET	TUBE COLLET
AS1580T04	1/4	320-1502-1G4 (Note 1)	
AS1580T06	3/8	320-1502-1G6 (Note 1)	
AS1580T08	1/2	320-1502-1G8 (Note 1)	
AS1581T04	1/4	320-1502-200	320-1502-1G4
AS1581T06	3/8	320-1502-300	320-1502-1G6
AS1581T08	1/2	320-1502-400	320-1502-1G8
AS1582T04	1/4	320-1502-500	320-1502-1G4
AS1582T06	3/8	320-1502-600	320-1502-1G6
AS1582T08	1/2	320-1502-700	320-1502-1G8

Note 1. AS1580T fittings are tube welded rings rather than end fittings. Collets are the same because they both support the tube on either side of the weld joint.

5.2.3 Preparation and Installation of Tungsten Electrodes

5.2.3.1 Prepare and install tungsten electrodes as follows:

Step 1. Grind tungsten electrode tips lengthwise (parallel to the direction of the grinding tool) as shown in Figure 2 to the diameter specified below, depending on the wall thickness of the tubing being welded.



Tube Wall Thickness	“A” Diameter
0.016" - 0.035"	0.010"
0.036" - 0.083"	0.020"
0.084" - 0.154"	0.030"

Figure 2 - Tungsten Electrode Dimensions

Step 2. Trim the electrodes to a length that leaves an arc gap of 0.028 ± 0.002" between the electrode tip and the surface of the workpiece when installed flush with the outside diameter of the welding head rotor (see Figure 3). Calculate tungsten electrode length using the following formula. Record the electrode length and the tip diameter on the applicable certified welding schedule.

- Electrode Length = 0.5 X (Rotor O.D. - Tube/Fitting O.D.) - Arc Gap (0.028")

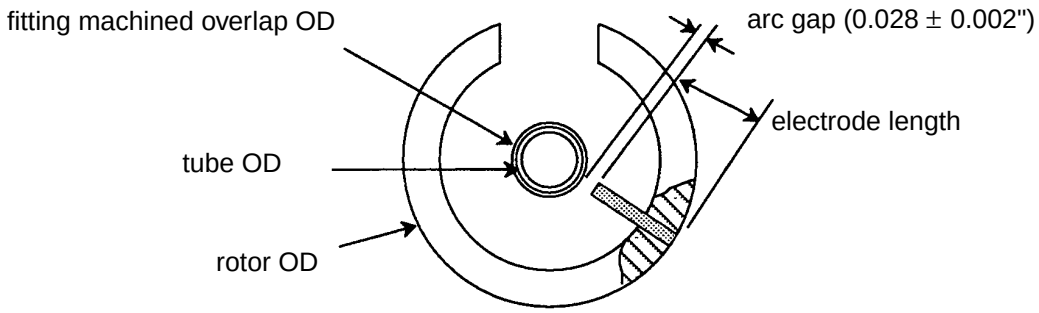


Figure 3 - Tungsten Electrode Location

Step 3. Once trimmed to length, install the tungsten electrode with the bottom flush with the outside diameter of the rotor. Hold the electrode in place by tightening the socket head screw on the rotor. When installed, the electrode tip must center on the machined overlap on the fitting with the arc gap set.

5.3 Qualification of Orbital Welding Equipment

5.3.1 Qualify orbital welding equipment before production use by welding 10 weld test assemblies of the maximum tube wall thickness and 10 weld test assemblies of the minimum tube wall thickness welded in production. Weld test assemblies for welding equipment qualification consist of a fitting and an approximate 6 inch length of tubing of the wall thickness for which the equipment is being qualified. Prepare weld test assemblies as specified herein. Weld all 10 weld test assemblies of each tube wall thickness consecutively without changing set-up parameters.

5.3.2 Submit welded test assemblies to either the Bombardier Toronto (de Havilland) Materials Laboratory or other Bombardier Aerospace approved laboratory for examination to the Class A weld requirements specified in PPS 37.10. Record inspection results and maintain them on file.

5.3.3 Consider welding equipment qualified for production use only after all test assemblies meet the Class A weld requirements specified in PPS 37.10. Re-qualify orbital welding equipment if there is any change in the tube wall thickness of production parts.

5.4 Certification of Welding Schedules

5.4.1 Establish the welding parameters for each welding schedule and maintain each welding schedule on file. For example, at Bombardier Toronto (de Havilland) each welding schedule shall be maintained on a separate DH Form #4894.

5.4.2 Certify welding schedules by producing 6 consecutive weld test assemblies without varying the welding parameters. Weld test assemblies for welding schedule certification consist of a fitting and an approximate 6 inch length of the tubing specified on the welding schedule. Prepare weld test assemblies as specified herein.

5.4.3 Submit welded specimens to either the Bombardier Toronto (de Havilland) Materials Laboratory or other Bombardier Aerospace approved laboratory for examination to the Class A weld requirements specified in PPS 37.10. Record inspection results and maintain them on file with the corresponding welding schedule.

5.4.4 Consider welding schedules certified only after all test specimens meet the Class A weld requirements specified in PPS 37.10.

5.5 Preparation of Parts

5.5.1 Prepare parts for welding as follows:

Step 1. Complete all tube bending operations.

Step 2. Degrease tubing according to PPS 31.04.

Step 3. Trim the tubing to final length.

Step 4. Clean the tubing according to PPS 31.09. After cleaning, handle tubing only while wearing clean white cotton gloves.

Step 5. Immediately before welding, solvent clean the interior and exterior tube end in the weld area according to PPS 31.17, then mechanically cleaning the area using a soft stainless steel wire brush or 180 - 240 grit aluminum oxide abrasive paper and final solvent clean the area again according to PPS 31.17.

5.5.2 Keep machined fittings in their original packages before use. Solvent clean fittings according to PPS 31.17 immediately before welding. After cleaning, only handle fittings while wearing clean white cotton gloves.

5.6 Production Welding

5.6.1 Select the applicable certified welding schedule for the fitting and tube combination being welded. Whenever selecting a certified welding schedule for production welding, follow the procedure specified below.

Step 1. Select the applicable collet set specified in Table 1 and install according to section 5.2.2.

Step 2. Select the tungsten electrode specified on the certified welding schedule. Prepare and install the appropriate electrode according to section 5.2.3.

Step 3. Adjust the argon (shielding gas) flow rate specified on the certified welding schedule.

Step 4. Locate the tube and fitting in the weld head and ensure that the tungsten electrode tip centers on the machined overlap exterior diameter of the fitting.

Step 5. Using a feeler gauge, ensure the gap between the tungsten electrode tip and surface of the workpiece is 0.028 ± 0.002".

Step 6. Ensure that the gap between the inside diameter of the fitting overlap and the outside diameter of the tube does not exceed 0.010".

Step 7. Weld the first production part and visually examine the weld according to PPS 37.10. If the first weld fails to meet the visual requirements specified in PPS 37.10, determine and correct the cause of failure before continuing production welding.

5.7 Post-Welding Procedure

5.7.1 Cap welded end fittings according to PPS 6.05.

5.7.2 Pressure test welded hydraulic line assemblies according to PPS 6.12.

6 Requirements

6.1 All welds must meet the requirements specified in PPS 37.10.

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 The use of grease, oil or any other lubricant on welding equipment is prohibited.

7.4 Wear suitable safety equipment.

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

8 Personnel Requirements

8.1 Only personnel certified and/or qualified according to PPS 37.05 shall perform orbital welding of fittings to titanium tubing.

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

9 Maintenance of Equipment

9.1 Once monthly, check the coolant level in the power supply and, if required, top up with a 50/50 mixture of ethylene glycol anti-freeze and water.