BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 1.06

PRODUCTION PROCESS STANDARD

TUBE SWAGING

Issue 5 - This standard supersedes PPS 1.06, Issue 4.
- Vertical lines in the left hand margin indicate changes over the previous issue.
- Direct PPS related questions to PPS.Group@aero.bombardier.com or (416) 375-4365.
- 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 swaging aluminum alloy and steel 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. 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 (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 PPS 1.02 - Forming Aluminum Alloy.

3.2 PPS 13.26 - General Subcontractor Provisions.

3.3 PPS 20.01 - Magnetic Particle Inspection.

3.4 PPS 20.03 - Fluorescent Penetrant Inspection.

3.5 PPS 30.01 - Heat Treatment of Aluminum Alloys.

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

3.7 PPS 30.08 - Steel Heat Treatment Martensitic Stainless Steel.

3.8 PPS 31.04 - Degreasing Processes.

4 MATERIALS AND EQUIPMENT

4.1 Materials

4.1.1 Tubes as specified on the engineering drawing.

4.1.2 Tube swaging lubricant: any industry standard swage lubricant (e.g., 10 parts kerosene to 1 part cutting oil).

4.2 Equipment

4.2.1 Swaging machine (e.g., ETNA #158).

4.2.2 Swaging tools (e.g., TS.277.XX.XX).

5 PROCEDURE

5.1 Set-Up of Swaging Machine

5.1.1 Set up swaging machines as follows:

Step 1. Select the appropriate matched die set for the work being done.

Step 2. Clean the die blocks, remove the die cap from the machine and install the die set in the slot in the spindle head. Install suitable swaging die shims along with the die set, as necessary.

Step 3. Select the appropriate set of nylon guide bushings and install in the guide attachement fitted to the front of the die cap.

Step 4. Re-install the die cap to the machine.

Step 5. Select the appropriate fibre guide sleeve for the size of tube being swaged.

Step 6. Where necessary, adjust the tail stop for the length of work being done.

Step 7. If reaming to size after swaging is not permitted, install a mandrel in the spindle so that it extends completely through the die blocks to produce the inside diameter during swaging.

5.2 Preparation of Tubes

5.2.1 Prepare tubes for swaging as follows:

Step 1. Except for aluminum alloy tubes, cut tubes to the length specified by the engineering drawing before swaging. Cut aluminum alloy tubes approximately 1/2" longer than specified in order to provide a trimming allowance after swaging.

Step 2. Deburr tubes before swaging so as to produce a slight chamfer on the inside and outside of the cut end of the tube. Take care to avoid producing a knife edge condition.

Step 3. Heat treat tubes to the condition shown in Table I according to the PPS specified. Tubes in conditions other than those specified in Table I may be swaged without heat treatment, provided experience has proven it possible.

Step 4. Ensure tubes are clean and free from grease, oil or foreign matter before swaging. If necessary, degrease parts according to PPS 31.04.

TABLE I - HEAT TREATING TUBING FOR SWAGING

MATERIAL	CONDITION	PPS
Aluminum	W - As Quenched (Note 1) or O - Annealed	PPS 30.01
Stainless Steel	Annealed	PPS 30.08
Carbon & Low Alloy Steel	Annealed or Normalized	PPS 30.04

Note 1. After quenching, or removal from the refrigerator, swage aluminum alloy tubes in the as quenched condition within the time limits specified in PPS 1.02.

5.3 Swaging

5.3.1 Swage tubes as follows:

Step 1. Place a fibre guide sleeve over the tube and secure the guide sleeve in the pneumatic clamp located on the sliding bed of the machine.

Step 2. Apply a light film of lubricant (see Materials section, paragraph 4.1.2) to the portion of the tube to be swaged, immediately before swaging.

Step 3. By means of the hand crank, bring the tail stop to bear against the end of the tube and feed the tube into the rotating dies. Feed the tube steadily into the dies at a rate that will produce a satisfactory swage. If a tube to be swaged is too short to be held and fed into the dies, fit a suitable extension holder to the tube and this used to hold and feed the tube during swaging.

Step 4. Resist rapid rotation of the tube during swaging by holding it manually and allowing the tube to rotate slowly. Wear a protective glove in order to hold the tube during swaging.

Step 5. After the required length of tube has been fed into the dies, pause momentarily in order to ensure concentricity of the finished product. On completion of swaging, carefully withdraw the tube from the dies.

Step 6. Check the first off tube of a production run to ensure that it meets the requirements of the engineering drawing and this standard (see Figure 1). The parallel swage length of aluminum alloy tubes after swaging, must be at least 1/4" greater than the drawing requirements in order to provide a trimming allowance.

Step 7. If the first off tube is satisfactory, continue with the swaging operation. If the first off tube fails to meet the specified requirements, determine the reason for failure and rectify before re-commencing production. Check each tube produced until satisfactory tubes are being produced.

5.4 Finishing

5.4.1 If possible, produce the finished inside diameter by swaging. If it is necessary to ream to the finished inside diameter, ream over the entire parallel swaged length in order to prevent forming an internal ridge in the tube (see Figure 1).

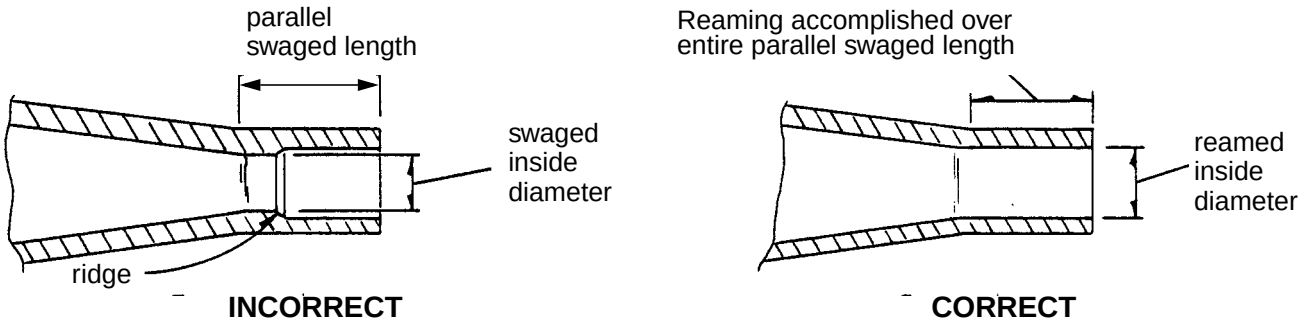

FIGURE 1 - REAMING OF SWAGED TUBE

5.4.2 After swaging, trim aluminum alloy tubes to length and deburr, ensuring that at least 1/4" is trimmed off each swaged end.

5.5 Non-Destructive Testing

5.6 Subject swaged tubes to non-destructive testing (i.e., magnetic particle inspection according to PPS 20.01 or fluorescent penetrant inspection according to PPS 20.03, as applicable) if cracks are suspected or non-destructive testing is specified on the engineering drawing. Non-destructive testing is also required (unless the engineering drawing indicates that flaw detection is not required) for all tempers of 2024 alloy, 4130-N and 6061-T6, if the swage reduction in diameter is greater than 15% and the swaged tube is not going to be non-destructive tested after a subsequent manufacturing operation.

6 REQUIREMENTS

6.1 Tubes not meeting the following requirements are not acceptable.

- The finished tube must conform to the dimensional requirements of the engineering drawing. The reamed wall thickness of tubes which have been reamed to size after swaging, shall not be less than the nominal wall thickness of the tube.
- There must be no evidence of cracks, fins, laps or roughness on the swaged surface.
- Longitudinal wrinkles up to 0.002" deep are acceptable. Refer tube assemblies with more severe wrinkling to Bombardier Toronto (de Havilland) MRB or Bombardier Toronto (de Havilland) delegated MRB for disposition.

7 SAFETY PRECAUTIONS

7.1 Ensure that swaging machines are disconnected from the power source when changing swaging dies.

8 PERSONNEL REQUIREMENTS

8.1 Personnel responsible for tube swaging must have a good working knowledge of the procedure and requirements as specified herein and must have exhibited their familiarity to their supervisor.

9 MAINTENANCE OF EQUIPMENT

9.1 The swaging machine shall be maintained by the Maintenance Department in accordance with the manufacturer's instructions.