BOMBARDIER Toronto (de Havilland) **Proprietary Information**	**PPS 6.14** **Production Process Standard (PPS)**

Swage Installation of Wiggins and Hydraflow Fittings

Issue 17

- This standard supersedes PPS 6.14, Issue 16.
- This PPS is effective as of the distribution date.
- Validation of issue status is the responsibility of the user.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
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Issue 17 - 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 section(s) of this PPS for detailed procedure and requirements.

- Added PPS 27.05 (Manual Edge Finishing) to section 3.2 (Bombardier Toronto (de Havilland) Specifications).
- Clarified procedure for assembly of fittings utilizing a swaged body and threaded closure (ref. para. 5.5.3 and subsequent steps) to specifically reference applicability to B0305118 rigid coupling bodies.
- Added an illustration (ref. Figure 4) of the required "installed gap" between the end of the nut assembly and shoulder of B0305118 rigid coupling bodies for applicable installed threaded fittings.

Issue 17 - Summary of Changes (over the previous issue) continued

- Revised para. 6.1.4, to clarify that swaged threaded bodies must also not be re-swaged.
- Revised para. 6.2.5, to clarify that the diameter of the tube 3/8” beyond the rear of a swaged threaded body must also not exhibit any increase.
- Revised para. 6.4.2, to clarify that diametral growth of the outside diameter of a swaged threaded body greater than 0.020" is also not acceptable.
- Revised section 8 (Personnel Requirements) to delete redundant paragraph specifying that personnel must have a good working knowledge of the applicable procedure and requirements as this PPS is categorized as a “Controlled Special Process” by PPS 13.39 which species applicable personnel requirements (ref. para. 8.1).

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1 Scope

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for swaging and installation of Wiggins and Hydraflow utilizing threadless clamshell closures or threaded closures on non-anodized tubes.

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 Site) 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 6.10 - Cleaning of Fluid System Components.

3.2.2 PPS 6.12 - Pressure Testing Hydraulic Components and High Pressure Fuel Lines.

3.2.3 PPS 13.26 - General Subcontractor Provisions.

3.2.4 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.2.5 PPS 27.05 - -Manual Edge Finishing.

3.2.6 PPS 31.04 - Degreasing Processes.

3.2.7 PPS 31.17 - Solvent Usage.

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 Scotch-Brite pads, Type A fine (maroon colour), 3M Canada Ltd.

4.1.3 Lubricating oil for lubricating expander rollers and "O" rings, Pennwalt DP-1212 or Boelube 70106-04.

4.1.4 Lubricating oil for swaging equipment internal lubrication (e.g., SAE 10W automotive engine oil). Use lubricating oil according to para. 4.1.3 for lubricating expander rollers.

4.2 Equipment

4.2.1 Chipless tube cutter.

4.2.2 Calibrated torque wrench with an accuracy of ±4% minimum for manual swaging. The torque limiting type is more convenient when performing repeated swages.

4.2.3 Swaging tools (Wiggins and Hydraflow) as specified in Table 1.

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 swage installation of Wiggins and Hydraflow fittings according to this PPS.

4.3.2 This PPS has been identified as a "controlled" specification according to Bombardier Aerospace and as such only facilities specifically approved by Bombardier Aerospace are authorized to perform swage installation of Wiggins and Hydraflow fittings according to this PPS. For the purposes of this PPS, a "controlled" specification is one which requires specific Bombardier Aerospace approval of particular facilities to perform the particular process or procedure specified by that specification.

4.3.3 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.

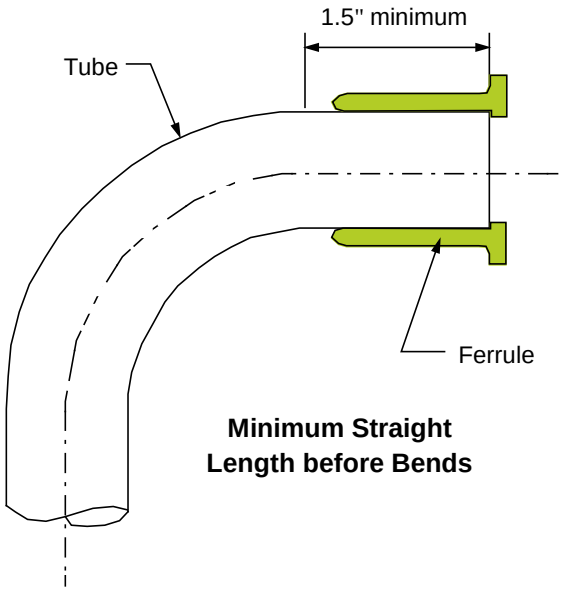
4.3.4 Facility approval shall be based on a facility report, a facility survey and completion of a qualification test program, if required. The facility report must detail the materials and equipment to be used, the process sequence to be followed and the laboratory facilities used to show compliance 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.

4.3.4.1 Unless otherwise specified by Bombardier Aerospace Supplier Quality Management, for approval of subcontractor facilities to perform swage installation of Wiggins and Hydraflow fittings 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 5.5.3.

5 Procedure

5.1 General

5.1.1 Tubing may be bent before or after the swaging operation provided that the tube bend does not begin less than 1.5" from the tube end as shown in the adjacent figure.



Minimum Straight Length before Bends

5.1.2 Store Wiggins and Hydraflow connectors and ferrules in their protective packages, as received, until required for installation.

5.1.3 Take care to ensure that hydraulic fluid lines and hydraulic system components used with MIL-H-5606 hydraulic fluid do not come into contact with solvent blends containing isopropyl alcohol (IPA), also known as isopropanol and 2-propanol. Hydraulic fluid lines and hydraulic system components used with MIL-H-5606 hydraulic fluid which have been contaminated with solvent blends containing isopropyl alcohol must be cleaned according to PPS 6.10.

5.1.4 Fittings with threadless clamshell closures utilize swaged ferrules with O ring seals on both tubes, a fitting body and a clamshell retainer/latch assembly, as shown in Figure 1.

5.1.5 Fittings with threaded closures utilize a swaged body on one tube and a nut/retainer assembly and swaged ferrule with O-ring seal on the other tube, as shown in Figure 2.

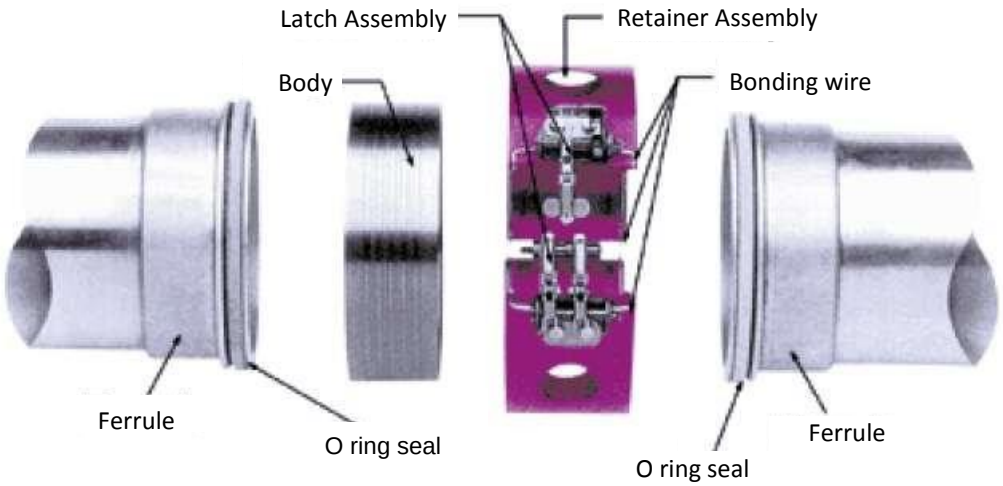


Figure 1. **Fitting with Threadless Clamshell Closure**

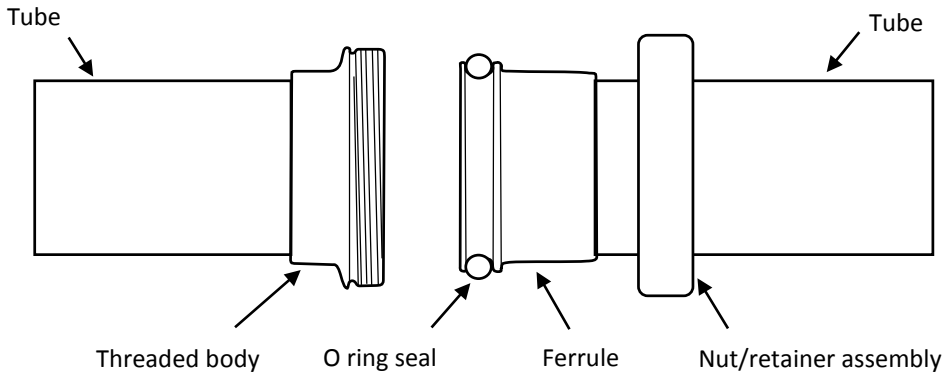


Figure 2. **Fitting with Threaded Closure**

5.2 Preparation of Tubing

5.2.1 Prepare tubes for swaging as follows:

Step 1. Using a chipless tube cutter, cut the tube to length. Ensure that the tube face is square with the outer diameter.

Step 2. Deburr the tube ends according to PPS 27.05.

Step 3. If the tube end has any scratches, gouges, etc., polish it with a Scotch-Brite pad using radial motions about the tube circumference. Do not polish the tube in a longitudinal direction. Scratches, gouges, etc. which cannot be removed by polishing, are not acceptable.

5.3 **Preparation of Ferrule**

5.3.1 Visually examine the ferrules for damage. Ensure that the inside of the ferrule is free from chips, burrs, lubricant or dirt and that both "O" rings are present, undamaged, but un-installed.

5.3.1.1 If the ferrule has been contaminated with dirt, grease or shop soil, wipe it with a clean dry cloth or, if necessary, solvent clean it according to PPS 31.17.

5.4 **Swaging Operation**

5.4.1 Perform manual swaging as follows:

Step 1. Select the die block holder, die block and expander assembly from Table 1 for the ferrule/tube or threaded body/tube combination to be swaged.

Step 2. Mount the die block holder into a bench-mounted vise with the shoulder stop on the side that the torque wrench is to be used. Remove any contaminants from the inside diameter of the holder.

Step 3. Visually examine the die block and expander assembly for chips, burrs and other contaminants before each use. Replace and re-certify the expander if there is evidence of damage, deformation or wear on the roller or mandrel. The inside corners of the die block, where it closes around the ferrule, must be sharp.

Step 4. Insert the ferrule or threaded body into one half of the die block and carefully close the other half block over the ferrule or threaded body.

Step 5. Insert the die block into the die block holder with the ferrule or threaded body facing towards the shoulder stop. Ensure there is no mismatch of the die block halves and that the two halves are flush with the holder.

Step 6. While holding the die block against the shoulder stop, tighten the holder clamp device to prevent separation of the die halves during swaging.

Step 7. Slide the tube into the ferrule until the tube makes contact with the shoulder stop (see Figure 3). To prevent scratching or shaving of the tube surface, the tube must slide freely without force or rotation. If the tube does not slide freely, check for an out-of-roundness condition. Tubes which do not slide freely are not acceptable.

Step 8. Apply lubricating oil (ref. para. 4.1.3) to the expander rollers.

Step 9. With the tube supported to ensure proper alignment, insert the expander into the ferrule (the mandrel must be fully retracted before insertion). Avoid displacing the tube when inserting the expander.

Step 10. Push the mandrel in as far as possible and rotate it clockwise by hand to start the self-feeding action.

Step 11. Using the appropriate calibrated torque wrench and torque wrench adapter, turn the mandrel clockwise continuously until the applicable swage torque as specified in Table 2 (adjusted according to para. 6.4.3, if necessary) is obtained.

Step 12. Reverse the direction of the expander rotation until the mandrel is free and can be withdrawn from the tube.

Step 13. Loosen the die block holder and remove the die block.

Step 14. Open the die block and remove the swaged tube assembly.

Table 1. **Swage Tools**

Ferrule or Threaded Body	Tube		Expander Assembly	Die Block	Die Block Holder
	Size	Wall Thickness			
B0305026 Ferrule (Wiggins W902 or Hydraflow 14F02)	-8 (1/2")	0.028"	TL118-8-28	TL120-8	DH6305-1
		0.035"	B908-35	DB900-08	
	-10 (5/8")	0.028"	B910-28	DB900-10	
		0.035"	B910-35		
	-12 (3/4")	0.028"	B912-28	DB900-12	
		0.035"	B912-35		
		0.042"	B912-42		
	-16 (1")	0.028"	B916-28	DB900-16	
		0.035"	B916-35		
	-20 (1 1/4")	0.028"	B920-28	DB900-20	
		0.035"	B920-35		
	-24 (1 1/2")	0.028"	B924-2835	DB900-24	DH6305-2
		0.035"			
	-28 (1 3/4")	0.028"	B928-2835	DB900-28	
		0.035"			
B0305066 Ferrule (Hydraflow 14K02)	-20 (1 1/4")	0.028"	TL176-20-28	TL174-20	TL113

Table 1. **Swage Tools**

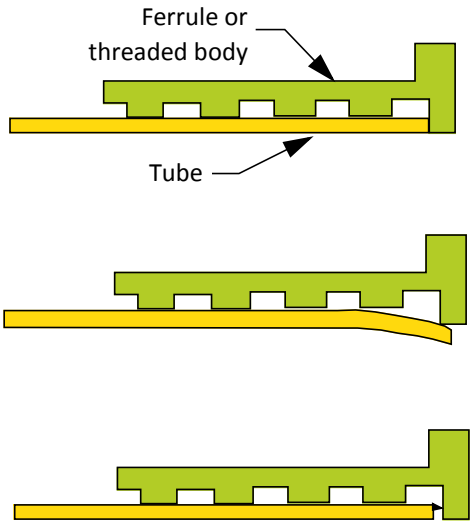
Ferrule or Threaded Body	Tube		Expander Assembly	Die Block	Die Block Holder
	Size	Wall Thickness			
B0305118 Threaded Body (Hydraflow 15C18)	-8 (1/2")	0.028"	TL176-8-28	TL847-08	TL113-2
	-10 (5/8")	0.028"	TL176-10-28	TL847-10	
	-12 (3/4")	0.028"	TL176-12-28	TL847-12	
	-16 (1")	0.028"	TL176-16-28	TL847-16	
	-20 (1 1/4")	0.028"	TL176-20-28	TL847-20	
	-28 (1 3/4")	0.028"	TL176-28-28	TL847-28	TL113-3
Hydraflow FC041 Ferrule	-12 (3/4")	0.028"	C912-28	DB900-12	DH6305-2
Hydraflow LC017 Ferrule	-20 (1 1/4")	0.028"	C924-2835	DB900-24	DH6305-2
Wiggins 63152 & DSC 533 Ferrules (Wiggins S3052 or Hydraflow 12F70)	-12 (3/4")	0.028"	B8312-28	DB6305-12	DH6305-1
		0.035"	B8312-35		
	-16 (1")	0.028"	B8316-28	DB6305-16	
		0.035"	B8316-35		
	-20 (1 1/4")	0.028"	B8320-28	DB6305-20	
		0.035"	B8320-35		
	-24 (1 1/2")	0.028"	B8324-28	DB6305-24	DH6305-2
		0.035"	B8324-35		
Wiggins W905 Ferrule	-12 (3/4")	0.028"	C912-28	DB900-12	DH6305-1
	-16 (1")	0.028"	C916-28	DB900-16	
		0.035"	C916-35		
	-24 (1 1/2")	0.028"	C924-2835	DB900-24	DH6305-2
		0.035"			

Table 2. **Swage Torque Values** (Note 1)

Tube		**Swage Torque** (inch-pounds)				
Size (Diameter)	**Wall Thickness**	**5052-O**	**6061-T4**	**6061-T6**	**300 Series CRES Tubes**	
					Threaded Body	**Ferrules** (Note 2)
-8 (1/2")	0.028"	8	9	10	28	28
	0.035"	9	10	11	n/a	35
-10 (5/8")	0.028"	13	14	17	47	42
-12 (3/4")	0.028"	17	21	25	59	54
	0.035"	19	23	28	n/a	70
	0.042"	22	27	32	n/a	80
-16 (1")	0.028"	30	36	46	100	100
	0.035"	33	40	51	n/a	115
-20 (1 1/4")	0.028"	56	62	75	160	160
	0.035"	62	68	95	n/a	
-24 (1 1/2")	0.028"	100	108	120	220	220
	0.035"	110	120	145	n/a	
-28 (1 3/4")	0.028"	140	150	180	300	300
	0.035"	155	165	200	n/a	

Note 1. If, through certification of expander assemblies, it has been established that a higher swage torque than specified in this table is required to achieve acceptable groove fill, use the higher swage torque thus established (ref. para. 6.4.3) for all applicable production parts. Use of a higher swage torque is **only** acceptable if thus established.

Note 2. For ferrules only, the swage torque values specified for 300 Series CRES tubes can be used for swaging ferrules to 21-6-9 CRES tubes.



Acceptable - The face of the tube must be square with the outer diameter and be free of burrs. The outside corner break must not exceed 0.005".

Unacceptable - Large radii on the tube end will result.in misalignment of the ferrule or threaded body.

Unacceptable - A burr on the front face of the tube will prevent proper seating of the tube end with the ferrule or threaded body.

Figure 3. **Insertion of Tubes into Ferrules**

5.5 Post Swage Procedure

5.5.1 After the swaged ferrule(s) and/or swaged threaded body have been checked as specified in section 5.5.3, degrease the tube according to PPS 31.04.

5.5.2 Assemble fittings utilizing threadless clamshell closures (see Figure 1) as follows:

Step 1. Lubricate (ref. para. 4.1.3) and install an “O” ring seal on each ferrule.

Step 2. Fit one half of the fitting body over one ferrule and the other half over the other ferrule.

Step 3. Install the retainer assembly centered over the connector body.

Step 4. Engage the latch assembly by squeezing the latches together until they “snap”.

5.5.3 Assemble fittings utilizing a B0305118 swaged threaded body and threaded closure (see Figure 2) as follows:

Step 1. Slide the nut assembly, knurled end first, over the swaged ferrule.

Step 2. Spirally deflect one split end of the retainer ring over both lands of the ferrule seal cavity. Trace around the ring circumference with a finger to make the entire ring follow into position.

Step 3. Place the "O" ring seal in the seal cavity of the ferrule and lubricate (ref. para. 4.1.3) the seal outside diameter.

Step 4. Slide the swaged fitting body over the installed O-ring seal on the ferrule.

Step 5. Secure the assembly in place with the nut assembly. The fitting is properly assembled when the nut is hand tight to an installed gap of 0.000" – 0.040" between the end of the nut assembly and the shoulder of the threaded body as shown in Figure 4. This condition makes the coupling self-locking by means of ratchet action between the nut and body.

If the installed gap is greater than 0.040", determine the cause of failure and correct; if an installed gap of 0.000" – 0.040" cannot be achieved, refer to Liaison Engineering for disposition. For proper aircraft grounding, as applicable, it is **imperative** that the installed gap shown in Figure 4 must not exceed 0.040".

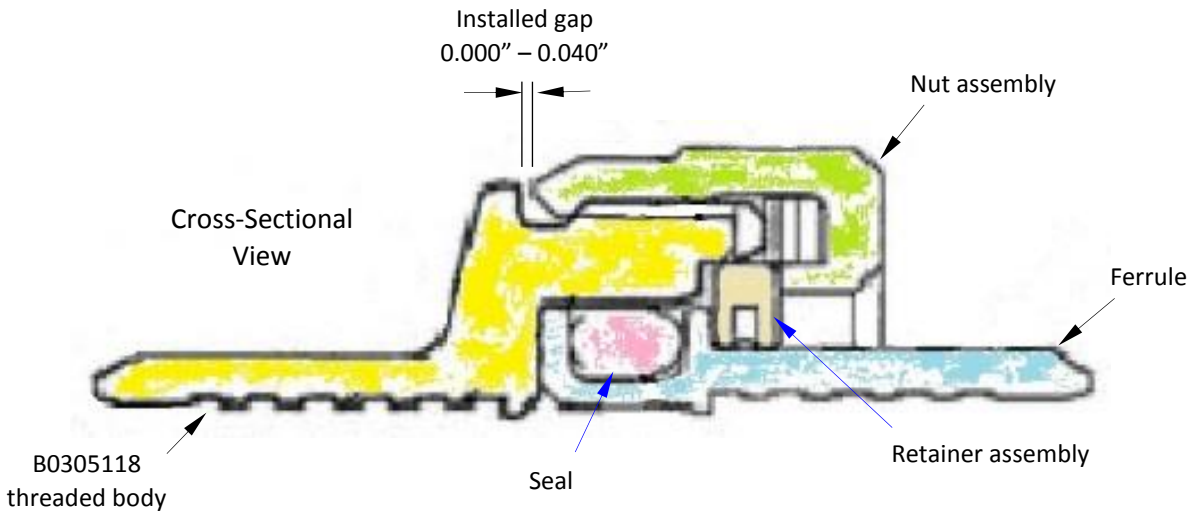


Figure 4. **Installed Gap** (ref. B0305118 Threaded Body)

6 Requirements

6.1 Visual Examination

6.1.1 Swaged ferrules and swage threaded bodies shall be tight on the tube.

6.1.2 Swaged assemblies shall be free from visible cracks.

6.1.3 The ferrule shall not have been damaged during swaging or by handling.

6.1.4 Swaged ferrules and swaged threaded bodies that exhibit signs of over-swaging or under-swaging are not acceptable. Over-swaging can result in ferrule deformation and excessive

extrusion of the tube material past the ferrule tube stop lip. Under-swaging can result in separation of the ferrule and the tube under vibration or leakage under pressure. Do not re-swage ferrules or swaged threaded bodies.

6.2 Dimensional Examination

6.2.1 For fittings utilizing a B0305118 swaged threaded body it is **imperative** to ensure an installed gap of 0.000" – 0.040" between the end of the nut assembly and the shoulder of the threaded body, as shown in Figure 4.

6.2.2 Swaged ferrules and swaged threaded bodies shall be square to the tube to within ±1°.

6.2.3 The sealing surface of swaged ferrules and swaged threaded bodies shall not have been disturbed by the split die blocks. A raised smooth rounded welt is acceptable at the die block parting line provided it does not exceed 0.002" in height. On non-sealing surfaces, a height of 0.004" is acceptable.

6.2.4 Diametral growth of the outside diameter of swaged ferrules and swaged threaded bodies shall not exceed 0.020" after swaging.

6.2.5 Scoring of the inside tube surface aft of the swaged area is unacceptable. Refer assemblies with scoring on the inside of the tube aft of the swaged area to Bombardier Toronto (de Havilland) MRB or Bombardier Toronto (de Havilland) delegated MRB for disposition.

6.2.6 An increase in tube diameter of not more than 0.032" for a maximum distance of 3/8" immediately behind the swaged ferrule or swaged threaded body is acceptable. The diameter of the tube at a point located 3/8" beyond the rear of the swaged ferrule or swaged threaded body shall not exhibit any increase.

6.3 Pressure Testing

6.3.1 Tube assemblies shall be proof pressure tested according to PPS 6.12 to the pressure specified in Table 3.

Table 3. **Proof Pressure Test for Swaged Assemblies**

Tube Size	Test Pressure	Tube Size	Test Pressure
1/2" (-08)	420 psi	1 1/4" (-20)	140 psi
5/8" (-10)	200 psi	1 1/2" (-24)	140 psi
3/4" (-12)	200 psi	1 3/4" (-28)	100 psi
1" (-16)	200 psi		

6.3.2 Assemblies that have been installed and swaged in situ in the aircraft shall be pressure tested by isolating the applicable section of line or, if this is not practical, shall be tested during the aircraft functional test procedures.

6.3.3 Connections that leak during pressure testing are not acceptable.

6.4 Expander Assembly Certification

6.4.1 All new and repaired tooling must be certified before being used for production. Re-certification is required every 13 weeks during periods when production parts are being processed. Thirteen weeks from the day the certification test assemblies are prepared, certification will expire; tools for which certification has expired shall not be used on production parts until further test assemblies have been prepared and satisfactory test results have been obtained. Therefore, it is strongly recommended that certification test assemblies be prepared and tested before tooling certification expires.

6.4.2 For certification or re-certification of a particular tool, swage one test assembly of each tube material, tube diameter, tube wall thickness and ferrule/tube or threaded body/tube combination to be swaged by that tool in production (for simplicity of keeping track of tool certification, it is recommended that all combinations which are expected to be used for that tool be prepared on the same day). The test assemblies shall be at least 4" long and be swaged at both ends. Ensure tooling has been checked and calibrated before using it to produce test assemblies. When producing test assemblies, record both the initial outside diameter and the post-swage outside diameter of the ferrule or threaded body on the job card. Diametral growth of the outside diameter of the swaged ferrule or swaged threaded body greater than 0.020" is not acceptable. Test each of the swaged test assemblies as follows:

Step 1. Proof pressure test the swaged test assembly according to PPS 6.12 to the pressure specified in Table 3.

Step 2. Using a cutting wheel, cut off one of the swaged tube ends.

Step 3. Mount the cut off tube end in resin.

Step 4. Allow the resin to fully cure before cutting the tube end through the longitudinal axis.

Step 5. Mount and polish the cross-sections using standard metallographic techniques to expose the tube/ferrule interface.

Step 6. Examine the mounted cross-sections at 50X magnification minimum in the unetched condition. Check that groove fill meets the requirements of Figure 5 and Figure 6. For CRES tubing, there will be some degree of spring back in sectioned CRES tubing ferrule assemblies; remove the gap due to spring-back from groove fill calculations (i.e., assume that the tube and ferrule are clamped together to overcome spring-back). Any evidence of cracking in the tubing or cracks in the ferrule lands greater than 0.018" in length is unacceptable.

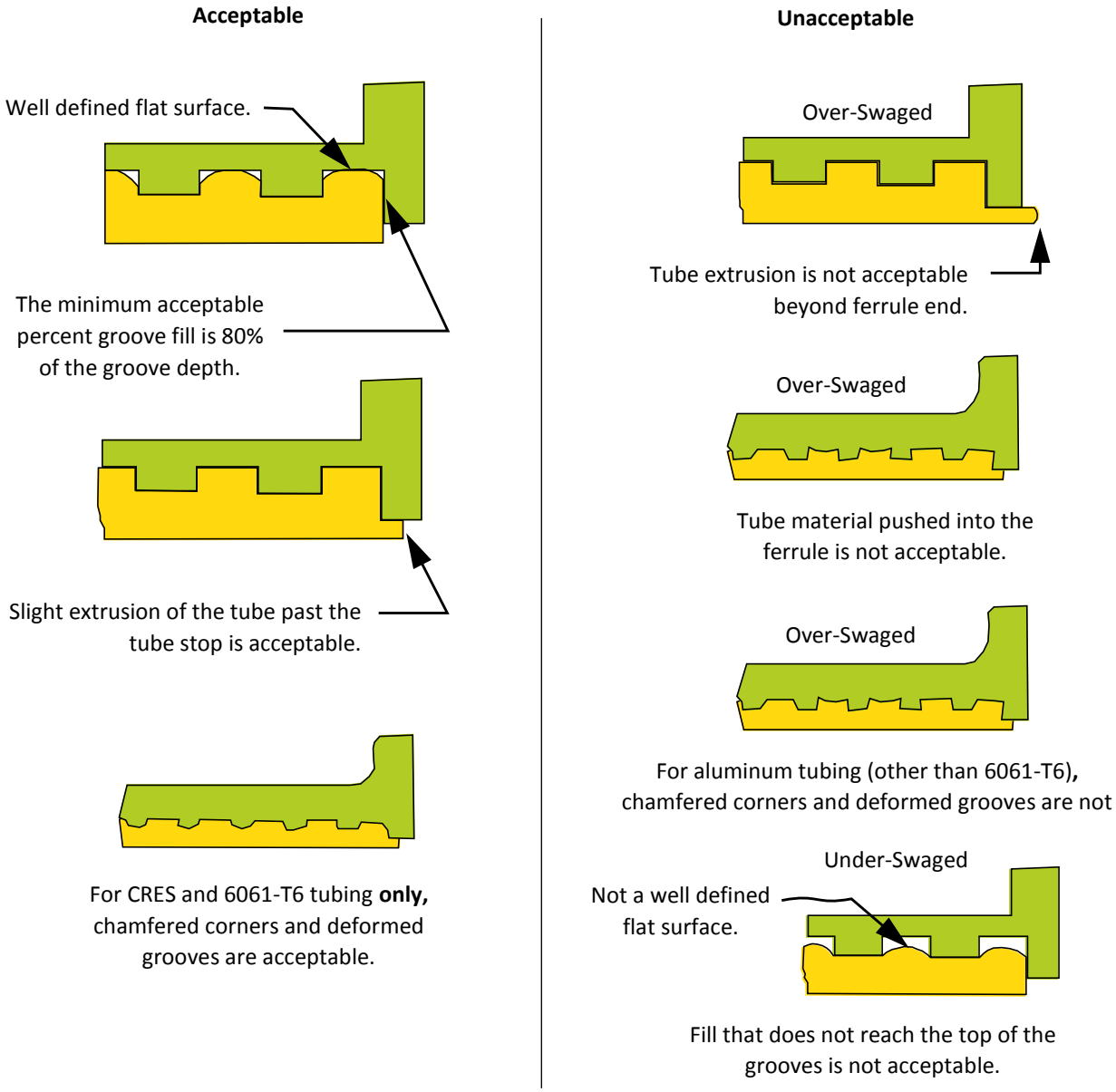


Figure 5. **Examination of Finished Swage**

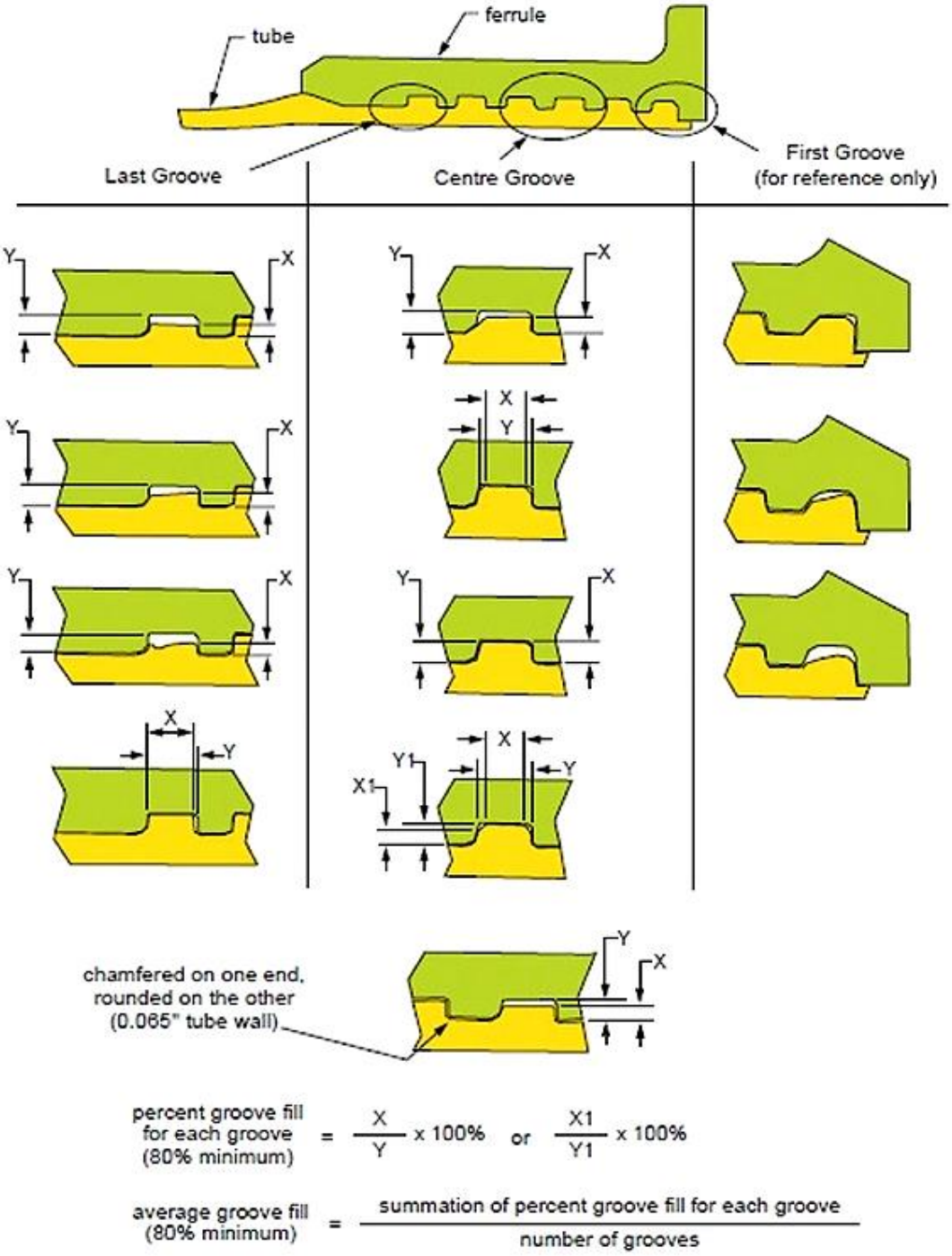


Figure 6. **Calculation of Percent and Average Groove Fill**

Step 7. Using a cutting wheel, cut off the other swaged tube end.

Step 8. Longitudinally section the other swaged tube end through the ferrule.

Step 9. Remove the ferrule halves from the tube halves and examine the outside diameter of the tube for cracks along the groove profile at 4X magnification minimum. Alternatively, it is acceptable to check for cracks in the outside diameter of the tube by fluorescent penetrant inspection according to PPS 20.03. Any evidence of cracks in the tubing is not acceptable.

6.4.3 If a failure of any test assembly is found, the corresponding tooling shall not be used for production purposes until the problem has been corrected and all production parts prepared since the last satisfactory certification are considered suspect pending MRB investigation. If inadequate groove fill was the cause of failure, to correct the problem it is acceptable to increase the swage torque beyond that specified in Table 2 as necessary to achieve acceptable groove fill provided that the expander wear limits (i.e., minimum expansion requirements) specified in Step 7 are met and resulting test samples do not exhibit evidence of over-swaging and all production parts from that point on which are swaged using that tool are swaged at the increased swage torque. A record of any change in swage torque must be maintained and displayed in the swaging work area; take care to ensure that the displayed adjusted swage torque is rigorously maintained and operators understand the nature and cause for this adjustment. After repair, new test assemblies must be produced and re-tested according to this section.

Table 4. **Expander Assembly Wear Limits**

Tube		Minimum Expander Expansion
Size (Diameter)	Wall Thickness	
-08 (1/2")	0.028"	0.481"
	0.035"	0.467"
-10 (5/8")	0.028"	0.609"
	0.035"	0.597"
-12 (3/4")	0.028"	0.734"
	0.035"	0.720"
	0.042"	0.701"

Tube		Minimum Expander Expansion
Size (Diameter)	Wall Thickness	
-16 (1")	0.028"	0.984"
	0.035"	0.970"
-20 (1 1/4")	0.028"	1.235"
	0.035"	1.218"
-24 (1 1/2")	0.028"	1.484"
	0.035"	1.470"
-28 (1 3/4")	0.028"	1.724"
	0.035"	1.720"

7 Safety Precautions

7.1 The safety precautions specified herein are specific to Bombardier Toronto (de Havilland) 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.

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.