BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 6.19

PRODUCTION PROCESS STANDARD

Installation of Internal Roller Swage Fittings

Issue 16 -
- This standard supersedes PPS 6.19, Issue 15.
- Vertical lines in the left hand margin indicate technical 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.

Prepared By:	(Michael Wright)	January 15, 2014
	Production Process Standards (PPS)	
Approved By:	(L.K. John)	January 15, 2014
	Materials Technology	
	(Adam Gordon)	January 16, 2014
	Quality	

Table of Contents

Sections **Page**

Tables

Figures

1 Scope

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for installation of internal roller swage fittings.

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 PPS 6.10 - Cleaning of Fluid System Components.

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

3.3 PPS 13.26 - General Subcontractor Provisions.

3.4 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.5 PPS 27.05 - Manual Edge Finishing Equipment.

3.6 PPS 31.04 - Degreasing Processes.

3.7 PPS 31.17 - Solvent Usage.

4 Materials, Equipment and Facilities

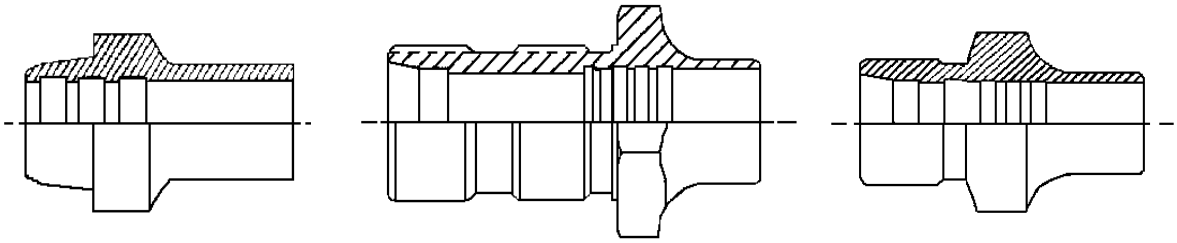
4.1 Materials

4.1.1 Extreme pressure roller lubricant, high viscosity (e.g., MIL-PRF-23827, Chicago Manufacturing & Distribution Co. Inc. Extreme Pressure Lube #3, etc.) for lubrication of swaging rollers.

4.1.2 Internal roller swage fittings as specified by the engineering drawing (see Figure 1 for a general description and Figure 2 for the part number breakdown).

4.1.3 SAE 10 non-detergent, phosphate-free oil.

4.1.4 General purpose machine oil (e.g., Kluber Corporation Isoflex NBU 15 high speed grease) for maintenance of 6777 swage machine.



Sleeve
B0302132

Bulkhead Union
B0302162

Union
B0302133

Figure 1 - Internal Roller Swage Fittings

Basic Part Number
B0302132 - Sleeve, flareless, shallow groove, roller swage
B0302133 - Union, flareless, shallow groove, roller swage
B0302162 - Union, flareless, bulkhead, shallow groove, roller swage

Material Code
AV - 15-5PH CRES, no dry film lube on outside diameter
GV - 7075-T73 Aluminum alloy
T - 6AL-4V Titanium
V - 15-5PH CRES, passivated
VN - 15-5PH CRES, cadmium plated

Tube Size

04 - 0.250"	08 - 0.500"	16 - 1.000"
05 - 0.312"	10 - 0.625"	20 - 1.250"
06 - 0.375"	12 - 0.750"	24 - 1.500"

B0302133 T 04

Figure 2 - Part Number Breakdown

4.2 Equipment

4.2.1 Sierracin/Harrison, Stanley-Harrison or Eaton Aerospace 6777 automatic swage machine.

4.2.2 Sierracin/Harrison, Stanley-Harrison or Eaton Aerospace external swaging tools for fittings as specified in Table 7.

4.2.3 Sierracin/Harrison, Stanley-Harrison or Eaton Aerospace internal swaging tools, expander assemblies as specified in Table 6.

4.2.4 Swage length inspection gauges and swaging machine gauges which indicate swaging pressure or swaging torque. These gauges must be calibrated at least every three months during periods when production parts are being processed.

4.2.5 Tube micrometer (e.g., Intertest).

4.2.6 Rotary type roller cutter.

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 installation of internal roller swage fittings 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.

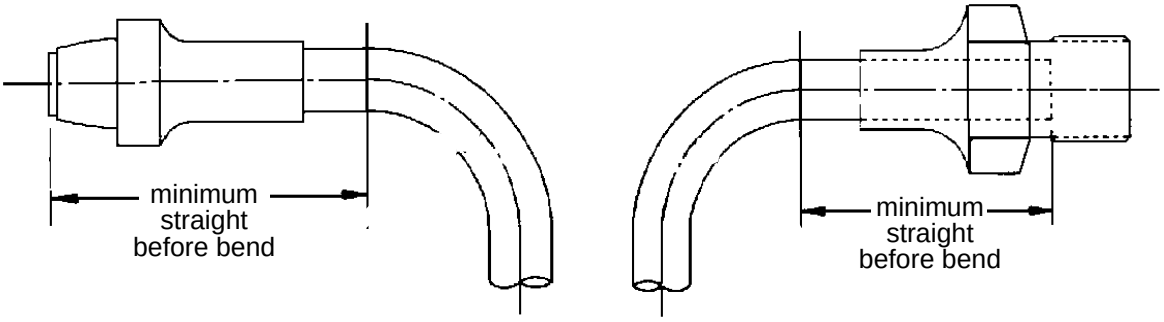
4.3.3.1 Unless otherwise specified by Bombardier Aerospace Supplier Quality Management, for approval of subcontractor facilities to perform installation of internal roller swage fittings according to this PPS, completion of a test program and submission of suitable test samples representative of production parts is required. Test samples must meet the requirements specified in section 6.

5 Procedure

5.1 Tube Preparation

5.1.1 Ensure there is a minimum straight length of tube as specified in Table 1 for correct placement of the fitting.

Table 1 - Minimum Straight Tube Length before Bends



Sleeve or Union Size	Minimum Straight before Bend		Sleeve or Union Size	Minimum Straight before Bend
-04 (1/4")	1.30"		-10 (5/8")	1.42"
-06 (3/8")			-12 (3/4")	1.40"
-08 (1/2")	1.38"		-16 (1")	

5.1.2 Prepare tubes for swaging as follows:

Step 1. Cut tube ends to length square to the axis of the tubing within ±1°. When determining the length of tubing to cut, allow for tube growth resulting from swaging as specified in Table 2. If installing fittings in the tube shop, cut tube ends using an abrasive saw or hacksaw (e.g., 32 teeth per inch) followed by appropriate end facing equipment. If installing fittings in-situ, cut tube ends using a roller cutter.

Step 2. Remove any metal chips, dirt, etc. from the tube bore. Flush with solvent according to PPS 31.04, if necessary. 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, 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.

Table 2 - Tube Growth After Swaging

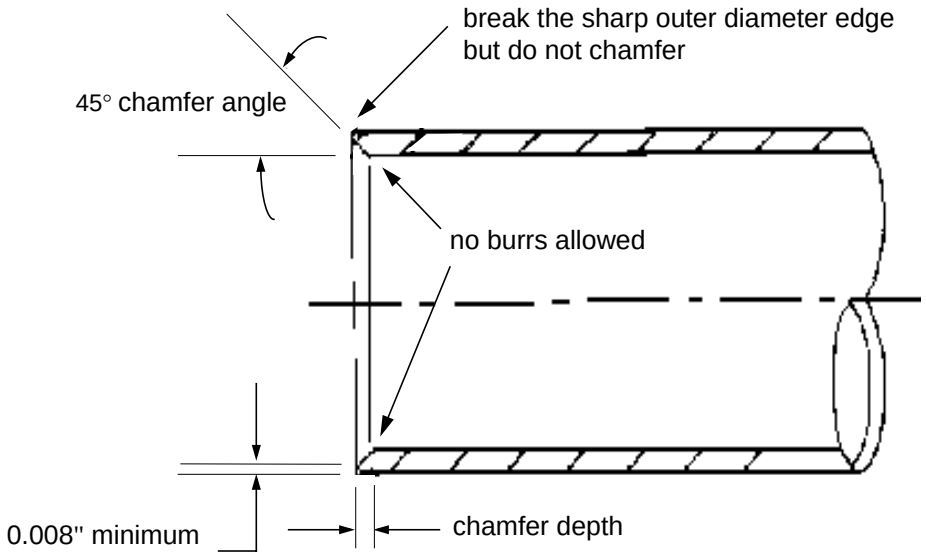
TUBING MATERIAL		SLEEVE OR UNION SIZE	TUBE WALL THICKNESS	TUBE GROWTH	
				SLEEVE	BULKHEAD UNION
Titanium	3Al-2.5V	-04 (1/4")	0.016"	0.023" - 0.031"	0.032" - 0.040"
		-06 (3/8")	0.019"	0.030" - 0.038"	0.033" - 0.041"
		-08 (1/2")	0.026"	0.019" - 0.027"	0.039" - 0.047"
		-10 (5/8")	0.032"	0.021" - 0.029"	0.024" - 0.032"
		-12 (3/4")	0.039"	0.036" - 0.044"	0.034" - 0.042"
		-16 (1")	0.051"	0.038" - 0.046"	0.038" - 0.046"
Aluminum	6061-T4	-04 (1/4")	0.028"	0.022" - 0.030"	n/a
		-06 (3/8")	0.028"	0.030" - 0.038"	
			0.035"	0.024" - 0.032"	
		-08 (1/2")	0.028"	0.026" - 0.034"	
			0.035"	0.045" - 0.053"	
		-10 (5/8")	0.028"	0.044" - 0.052"	
	6061-T6	-04 (1/4")	0.028"	0.022" - 0.030"	
		-06 (3/8")	0.028"	0.030" - 0.038"	
			0.035"	0.026" - 0.034"	
		-08 (1/2")	0.028"	0.028" - 0.036"	
			0.035"	0.048" - 0.056"	
		-10 (5/8")	0.035"	0.042" - 0.050"	
		-12 (3/4")	0.035"	0.022" - 0.030"	
		-16 (1")	0.028"	0.018" - 0.026"	
CRES	304 1/8HD	-04 (1/4")	0.028"	0.024" - 0.032"	
		-06 (3/8")	0.028"	0.028" - 0.036"	
		-12 (3/4")	0.035"	0.022" - 0.030"	
	321	-06 (3/8")	0.028"	0.020" - 0.028"	
		-10 (5/8")	0.028"	0.024" - 0.032"	
		-12 (3/4")	0.035"	0.020" - 0.028"	
	21-6-9	-04 (1/4")	0.016"	0.018" - 0.026"	

Step 3. Remove any tube end distortion, such as that produced by rolling type cutters, to allow insertion of the expander assembly.

Step 4. Deburr and chamfer the tube ends as specified in Table 3 according to PPS 27.05. Remove chips resulting from cutting with compressed air or another non-contaminating method without contaminating the line with debris.

Table 3 - Chamfer Depth

TUBE SIZE	MINIMUM CHAMFER DEPTH		TUBE SIZE	MINIMUM CHAMFER DEPTH
-04 (1/4")	0.006"		-10 (5/8")	0.020"
-06 (3/8")	0.010"		-12 (3/4")	0.025"
-08 (1/2")	0.015"		-16 (1")	0.030"



Step 5. Ensure tube surfaces are clean and free of scratches, oil, grease or other foreign material for at least 4" from the tube end. If necessary, clean tubes according to PPS 31.17. Do not use chloride-bearing solvents on titanium tubing. 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, 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.

5.2 Selection and Preparation of Expander Assemblies

5.2.1 Refer to Table 4 for the appropriate expander assembly for the sleeve or union to be swaged. Ensure that expander assemblies are kept in good condition. Expander assemblies in less than optimal condition may tend to leave unacceptable longitudinal, radial or sharp bottomed scratches deeper than 0.001" in the straight rolling area of the inner tube surface. Prepare expander assemblies as follows:

Step 1. If using the expander assembly for the first time that shift or if the high pressure roller lubricant has become contaminated during use, thoroughly solvent clean the expander rollers and cage according to PPS 31.17. 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, 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.

Step 2. Adjust the expander assembly to the swage length “L” specified in Table 5. This is accomplished by loosening the three set screws in the body of the expander and threading the cage in the required direction. Re-tighten set screws after adjustment.

Step 3. Install the expander assembly in the swaging machine with the mandrel at the most forward position.

Step 4. Retract the mandrel completely.

Step 5. Slip the inspection gauge specified in Table 5 over the rollers and cage and press it against the spring retainer until it stops at the guard (see Figure 3).

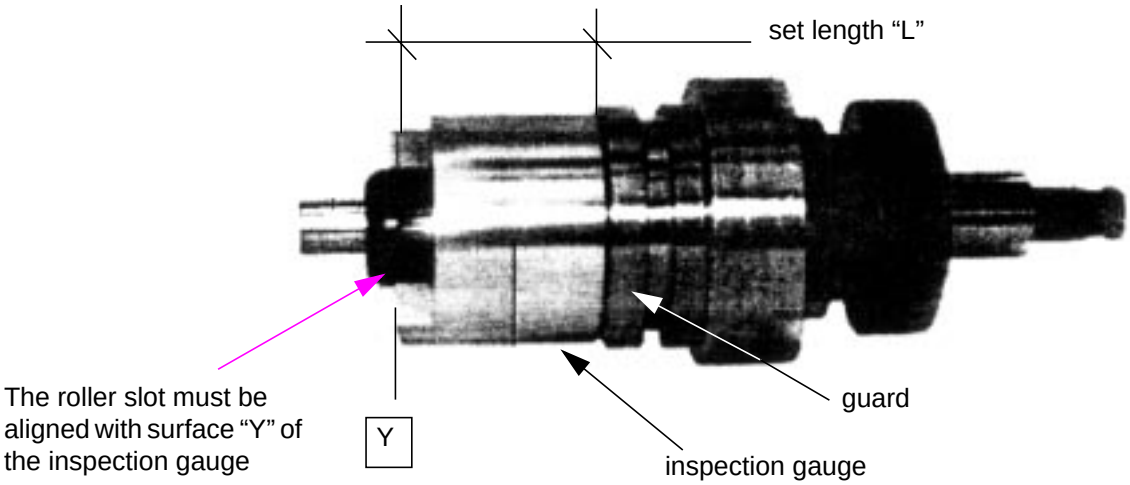


Figure 3 - Use of Expander Assembly Swage Length Inspection Gauges

Step 6. Hold the cage firmly against the guard while pushing the mandrel forward until it stops.

Step 7. Turn the mandrel until the expander engages the inspection gauge (about half a turn).

Step 8. Release the inspection gauge slowly and check that there is a slight interference fit between the expander and the inspection gauge. If not, verify that the roller and mandrel dimensions are correct for the tube size and wall thickness being swaged. Replace components using spare parts as specified in Table 6 if required.

Step 9. Check the opening of the inspection gauge. If necessary, re-adjust “L” until surface “Y” of the inspection gauge is aligned with the end of the roller slots (see Figure 3).

Step 10. At full extension, ensure that the diameter of the rollers meets or exceeds the minimum required diameter specified in Table 5.

Table 4 - Expander Assembly Selection

FITTING	TUBING MATERIAL	SLEEVE OR UNION SIZE	TUBE WALL THICKNESS	EXPANDER ASSEMBLY
B0302132 Sleeves and B0302133 Unions	Aluminum or CRES (Note 1)	-04 (1/4")	0.016"	7320-04016
			0.028"	7320-04028
		-06 (3/8")	0.019"	7320-06019
			0.028"	7320-06028
			0.035"	7320-06035
		-08 (1/2")	0.028"	7320-08028
			0.035"	7320-08035
		-10 (5/8")	0.028"	7320-10028
		-12 (3/4")	0.035"	7320-12035
		-16 (1")	0.028"	7320-16028
	Titanium	-04 (1/4")	0.016"	7320-04016
		-06 (3/8")	0.019"	7320-06019
			0.026"	7320-06028
		-08 (1/2")	0.026"	7320T-08026
		-10 (5/8")	0.032"	7320T-10032
		-12 (3/4")	0.039"	7320T-12039
		-16 (1")	0.051"	7320T-16051
B0302162 Bulkhead Union	Aluminum or CRES (Note 1)	-04 (1/4")	0.016"	7350-04016
			0.028"	7350-04028
		-06 (3/8")	0.019"	7350-06019
	Titanium	-04 (1/4")	0.016"	7350-04016
		-06 (3/8")	0.019"	7350-06019
			0.026"	7350-06028
		-08 (1/2")	0.026"	7350T-08026
		-10 (5/8")	0.032"	7350T-10032
		-12 (3/4")	0.039"	7350T-12039

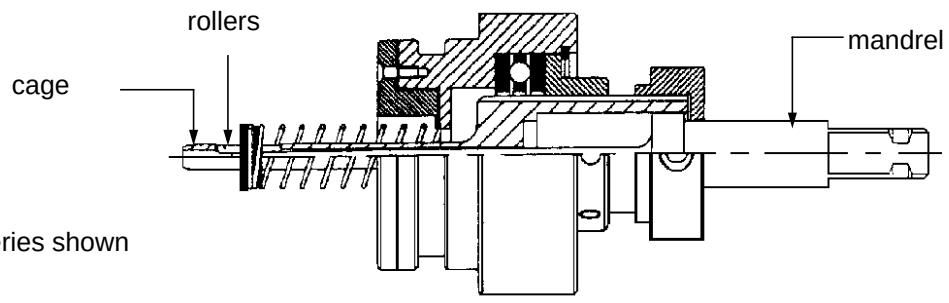
Note 1. If the same expander assembly is to be used for both CRES and aluminum tubing, the expander assembly must be thoroughly cleaned according to PPS 31.17 before swaging new material to remove all traces of the previous metal that may become embedded in the tube.

Table 5 - Expander Assembly Set-Up Data

EXPANDER ASSEMBLY	SWAGE LENGTH "L"	INSPECTION GAUGE	MINIMUM REQUIRED ROLLER DIAMETER AT FULL EXTENSION
7320-04016	1.010" + 0.010" - 0.010"	7324-04016	0.238"
7320-04028		7360-04028	0.220"
7320-06019	1.205" + 0.000" - 0.020"	7324-06019	0.360"
7320-06028		7360-06028	0.345"
7320-06035		7360-06035	0.330"
7320-08028	1.310" + 0.010" - 0.000"	7360-08028	0.470"
7320-08035		7360-08035	0.460"
7320-10028	1.382" + 0.000" - 0.020"	7360-100.28	0.605"
7320-12035	1.474" + 0.000" - 0.020"	7360-12035	0.705"
7320-16028	1.600" + 0.010" - 0.010"	7360-16028	0.960"
7320T-08026	1.310" + 0.010" - 0.000"	7324T-08026	0.470"
7320T-10032	1.370" ± 0.005"	7324T-10032	0.591"
7320T-12039	1.450" ± 0.005"	7324T-12039	0.701"
7320T-16051	1.600" ± 0.005"	7324T-16051	0.930"
7350-04016	1.520" ± 0.005"	7410-04016	0.238"
7350-04028		7410-04028	0.220"
7350-06019	1.590" ± 0.005"	7410-06019	0.360"
7350T-08026	1.902" ± 0.005"	7410-08026	0.470"
7350T-10032	2.065" ± 0.005"	7410-10032	0.591"
7350T-12039	2.210" ± 0.005"	7410-12039	0.701"

Table 6 - Expander Assembly Spare Parts

EXPANDER SERIES	EXPANDER ASSEMBLY	MANDREL	ROLLERS	CAGE
7320	7320-04016	7321-04016	7322-04016	7323-04016
	7320-04028	7339-04028	7340-04028	7338-04028
	7320-06019	7321-06019	7322-06019	7323-06019
	7320-06028 interchangeable with 7320-06035	7339-06028 interchangeable with 7339-06035	7340-06028 interchangeable with 7340-06035	7338-06028 interchangeable with 7338-06035
	7320-08028	7339-08028	7340-08028	7338-08028
	7320-08035	7339-08035	7340-08035	7338-08035
	7320-10028	7339-10028	7340-10028	7338-10028
	7320-12035	7339-12035	7340-12035	7338-12035
	7320-16028	7339-16028	7340-16028	7338-16028
7320T	7320T-08026	7321-08026	7370-08026	7323-08026
	7320T-10032	7321-10032	7370-10032	7323-10032
	7320T-12039	7321-12039	7370-12039	7323-12039
	7320T-16051	7321-16051	7370-16051	7372-16051
7350	7350-04016	7352-04016	7353-04016	7351-04016
	7350-04028	7352-04028	7353-04028	7351-04028
	7350-06019	7352-06019	7353-06019	7351-06019
7350T	7350T-08026	7352-08026	7371-08026	7351-08026
	7350T-10032	7352-10032	7371-10032	7351-10032
	7350T-12039	7352-12039	7371-12039	7351-12039



7320 series shown

5.3 Swaging Procedure

5.3.1 Swage each fitting as follows:

Step 1. Assemble the external swaging tools (i.e., jaws and/or retainer) specified in Table 7 in the die housing (see Figure 4).

Step 2. Connect the correctly adjusted expander assembly and the expander cover to the spline drive assembly.

Step 3. Set the torque thumbwheel selectors to the torque setting specified in Table 8.

Step 4. Inspect the rollers and mandrel for damage or wear. Replace them, if necessary.

Step 5. Generously lubricate the expander rollers with clean extreme pressure lubricant. Expander rollers must be lubricated before each swage.

Step 6. Inspect the tube inner diameter for scratches.

Step 7. Insert the tube and fitting into the external die set assembly. Ensure that the tube butts up against the retainer. For installation of sleeves, the tube must protrude **through the sleeve** to butt up against the retainer (refer to Table 9 for the reference protrusion before swage). For installation of unions, the tube will not protrude through the fitting but must butt against the retainer in the fitting.

Step 8. Close the jaw and engage the jaw locking mechanism.

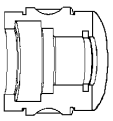
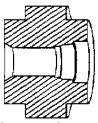
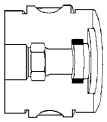
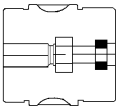
Step 9. Press the “SWAGE” button. The mandrel will turn clockwise and the expander assembly will move forward into the tube. Then, the mandrel will move forward and the rollers will swage the tube. After the preset torque value is reached, the machine will stop and reverse the cycle.

Step 10. Turn the jaw selector to the RELEASE position to open the jaws manually.

Step 11. Remove the swaged tube/fitting assembly.

Step 12. Degrease the swaged tube/fitting assembly according to PPS 31.04.

Table 7 - External Tooling

FITTING SIZE	SLEEVES		UNIONS	BULKHEAD UNIONS
	Jaw	Retainer	Jaw	Jaw
-04 (1/4")	6884-04	6885-104	6886-04	7349-04
-06 (3/8")	6884-06	6885-106	6886-06	7349-06
-08 (1/2")	6884-08	6885-108	6886-08	7349-08
-10 (5/8")	6884-10	6885-110	6886-10	7349-10
-12 (3/4")	6884-12	6885-112	6886-12	7349-12
-16 (1")	6884-16	6885-116	6886-16	7349-16
	 one half shown	 section shown	 one half shown	 one half shown

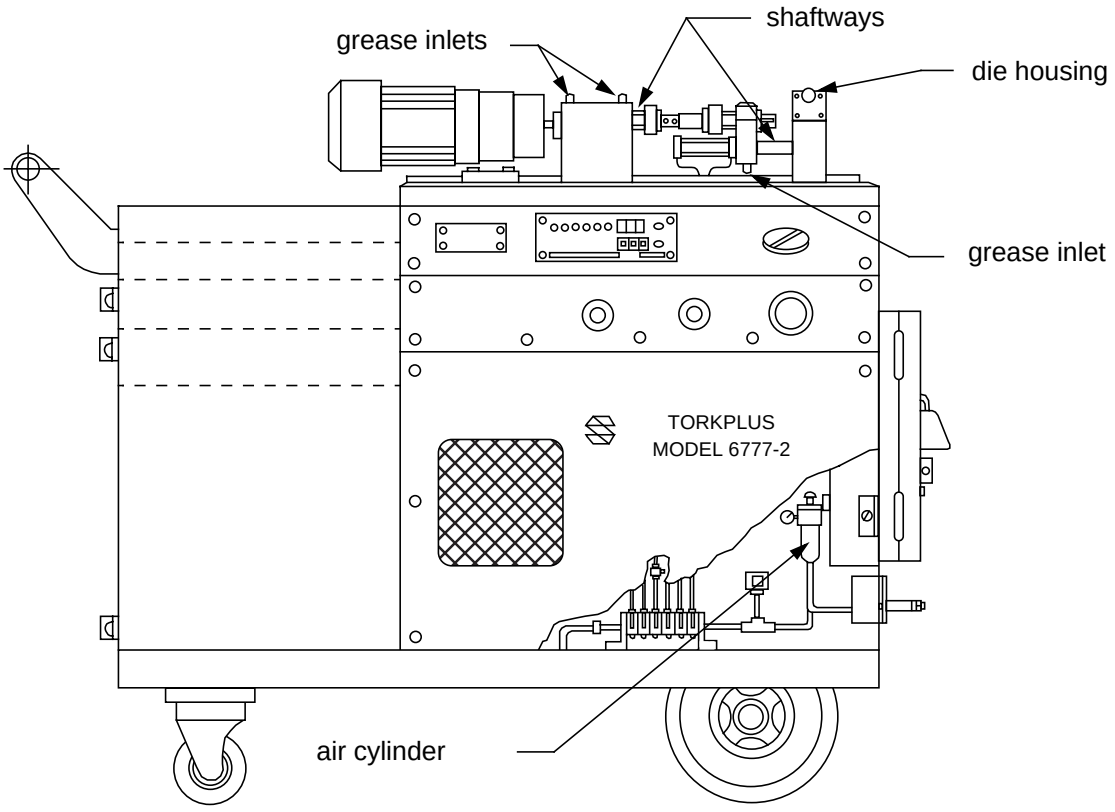


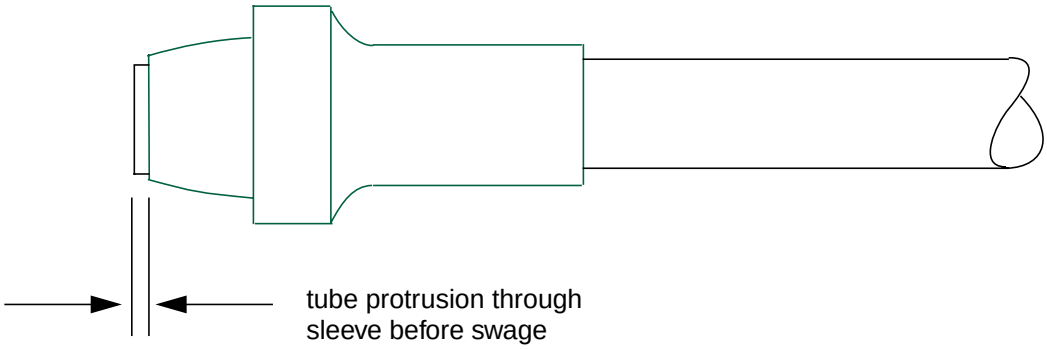
Figure 4 - Components of the 6777 Swage Machine

Table 8 - Required Swage Torque

TUBE MATERIAL	TUBE ALLOY/TYPE	FITTING SIZE	TUBE WALL THICKNESS	TORQUE (in·lbs)
Aluminum	6061-T4	-04 (1/4")	0.028"	4
		-06 (3/8")	0.028"	4
			0.035"	4
		-08 (1/2")	0.028"	4
			0.035"	6
		-10 (5/8")	0.028"	10 - 11
	6061-T6	-04 (1/4")	0.028"	5
		-06 (3/8")	0.028"	5
			0.035"	4
		-08 (1/2")	0.028"	6 - 8
			0.035"	10
		-10 (5/8")	0.028"	13
			0.035"	16
		-12 (3/4")	0.035"	20
		-16 (1")	0.028"	12
			0.035"	15
CRES	21-6-9	-04 (1/4")	0.016"	4
	304 1/8 HD	-04 (1/4")	0.016"	5
			0.028"	8
		-06 (3/8")	0.028"	10
		-12 (3/4")	0.035"	30
	321	-06 (3/8")	0.028"	6
		-10 (5/8")	0.028"	20
		-12 (3/4")	0.035"	20
Titanium	3Al-2.5V	-04 (1/4")	0.016"	6
		-06 (3/8")	0.019"	11
			0.026"	13 - 14
		-08 (1/2")	0.026"	20 (Note 1)
		-10 (5/8")	0.032"	35 (Note 1)
		-12 (3/4")	0.039"	40 (Note 1)
		-16 (1")	0.051"	75

Note 1: For fittings sizes -08, -10 and -12 to be installed on titanium tubes only, if the IDAS lower limit specified in Table 10 cannot be achieved, it is acceptable to increase the swage torque by up to 2 in·lbs.

Table 9 - Tube Protrusion Though Sleeves before Swage



Sleeve Size	-04 (1/4")	-06 (3/8")	-08 (1/2")	-10 (5/8")	-12 (3/4")	-16 (1")
Protrusion through Sleeve before Swage (± 0.010")	0.070"	0.070"	0.060"	0.060"	0.060"	0.060"

6 Requirements

6.1 Visually examine all production parts for the following defects:

- The sealing surfaces of the fittings must not be scratched or otherwise damaged during fabrication. Die marks on the external skirt and shoulder areas of sleeves up to 0.005" in height are acceptable provided that they do not cause interference with the nut.
- The inner surface of the tube in the straight rolling area of the inner tube surfaces must be free from longitudinal, radial or sharp bottomed scratches deeper than 0.001".
- Helical extrusion marks at the extreme end of the rolled area resulting from the first revolutions of the rollers and the subsequent growth of the tube wall are acceptable.
- For aluminum alloy tubing, a slight ridge at the tube end resulting from roller swage action (see Figure 6) is acceptable.

6.2 Dimensionally examine all production parts using a tube micrometer as shown in Figure 5. Ensure that the inside diameter of the tube under the groove area meets the requirements specified in Table 10. Take care not to scratch the inside surface of the tube by pulling the extended calipers out of the tube.

6.3 Proof pressure test all tube assemblies according to PPS 6.12 to the pressure specified in Table 11. Tube assemblies may be proof pressure tested at the final assembly stage if testing at the detail stage is not practical.

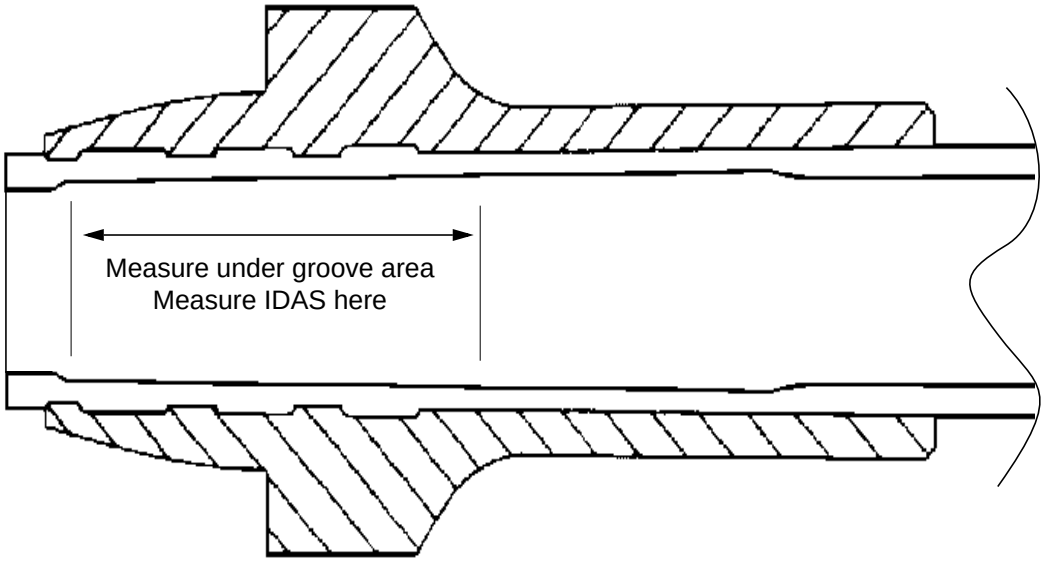


Figure 5 - Location of Micrometer for Inspection of Swaged Tubes

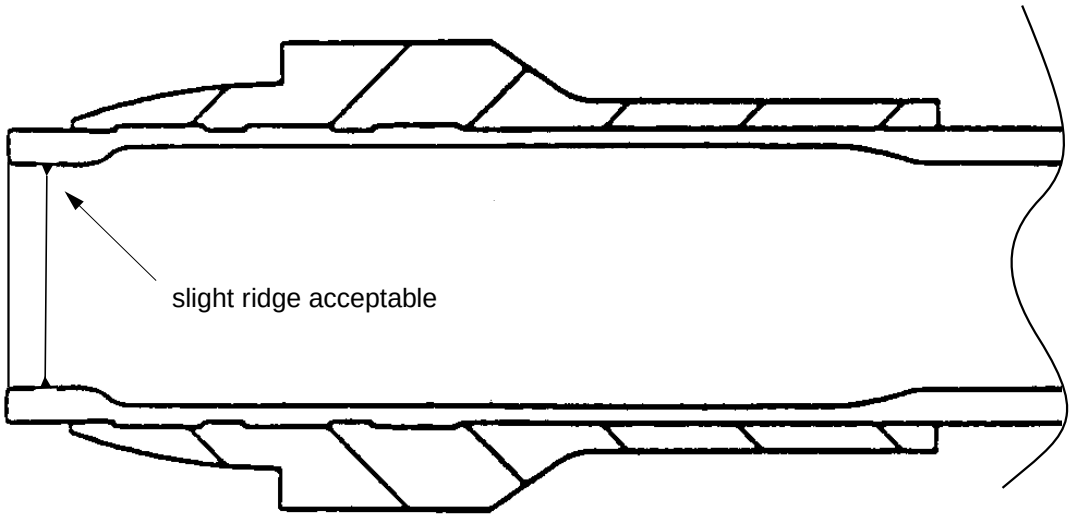


Figure 6 - Acceptable Ridges

Table 10 - IDAS Requirements

TUBE MATERIAL	TUBE ALLOY/TYPE	FITTING SIZE	TUBE WALL THICKNESS	TUBE INNER DIAMETER AFTER SWAGING (IDAS)
Aluminum	6061-T4	-04 (1/4")	0.028"	0.208" - 0.214"
		-06 (3/8")	0.028"	0.332" - 0.339"
			0.035"	0.315" - 0.323"
		-08 (1/2")	0.028"	0.456" - 0.463"
			0.035"	0.445" - 0.452"
		-10 (5/8")	0.028"	0.582" - 0.588"
	6061-T6	-04 (1/4")	0.028"	0.206" - 0.211"
		-06 (3/8")	0.028"	0.332" - 0.339"
			0.035"	0.317" - 0.323"
		-08 (1/2")	0.035"	0.445" - 0.450"
		-10 (5/8")	0.028"	0.582" - 0.588"
			0.035"	0.573" - 0.579"
		-12 (3/4")	0.035"	0.693" - 0.699"
		-16 (1")	0.028"	0.956" - 0.960"
			0.035"	0.943" - 0.949"
CRES	21-6-9	-04 (1/4")	0.016"	0.223" - 0.231"
	304 1/8 HD	-04 (1/4")	0.016"	0.223" - 0.231"
			0.028"	0.206" - 0.211"
		-06 (3/8")	0.028"	0.332" - 0.339"
		-12 (3/4")	0.035"	0.691" - 0.699"
	321	-06 (3/8")	0.028"	0.332" - 0.338"
		-10 (5/8")	0.028"	0.581" - 0.586"
		-12 (3/4")	0.035"	0.694" - 0.702"
Titanium	3Al-2.5V	-04 (1/4")	0.016"	0.225" - 0.232"
		-06 (3/8")	0.019"	0.347" - 0.354"
			0.026"	0.332" - 0.337"
		-08 (1/2")	0.026"	0.456" - 0.465" (Note 1)
		-10 (5/8")	0.032"	0.572" - 0.580" (Note 1)
		-12 (3/4")	0.039"	0.682" - 0.695" (Note 1)
		-16 (1")	0.051"	0.913" - 0.921"

Note 1: For fittings sizes -08, -10 and -12 to be installed on titanium tubes only, if the IDAS lower limit specified in this table cannot be achieved, it is acceptable to increase the swage torque by up to 2 in·lbs.

Table 11 - Proof Pressure Test Data

TUBE MATERIAL	TUBE DIAMETER	TUBE WALL THICKNESS	PROOF PRESSURE
CRES	All	All	4500 psi
Titanium	All	All	4500 psi
Aluminum WW-T-700/6 6061-T4 & -T6	All	All	2000 psi
Aluminum MIL-T-7081 6061-T6	3/16"	over 0.010"	4500 psi
	1/4"	over 0.013"	4500 psi
	5/16"	over 0.017"	4500 psi
	3/8"	over 0.020"	4500 psi
	1/2"	0.020" - 0.028"	3000 psi
		over 0.028"	4500 psi
	5/8"	0.025" - 0.035"	3000 psi
		over 0.035"	4500 psi
	3/4"	0.030" - 0.042"	3000 psi
		over 0.042"	4500 psi

7 Safety Precautions

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

7.2 Tooling is subject to extremely high pressure during swaging. Improper use may result in injury and/or tool damage.

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.

9 Recommended Maintenance of Equipment

9.1 On a suitable regular basis, check the air cylinder oil level at the air filter inside the 6777 swage machine. As necessary, add SAE 10 phosphate-free oil.

9.2 On a suitable regular basis, apply general purpose machine lubricant to all shaftways (see Figure 4) and hinge points for smoother movement and to prevent corrosion.

9.3 On a suitable regular basis, fill grease inlets (see Figure 4) with grease.