BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 3.04

PRODUCTION PROCESS STANDARD

Swaging of Ball Terminals

Issue 20
- This standard supersedes PPS 3.04, Issue 19.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS 3.04 related questions to michael.wright@aero.bombardier.com.
- This PPS is effective as of the distribution date.

Prepared By:	(Michael Wright)	July 14, 2014
	Production Process Standards (PPS)	
Approved By:	(L.K. John)	July 15, 2014
	Materials Technology	
	(Adam Gordon)	July 16, 2014
	Quality	

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1 Scope

1.1 This PPS (Production Process Standard) specifies the procedure and requirements for swaging of ball terminals.

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 3.05 - Proof Loading Cable and Chain Assemblies.

3.2 PPS 13.13 - Protective Respiratory Equipment.

3.3 PPS 13.26 - General Subcontractor Provisions.

3.4 PPS 13.39 - Bombardier Toronto Engineering Process Manual.

3.5 PPS 15.01 - Part Marking.

3.6 PPS 31.17 - Solvent Usage.

4 Materials, Equipment and Facilities

4.1 Materials

4.1.1 Terminals and wire rope as specified on the engineering drawing. If the engineering drawing specifies the use of MIL-W-1511, MIL-W-83420 Composition A or MIL-DTL-83420 Composition A carbon steel cables, the cables must have a protective treatment coating of either zinc or tin over zinc (tin over zinc is preferred, if available)

4.1.2 Red lacquer (e.g., GE1201 Red Glyptol). If necessary, thin GE1201 Glyptol with toluol to maintain a suitable working viscosity for brush application.

4.1.3 Light machine oil (e.g., 3-IN-ONE).

4.2 Equipment

4.2.1 Hand operated cable cutting tool (e.g., PC#1406MS).

4.2.2 Reciprocal type swaging machines and swaging dies (e.g., as listed in Table 1). It is acceptable to use alternative swaging machines and/or swaging dies provided that all the requirements specified in section 6 are met. Operate swaging machines according to the manufacturer's instructions.

4.2.3 Wiping cloths (e.g., DSC 378-2).

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 swaging of ball terminals 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 swaging of ball terminals 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 Certification of Swaging Tool Die Sets

5.1.1 Before use on production parts, certify all new or reworked die sets for each wire or steel cable type (e.g., BAMS 511-001, MIL-DTL-84320 Type I Composition A, etc.) to which terminals may be swaged in production as follows:

Step 1. Dimensionally check the die set according to the manufacturer's specifications.

Step 2. For each wire or steel cable type to which terminals may be swaged in production, produce 2 sample cable assemblies (12" long minimum) according to the procedure specified herein. If possible, to ensure uniformity of samples, have the same operator set up and swage all samples. Complete a record sheet for each tool proving set-up.

Step 3. Check all of the swaged terminals to ensure that they meet the requirements of section 6.

Step 4. Tensile test one sample cable assembly to destruction according to PPS 3.05. If the assembly fails before the minimum breaking load specified is reached, the swage dies are considered unacceptable for production use. Determine the cause of any failure and rectify it before attempting to re-certify the die set as specified herein.

Step 5. Section the terminals on the remaining sample assembly as shown in Figure 1.

Step 6. Mount and polish the sections for microscopic examination at no less than 50X magnification of the faces. For the purposes of this PPS, consider crack length as the linear length of the actual crack path rounded to the nearest 0.001". Measure and record all cracks in the terminal 0.001" and longer (ignore cracks shorter than 0.001") as well as the minimum wall thickness of each section being examined. If any individual crack in the terminal exceeds 25% of the minimum wall thickness or if the sum of the lengths of all cracks in the terminal exceeds a value equal to 50% of the minimum wall thickness the die set will be considered unacceptable for production use. Determine the cause of any failure and rectify it before attempting to re-certify the die set as specified herein.

Step 7. Complete and maintain on file numbered swaged cable test reports, indicating results and status of each die set.

Step 8. Stamp or etch the set of dies with a tool number, matched die set number, the swaged cable test report number and the date finished. Do not assign the same die set number to more than one die set.

Step 9. Raise a die set data card for each acceptable die set, showing the tool number, matched die set number, swaging time and shim size (if applicable) and the date the tool was certified. Keep this data card with the die set for reference purposes.

5.1.2 Re-certify each set of dies every 300 swages or less as follows. If previous examination of a particular die set has revealed cracks in the terminal exceeding 0.003" in length, submit samples for that die set every 100 swages or less until the die set is reworked.

Step 1. For each wire or steel cable type to which terminals may be swaged in production, prepare two sample assemblies (12" long minimum), complete with swaged terminals, along with a production batch.

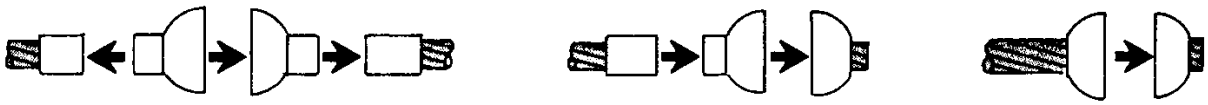
Step 2. Proof load one of the two sample assemblies of each type of wire or cable according to PPS 3.05.

Step 3. Tensile test the proof loaded sample assembly to destruction according to PPS 3.05 to determine the breaking load. The swage die set is considered to be unacceptable if, during the tensile test, the cable slips out of the terminal, breaks inside the terminal or fails at the swaged portion below the minimum breaking load specified in PPS 3.05. It is considered a void test if the cable or terminal breaks below the minimum breaking load at a location other than at the swage.

Step 4. Section the terminals of the remaining sample assembly through the swaged portion as shown in Figure 1.

Step 5. Mount and polish the sections for microscopic examination at no less than 50X magnification. For the purposes of this standard, consider crack length as the linear length of the actual crack path rounded to the nearest 0.001". Measure and record all cracks 0.004" and longer (ignore cracks 0.003" and shorter) as well as the minimum wall thickness of each section being examined. If any individual crack exceeds 30% of the minimum wall thickness or the sum of all cracks exceeds a value equal to 60% of the minimum wall thickness, the die set will be considered unacceptable. If the die set is determined to be unacceptable, refer to Bombardier Toronto (de Havilland) MRB or Bombardier Toronto (de Havilland) delegated MRB for disposition.

Step 6. Retain on file all reports pertaining to the two sample cables.



→ denotes sectioned faces to be examined

Figure 1 - Sectioning Swaged Terminal for Metallographic Examination

5.2 Preparation of Cable for Swaging

5.2.1 Measure off the required length of cable and mark with masking tape at the point where it is to be cut. Allow sufficient extra length of cable to protrude through the terminal to facilitate holding the cable/terminal assembly during swaging. When determining the length required, take into account the permanent stretch or permanent increase in length after proof loading. Cut the cable cleanly and squarely, using hand operated cutters (see Equipment section, paragraph 4.2.1).

5.2.2 Immediately before swaging, remove any foreign matter from cable ends by lightly solvent wiping according to PPS 31.17. Solvent wiping of cable ends free of foreign matter is not required. When solvent wiping, take care not to remove the manufacturer's lubricant on carbon steel or corrosion resistant steel cables.

5.3 Swaging

5.3.1 Before any use of a swage tool die set, ensure that the swage tool die set has been certified according to section 5.1 and validate that the certification has not expired.

5.3.2 Swage terminals as follows:

Step 1. Insert the cable through the terminal and position the terminal correctly on the cable. Assemble plain ball terminals onto the cable so that the countersunk end of the ball faces the centre of the assembly (see Table 3).

Step 2. Apply a piece of masking tape to the cable on one side of the positioned terminal to act as a locating stop.

Step 3. Select the correct set of matched die halves, as specified in Table 1, for the applicable type and size of terminal to be swaged and install in the appropriate swaging machine. Clean and lubricate the swaging dies with a thin film of light machine oil before installing in the swaging machine.

Step 4. Lubricate the outside of the terminal with a thin film of light machine oil.

Step 5. Insert the terminal between the dies and swage momentarily to lock the terminal on the cable.

Step 6. Remove the masking tape applied in Step 2.

Step 7. Swage the terminal for the applicable time specified in Table 1. Rotate the cable and terminal slowly during swaging. When using an AT520D machine, set the swaging time on the automatic timer.

Step 8. Inspect the first-off terminal of a production run to ensure that it meets the dimensional and visual requirements of section 6.

Step 9. If the first-off terminal is satisfactory, continue the production run. If the first-off terminal fails to meet the requirements of section 6, determine the cause of failure and rectify before continuing.

Table 1 - Ball Terminal Swaging Dies and Times

CABLE SIZE	TYPE OF TERMINAL	TERMINAL PART NUMBER	SWAGING DIE SET	SWAGING TIMES (SECONDS)	
				AT520D	AT520J
1/16"	Single shank	MS20664C2	TS.276.11.10 Mk 2S	3	4
	Double shank	MS20663C2	TS.276.11.20 Mk 2D		
	Plain ball	RA2487-2	TS.276.11.30 Mk 2P		
3/32"	Single shank	MS20664C3	TS.276.11.10 Mk 3S	4	7
	Double shank	MS20663C3	TS.276.11.20 Mk 3D		
	Plain ball	SA110-3	TS.276.11.30 Mk 3P		
		RA2487-3			
1/8"	Single shank	MS20664C4	TS.276.11.10 Mk 4S	6	15
	Double shank	MS20663C4	TS.276.11.20 Mk 4D		
5/32"	Single shank	MS20664C5	TS.276.11.10 Mk 5S	25	60
	Double shank	MS20663C5	TS.276.11.20 Mk 5D		
3/16"	Single shank	MS20664C6	TS.276.11.10 Mk 6S	45	150
	Double shank	MS20663C6	TS.276.11.20 Mk 6D		

5.4 Post Swaging Procedure

5.4.1 After swaging, finish the assembly as follows:

Step 1. Trim excess cable from the free end of plain ball and single shank terminals, flush to a maximum of 1/16" from the ball (see Table 3). Cable ends may be trimmed to length using a suitable bench mounted grinder. **Do not** remove **any** material from plain ball or single shank terminals when trimming excess cable from the free end.

Step 2. Remove excess grease from the outside diameter of cables (e.g., using a clean dry cloth). Do **not** use solvent when removing excess grease.

Step 3. Mark the cable at the point of entry into the terminal, with a band of red lacquer, ensuring that there is no bare cable visible between the band of lacquer and the terminal.

Step 4. Unless the engineering drawing states “PROOF LOAD TESTING NOT REQUIRED”, proof load according to PPS 3.05.

Step 5. Check the cable assembly length to ensure that the specified dimensions have met the tolerances listed in PPS 3.05. Also, ensure that no bare cable is visible between the ball and the edge of the red band of lacquer.

Step 6. Part mark the cable assembly according to PPS 15.01.

Step 7. For transport or storage, roll each cable assembly into a coil. Ensure that the coil meets the minimum acceptable coil diameter specified in Table 2.

Step 8. For transportation purposes, enclose coiled cable assemblies in suitable containers, such as boxes or bags, so that they remain coiled and protected from abrasion and contamination.

Table 2 - Coil Diameter

CABLE DIAMETER	MINIMUM ACCEPTABLE COIL DIAMETER
3/32" or less	8"
1/8"	10"
5/32" to 5/16"	12"
3/8"	15"

6 Requirements

6.1 The type and size of cable and terminals in the assembly shall be as specified on the relevant engineering drawing.

6.2 Swaged terminals shall conform to the dimensional limits specified in Table 3.

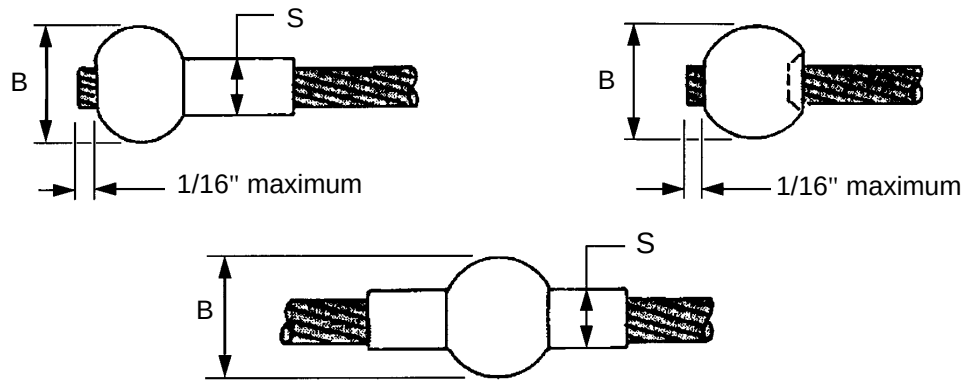
6.3 Single shank terminals and plain ball terminals shall have the end of the cable trimmed flush to a maximum of 1/16" from the terminal ball as shown in Table 3.

6.4 There shall be no evidence that material has been removed from single shank or plain ball terminals (e.g., by machining, grinding, etc.).

6.5 Terminals shall be free from visible cracks and surface roughness. Indentations on the surface of the terminal resulting from the manufacturer's identification marks are acceptable.

6.6 The cable shall be free of kinks and the cable lay shall be uniform over its entire length, with no looseness or looping of individual wires or strands.

Table 3 - Swaged Terminal Dimensions



CABLE DIAMETER	BALL DIAMETER "B"	SHANK DIAMETER "S"
1/16"	0.187" - 0.190"	0.109" - 0.112"
3/32"	0.250" - 0.253"	0.140" - 0.143"
1/8"	0.312" - 0.315"	0.187" - 0.190"
5/32"	0.375" - 0.379"	0.218" - 0.222"
3/16"	0.437" - 0.442"	0.250" - 0.255"

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 Lacquer and solvents specified herein are flammable and shall be kept away from open flames or other sources of ignition.

7.4 Operators shall wear the appropriate personal protective respiratory equipment specified in PPS 13.13, at all times when cutting or grinding cables using a bench grinder.

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.