BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 3.02

PRODUCTION PROCESS STANDARD

Swaging Straight Shank Terminals

Issue 26
- This standard supersedes PPS 3.02, Issue 25.
- Vertical lines in the left hand margin indicate technical changes over the previous issue.
- Direct PPS 3.02 related questions to michael.wright@aero.bombardier.com.
- 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 straight shank terminals onto aircraft steel cable and wire rope.

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 Refer to PPS 3.04 for swaging of ball end terminals.

1.1.4 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 13.26 - General Subcontractor Provisions.

3.3 PPS 15.01 - Part Marking of Aircraft Parts and Assemblies.

3.4 PPS 15.04 - Use of Markers for Marking Aircraft Parts and Assemblies.

3.5 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, GE1201 Red Glyptol.

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

4.1.4 Vinyl plastic caps - Sinclair and Rush S-Cap Series as specified In Table 3.

4.2 Equipment

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

4.2.2 Belt sander, 180 - 220 grit abrasive.

4.2.3 Rotary type swaging machine, reversible, with braking mechanism.

4.2.4 Swaging dies (e.g., as specified in Table 1), certified according to section 5.1. It is acceptable to use alternative swaging dies provided that the dies are certified according to section 5.1 and all the requirements specified in section 6 are met.

4.2.5 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 straight shank terminals onto aircraft steel cable and wire rope 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 straight shank terminals onto aircraft steel cable and wire rope 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-83420 Composition A, etc.) to which terminals may be swaged in production as follows. Complete a record sheet for each tool proving set-up.

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

Step 2. Swage one MS21260 terminal onto a suitable length (12" minimum) of each wire or steel cable type to which terminals may be swaged in production and note the swaging time in each case. The swaging time should range between approximately 3 seconds for 1/16" terminals to 6 seconds for 3/16" terminals. The swaging time for larger terminals will be correspondingly longer.

Step 3. Verify that the swage meets the requirements of section 6. If the swaged terminal does not meet the requirements, determine the cause of failure and rectify it before repeating the process from Step 2 on a new cable length.

Step 4. Cut two suitable lengths (12" minimum) of each wire or steel cable type to which terminals may be swaged in production according to section 5.2.

Step 5. On each of the cable lengths, swage a MS21260 terminal on one end and a MS20667 terminal on the other end according to section 5.3. If possible, to ensure uniformity of samples, have the same operator set up and swage all samples.

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

Step 7. Tensile test one sample of each type of wire or cable to destruction according to PPS 3.05. If the assembly fails before the minimum breaking load 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 8. Section the terminals on the remaining sample assemblies transversely as shown in Figure 1.

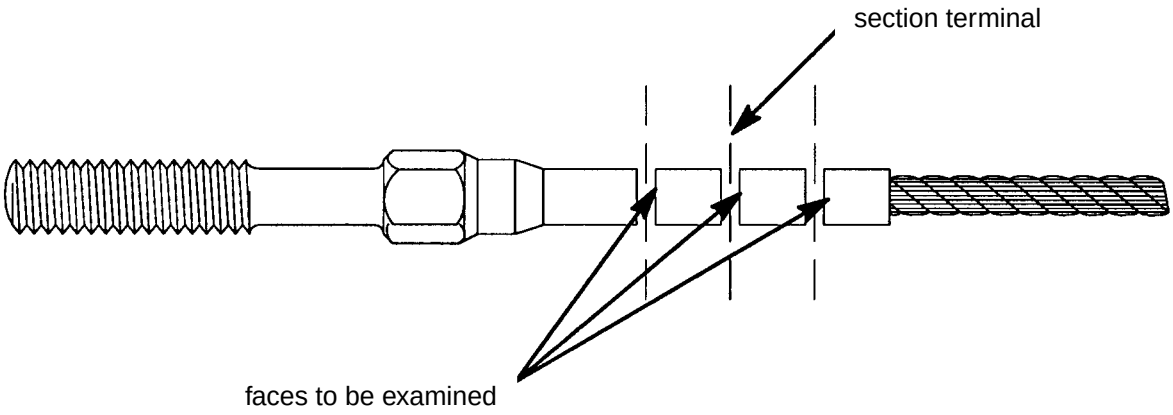


Figure 1 - Sectioning Terminal for Metallographic Examination

Step 9. Mount and polish the sections for microscopic examination at no less than 50X magnification. 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 (discount 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 failure and rectify it before attempting to re-certify the die set as specified herein.

Step 10. Complete and maintain on file numbered swaged cable test reports, indicating results and status of each die set.

Step 11. 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 12. 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 as follows. If previous examination of a particular die set has revealed cracks exceeding 0.003" in length, submit samples for that die set after every 100 swages instead of every 300 swages until the die set is reworked.

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

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

Step 3. Ensure that the proof loaded assembly is free of terminal distortion such as malformation, misshape, twist, bends, warping, kink, etc. caused by swaging or proof loading. Also, elongation of the terminal greater than 0.001 inches per inch of terminal length is not acceptable.

Step 4. 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 5. Section one terminal of the remaining sample assembly of each wire or steel cable type through the swaged portion as shown in Figure 1.

Step 6. Mount and polish the sections for microscopic examination at no less than 50X magnification. 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 0.004" and longer (ignore cracks 0.003" and shorter) as well as the minimum wall thickness of each section being examined. If any individual crack in the terminal exceeds 30% of the minimum wall thickness or the sum of all cracks in the terminal 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 7. Retain on file all reports pertaining to the two sample cables.

5.2 Preparation of Cables and Terminals

5.2.1 Measure the required length of cable and mark it with masking tape at the point where it is to be cut. 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.

5.2.2 Before assembly of cables and terminals, wipe terminals showing evidence of contamination with a clean cloth to remove all traces of dirt, swarf, etc. from the terminal barrel. New terminals, just removed from their storage bags, do not require cleaning. Rework all 5/16" terminals (which have been drilled out for 3/8" cable) to blend out the taper transition at the end of the barrel over approximately 1". Accomplish blending of the taper using a belt sander followed by polishing with a buffing wheel to remove all sander marks.

5.2.3 Before assembly of the cable and terminal, 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 Swage terminals as follows:

Step 1. Insert the cable end approximately halfway into the terminal bore and bend the cable through an angle of approximately 30 degrees to kink the cable end (see Figure 2). Take care not to displace the cable strands.

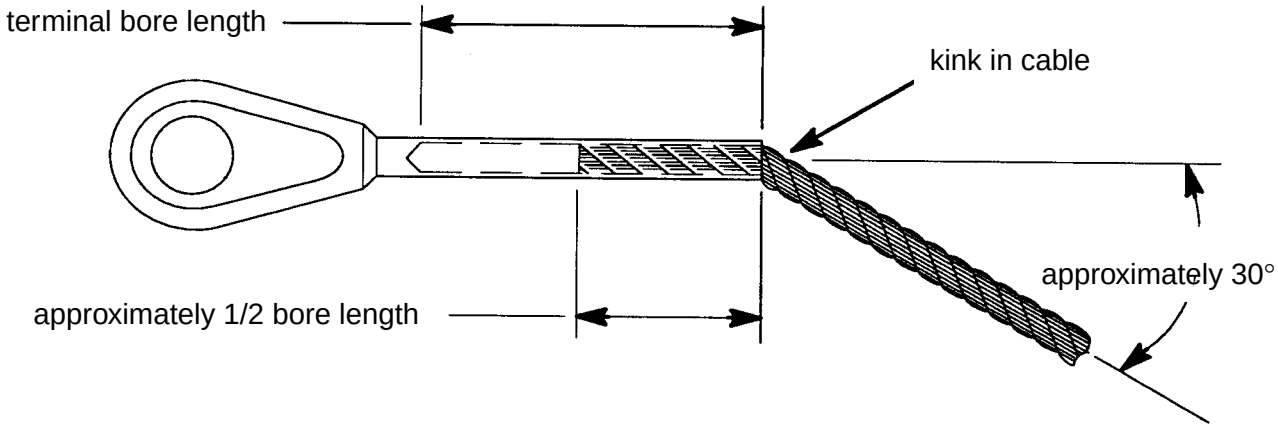


Figure 2 - Preparation of Cable

Step 2. Insert the cable fully into the bore of the terminal barrel and mark a band around the cable at the point of entry into the terminal using red lacquer (ref. para. 4.1.2) or a permanent marker according to PPS 15.04. Ensure that no bare cable is visible between the band and the terminal; however, do not extend the band (lacquer or permanent marker) onto the body of the terminal. Do not use permanent markers if the terminal or the cable are composed of titanium alloy.

Step 3. Select the correct set of matched die halves as specified in Table 1.

Table 1 - Straight Shank Terminal Swaging Dies

CABLE DIA.	SWAGING DIES	
	FENN M/C	ETNA M/C
1/16"	TS277.22.11 MK2	—
3/32"	TS277.22.11 MK3	—
1/8"	TS277.22.11 MK4	—
5/32"	TS277.22.11 MK5	—
3/16"	TS277.22.11 MK6	—
3/8"	—	TS277.22.11 MK9B (Note 1)
Note 1: Applicable only for 5/16" fittings drilled out to 3/8".		

Step 4. Install the die halves, together with the appropriate shims, in the swaging machine.

Step 5. Rotate the machine by hand to ensure that the dies and shims are correctly installed.

Step 6. Insert the cable/terminal assembly into the swaging machine.

Step 7. Lubricate the outside of the terminal barrel with light machine oil (see Materials section, para. 4.1.3).

Step 8. Start the swaging machine and immediately commence feeding the terminal into the die at a uniform rate of speed as the speed of the machine increases. Ensure that the machine rotation is in the same direction as the lay of the cable (i.e. so that any rotation of the terminal during swaging will not tend to unravel the cable). Swage the terminal within the applicable limits specified in Table 2 for the particular type of terminal involved. Complete the swaging operation within the time limit stated on the data card kept with the die set. The swaging time specified is the maximum time permitted to insert the terminal fully into the dies, including a momentary pause after feeding the required length of terminal into the dies to ensure concentricity of the finished product. If necessary, restrict rapid rotation of the terminal during swaging by holding it by hand (slow rotation of the terminal is desirable).

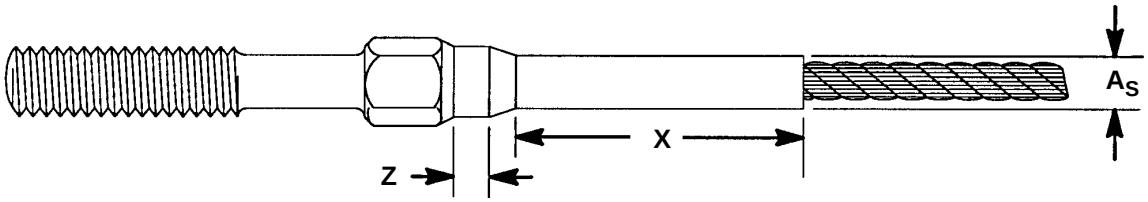
Step 9. On completion of swaging, switch off the machine and remove the cable assembly from the dies.

Step 10. Check that there is no bare cable visible between the band (lacquer or permanent marker) and the terminal; any bare cable visible between the band and the terminal indicates that the cable has pulled out of the terminal during swaging and is unacceptable.

Step 11. Check the first-off terminal of a production run to ensure that it meets the dimensional and visual requirements of section 6. If the first-off terminal is satisfactory, continue the production run. If the first-off terminal fails to meet the requirements, determine the cause of failure and rectify it before re-commencing production. Check each subsequent terminal until satisfactory products are being produced.

Table 2 - Swage Limits

MS21259 AND MS21260 (AN 666 AND AN 669) TERMINALS

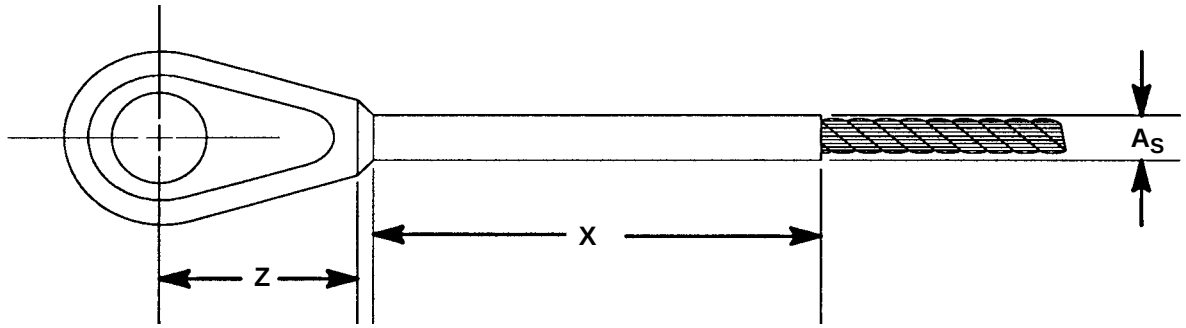


DASH NUMBER	CABLE SIZE	A_S DIAMETER	X MINIMUM	Z MINIMUM
-2	1/16"	0.133" - 0.138"	0.70"	0.03"
-3	3/32"	0.185" - 0.190"	0.80"	
-4	1/8"	0.214" - 0.219"	1.05"	
-5	5/32"	0.245" - 0.250"	1.29"	
-6	3/16"	0.308" - 0.313"	1.31"	
-7	7/32"	0.368" - 0.375"	1.55"	
-8	1/4"	0.431" - 0.438"	1.70"	
-9	9/32"	0.492" - 0.500"	1.89"	
-10	5/16"	0.555" - 0.563"	2.06"	

NOTE: Swaged terminals shall conform to A_S diameter over length X.

Table 2 - Swage Limits

MS20668 (AN 668) TERMINALS

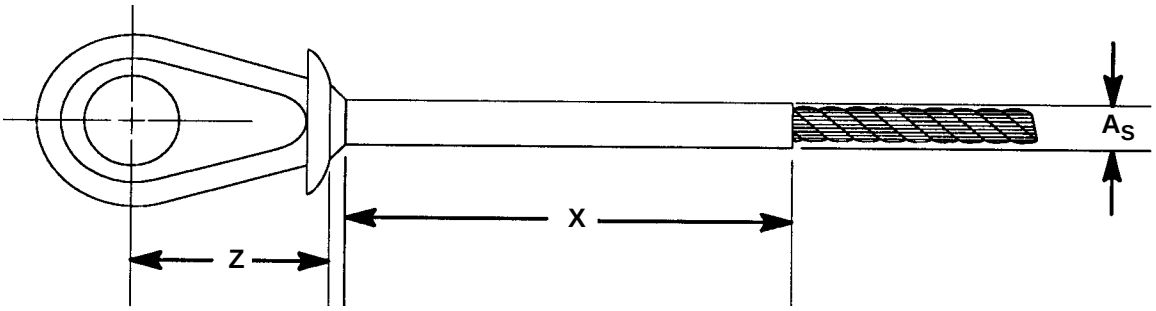


DASH NUMBER	CABLE SIZE	A_S DIAMETER	X MINIMUM	Z MINIMUM
-2	1/16"	0.133" - 0.138"	0.70"	0.662"
-3	3/32"	0.185" - 0.190"	0.80"	0.856"
-4	1/8"	0.214" - 0.219"	1.05"	0.900"
-5	5/32"	0.245" - 0.250"	1.29"	0.997"
-6	3/16"	0.308" - 0.313"	1.31"	1.082"
-7	7/32"	0.368" - 0.375"	1.55"	1.195"
-8	1/4"	0.431" - 0.438"	1.70"	1.326"
-9	9/32"	0.492" - 0.500"	1.89"	1.465"
-10	5/16"	0.555" - 0.563"	2.06"	1.609"

NOTE: Swaged terminals shall conform to A_S diameter over length X.

Table 2 - Swage Limits

MS20667 (AN 667) AND CSP 97, CSP 107 AND CSP 163 TERMINALS

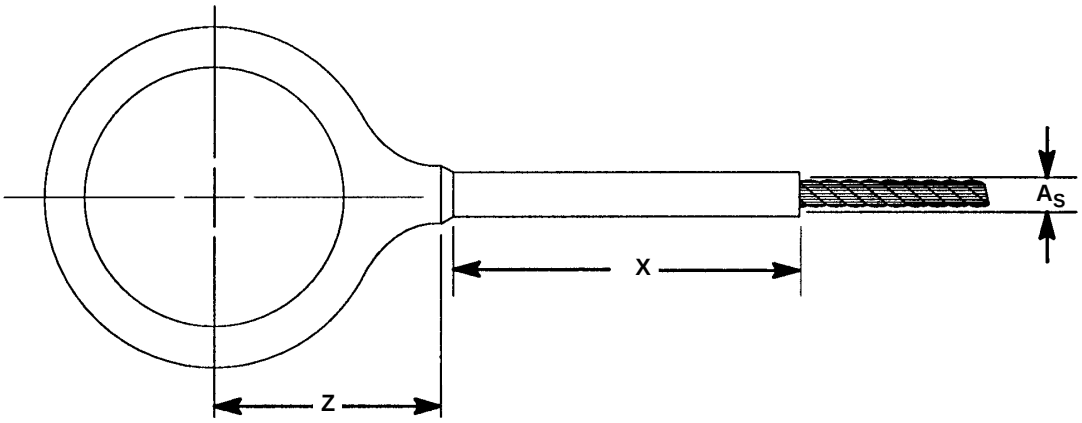


TERMINAL	CABLE SIZE	A_S DIAMETER	X MINIMUM	Z MINIMUM
MS20667-2	1/16"	0.133" - 0.138"	0.70"	0.603"
MS20667-3	3/32"	0.185" - 0.190"	0.80"	0.757"
MS20667-4	1/8"	0.214" - 0.219"	1.05"	0.914"
MS20667-5	5/32"	0.245" - 0.250"	1.29"	0.967"
MS20667-6	3/16"	0.308" - 0.313"	1.31"	1.133"
MS20667-7	7/32"	0.368" - 0.375"	1.55"	1.252"
MS20667-8	1/4"	0.431" - 0.438"	1.70"	1.368"
MS20667-9	9/32"	0.492" - 0.500"	1.89"	1.432"
MS20667-10	5/16"	0.555" - 0.563"	2.06"	1.500"
CSP 97	5/32"	0.245" - 0.250"	1.29"	1.310"
CSP 107	3/16"	0.308" - 0.313"	1.31"	1.740"
CSP 163	5/32"	0.245" - 0.250"	1.29"	1.850"

NOTE: Swaged terminals shall conform to A_S diameter over length X.

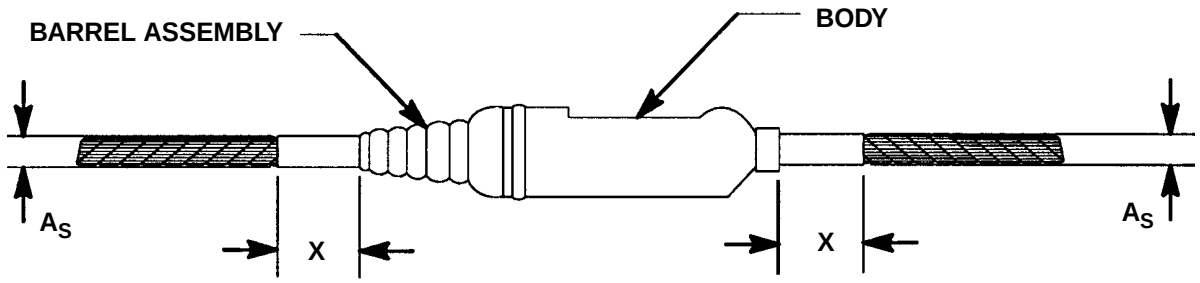
Table 2 - Swage Limits

CSP 161 AND CSP 199 TERMINALS



TERMINAL	CABLE SIZE	A_S DIAMETER	X MINIMUM	Z MINIMUM
CSP 161	5/32"	0.240" - 0.250	1.29"	1.020"
CSP 199	1/8"	0.209" - 0.219	1.05"	1.058"

SPEED RIG TERMINAL

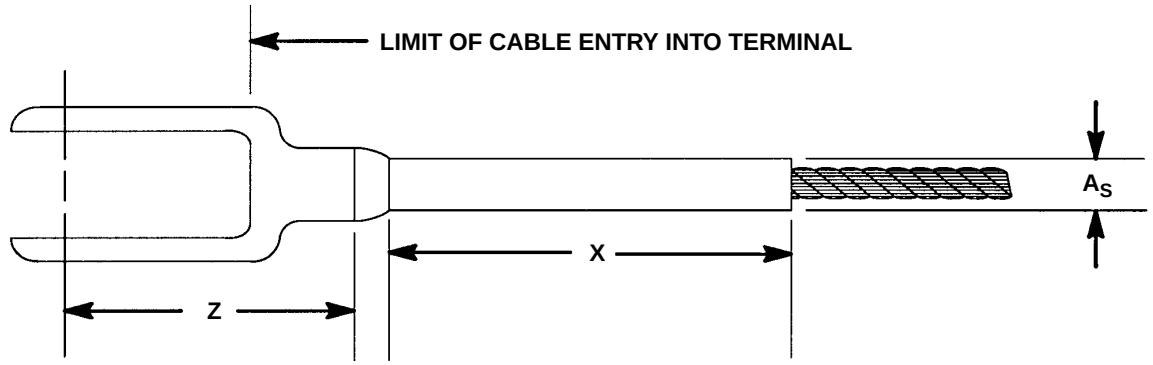


TERMINAL	BARREL ASSY. NO	BODY NO.	CABLE SIZE	A_S DIAMETER	X MINIMUM
D7-1001-2-1A	0301232	0301225	1/16"	0.133" - 0.138"	0.320"
D7-1001-3-1A	0301212	0301204	3/32"	0.185" - 0.190"	0.500"
D7-1001-4-1A	0301247	0301237	1/8"	0.214" - 0.219"	0.604"
D7-1001-5-1A	0301248	0301236	5/32"	0.245" - 0.250"	0.738"
D7-1001-6-1A	0301223	0301215	3/16"	0.308" - 0.313"	0.875"

NOTE: Swaged terminals shall conform to A_S diameter over length X.

Table 2 - Swage Limits

MS20658 TERMINALS



TERMINAL	CABLE SIZE	A_S DIAMETER	X	Z
MS20658-3	3/32"	0.185" - 0.190"	0.80"	1.344"
MS20658-4	1/8"	0.214" - 0.219"	1.05"	1.625"
MS20658-5	5/32"	0.245" - 0.250"	1.29"	
MS20658-6	3/16"	0.308" - 0.313"	1.31"	
MS20658-7				1.750"

NOTE: Swaged terminals shall conform to A_S diameter over length X.

5.4 Proof Load Test

5.4.1 Unless the engineering drawing states “Proof Load Testing Not Required”, proof load all completed cable assemblies according to PPS 3.05. After proof loading check that the cable assembly length conforms to the length specified on the engineering drawing within the tolerances listed in PPS 3.05. Also, ensure that no bare cable is visible between the terminal shank and the edge of the band (lacquer or permanent marker) on the cable where the cable enters the terminal; any bare cable visible between the band and the terminal indicates that the cable has pulled out of the terminal during swaging or proof loading and is unacceptable.

5.5 Part Marking

5.5.1 Part mark the terminal shank ends of cable assemblies according to PPS 15.01.

5.6 Protective Treatment

5.6.1 After part marking, protect the threads of threaded type terminals (MS21259 and MS21260) with the vinyl plastic caps listed in Table 3 or by wrapping with vinyl plastic tape.

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

Table 3 - Threaded Terminal Protective Caps

TERMINAL DASH NUMBER	CABLE DIAMETER	PROTECTIVE CAP	
		PART NUMBER	COLOUR
-2	1/16"	125-1/2	BLACK
-3	3/32"	187-3/4	RED
-4	1/8"	234-1	BLACK
-5	5/32"		
-6	3/16-"	281-1	BLACK
-7	7/32"	343-1	BLACK
-8	1/4"		
-10	5/16" (Note 1)	484-1 (Note 2)	RED

Note: (1) Drilled out for 3/8" cable
(2) Normally supplied with terminal

5.7 Handling and Transport

5.8 For transport or storage, roll each cable assembly into a coil. Ensure that the coil meets the minimum acceptable coil diameter specified in Table 4.

5.9 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 4 - 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 Cables and terminals shall be specified on the engineering drawing.

6.2 The swaged portion of the terminal barrel must conform to the dimensional limits specified in Table 2.

6.3 Swaged assemblies must be free of cracks, fins or roughness visible without magnification. The terminals shall not be distorted.

6.4 The cable must be free of kinks and the cable lay must be uniform over its whole length with no looseness or looping of individual wires or strands.

6.5 Ensure that swaged assemblies are free of terminal distortion such as malformation, misshape, twist, bends, warping, kink, etc.

6.6 There must be no bare cable visible between the terminal shank and the edge of the band (lacquer or permanent marker) on the cable where the cable enters the terminal; any bare cable visible between the band and the terminal indicates that the cable has pulled out of the terminal during swaging or proof loading and is unacceptable.

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 and other sources of ignition.

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.