BOMBARDIER
Toronto (de Havilland)
PROPRIETARY INFORMATION

PPS 6.23

PRODUCTION PROCESS STANDARD

Installation of Cryoflare Sleeves/Nuts

Issue 6
- This standard supersedes PPS 6.23, Issue 5.
- 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 29, 2014
	Production Process Standards (PPS)	
Approved By:	(L.K. John)	February 3, 2014
	Materials Technology	
	(Adam Gordon)	February 3, 2014
	Quality	

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1 Scope

1.1 This Production Process Standard (PPS) specifies the procedure and requirements for the installation of Cryoflare shape memory alloy sleeves.

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 6.01 - Fabrication of Rigid Fluid Lines.

3.2 PPS 6.10 - Cleaning of Fluid System Components.

3.3 PPS 13.26 - General Subcontractor Provisions.

3.4 PPS 27.05 - Manual Edge Finishing.

3.5 PPS 31.07 - Cleaning and Stripping of Painted Surfaces.

3.6 PPS 31.17 - Solvent Usage.

4 Materials and Equipment

4.1 Materials

4.1.1 Cryoflare sleeves/nuts as specified by the engineering drawing (see Figure 1). Refer to Figure 2 for a part number breakdown. The sleeves are supplied as an assembly consisting of the sleeve, the nut and an installation package; the installation package is a

disposable device which encloses the sleeve and provides for proper insertion depth at installation and the nut threads onto the installation package to provide a complete assembly that can only be installed in the correct orientation.

4.1.2 Liquid nitrogen.

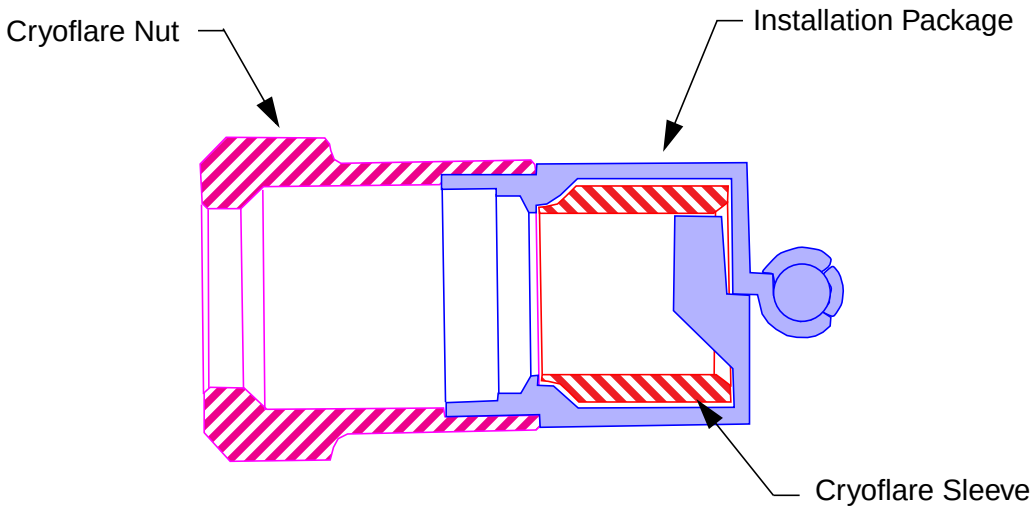


Figure 1 - Cryoflare Sleeve/Nut with Fitted Installation Package

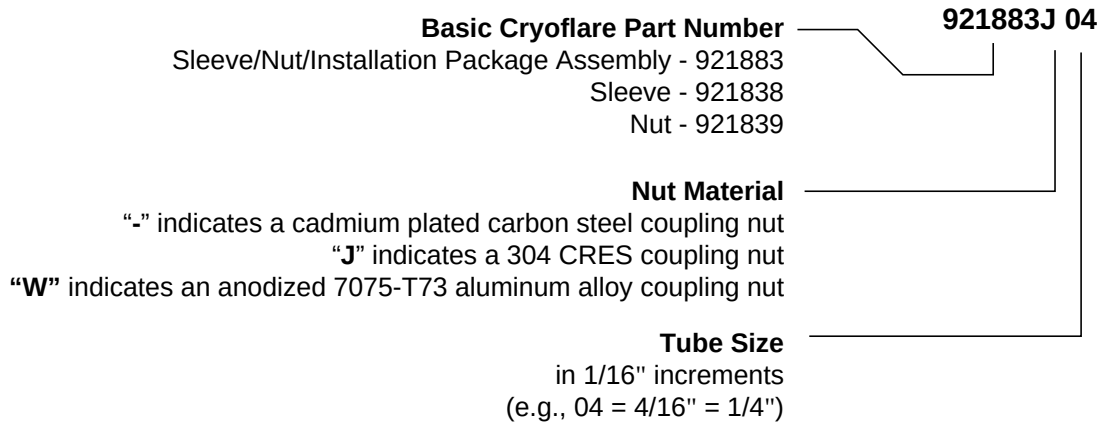


Figure 2 - Cryoflare Part Number Breakdown

4.2 Equipment

4.2.1 Chipless tube cutter (e.g., TS.621.32.11).

4.2.2 Plunger type deburring tools (e.g., as specified in Table 1).

4.2.3 Abrasive pads (e.g., 3M Scotch-Brite Type A maroon (fine)).

4.2.4 Tongs (e.g., CanLab #T5011 or AMCI #AT911094).

4.2.5 Cryogenic storage containers: “dewars”, half-trays and canisters.

4.2.6 Insulated transport/work boxes (e.g., SD8878 or AMCI #WB910825).

4.2.7 Inspection aid (e.g., Go/No-Go gauge).

Table 1 - In-Situ Deburring Tools

TUBE SIZE	DEBURRING TOOL	STEM ASSEMBLY
04 (0.250")	D9851-14	D9851-13-04
06 (0.375")	D9851-14	D9851-13-06
08 (0.500")	D9850-14	D9850-13-08
10 (0.625")	D9850-14	D9850-13-10
12 (0.750")	D9850-14	D9850-13-12
16 (1.000")	D9849-15	D9849-13-16

5 Procedure

5.1 General

5.1.1 Cryoflare shape-memory alloy sleeves and Cryoflare coupling nuts are components of a flared fluid connection. The sleeves are installed on the ends of tubes and permit tubes to be connected to fittings (i.e., tee’s, elbows, unions, etc.) with ends machined as per MS 33656.

5.1.2 Cryoflare sleeves/nuts are made of a shape-memory alloy. When removed from storage in liquid nitrogen it “shrinks” from its manufactured diameter to a diameter smaller than the tube to which it is being applied. When properly installed the Cryoflare sleeve is essentially clamped around the tube.

5.1.3 Cryoflare sleeves are manufactured from Tinel A-HS, a proprietary shape-memory alloy. Shape-memory alloys are unusual in that parts manufactured from them can be deformed when below -150°F (-101°C) and will return or recover to their original shape when allowed to warm to room temperature. With Cryoflare sleeves, the Tinel® shape-memory effect is utilized to attach the sleeve to a tube. First the sleeve is machined to a size slightly smaller than the OD of the tube the sleeve is to be installed upon. Next, the sleeve is cooled in liquid nitrogen. When cooled, the Tinel® sleeve

becomes more malleable and is expanded to a size somewhat larger than the OD of the tube the sleeve is to be installed upon. After being expanded, the sleeve is stored in liquid nitrogen. When the sleeve is removed from the liquid nitrogen and allowed to warm, it will attempt to recover to its pre-expanded size.

5.1.4 Cryoflare sleeves/nuts are shipped and stored in special insulated liquid nitrogen containers called “dewars”. Large quantities of Cryoflare sleeves/nuts are typically shipped and stored in 40 litre dewars while smaller quantities are shipped in 10 litre dewars (see Figure 3). For protection during shipment, Cryoflare sleeves/nuts are shipped in canister tubes in small dewars or half trays in large dewars. For shipping, the dewar is attached to a large pallet designed to prevent it from being tipped over.

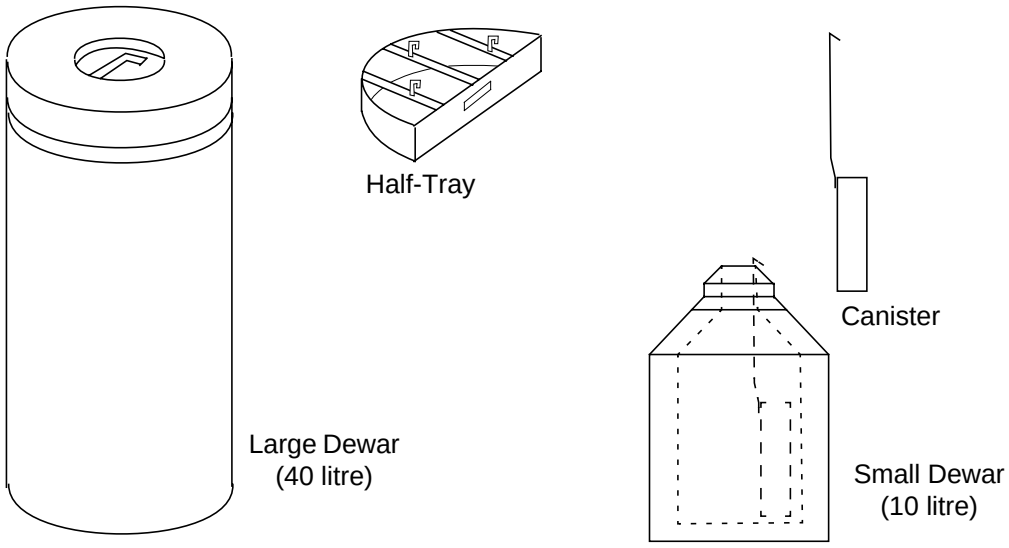


Figure 3 - Cryoflare Storage and Transport Containers (Dewars)

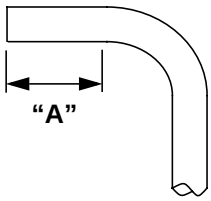
5.1.5 Every 6 months, or in the event that a process problem is detected or suspected, prepare at least one test assembly for metallographic examination. Examine at least two mounted and polished test specimen cross-sections at 200X minimum magnification in both the etched and unetched conditions (i.e., for each test assembly, examine at least 4 test specimens, 2 etched and 2 unetched). Test assemblies shall consist of a 4" long (approximately) tube cut from production tubing with Cryoflare sleeves/nuts installed on each end. Take test specimen cross-sections from the test assembly in the area of sleeve installation. If any crack indications are found, refer to MRB for review.

5.1.6 When handling Cryoflare sleeves/nuts, take care to limit the amount of time the sleeves/nuts spend outside of liquid nitrogen up to the point of installation. Exposure of Cryoflare sleeves/nuts to air for as little as 10 seconds can cause warming. Premature warming of the sleeve/nut may cause it to “shrink” such that it cannot be properly installed. If warming of a Cryoflare sleeve/nut is suspected, check it according to section 5.3.

5.1.7 The tube end must be straight for the minimum specified in Table 2 before the first bend.

Table 2 - Minimum Straight before First Bend

NOMINAL TUBE DIAMETER	"A" MINIMUM
1/4" (0.250")	0.250"
3/8" (0.375")	0.315"
1/2" (0.500")	0.420"
5/8" (0.625")	0.475"
3/4" (0.750")	0.570"



5.2 In-House Storage of Cryoflare Sleeves/Nuts after Receipt

5.2.1 When a shipment of Cryoflare sleeves/nuts is received, check the nitrogen level in the shipping dewar. If the level of liquid nitrogen has dropped to the level of the Cryoflare sleeves/nuts, replenish the level of liquid nitrogen and check that the Cryoflare sleeves/nuts have not warmed according to section 5.3.

5.2.2 As soon as possible after receipt, transfer Cryoflare sleeves/nuts from the shipping dewar to a storage dewar. The following transfer procedure is recommended:

Step 1. Fill the storage dewar with liquid nitrogen.

Step 2. Fill the storage half-tray or canister with liquid nitrogen.

Step 3. Fill two insulated foam trays with approximately 3" of liquid nitrogen. Allow the bubbling to cease before proceeding. The insulated foam trays must be large enough to allow adding the half-trays and/or canisters without overflowing.

Step 4. Cool transfer tools (e.g., tongs) in the liquid nitrogen in one of the foam trays until bubbling stops.

Step 5. Remove the shipping half-tray or canister from the shipping dewar and place it in one insulated foam tray. For sleeves/nuts in canisters, remove the shop towel from the mouth of the canister and place the shipping canister on its side so that the entire canister will be covered with liquid nitrogen. After placing shipping canisters in the liquid nitrogen, remove Cryoflare sleeves/nuts by lifting the shipping canister and allowing the fittings to slide into the insulated foam tray without leaving the liquid nitrogen.

Step 6. Place the storage half-tray or canister in the other insulated foam tray.

Step 7. Using the cooled tools, transfer the Cryoflare sleeves/nuts from the shipping half-tray or canister to the storage half-tray or canister. While transferring the Cryoflare sleeves/nuts, verify and record the quantity received. Transfer Cryoflare sleeves/nuts with deliberate speed.

Step 8. Return the storage half-tray or canister containing the Cryoflare sleeves/nuts to the storage dewar.

Step 9. Return the shipping half-tray or canister to the shipping dewar.

5.2.2.1 If filling an empty storage half-tray (i.e., not adding additional sleeves/nuts), it is acceptable to simply exchange the shipping half-tray for the storage half-tray as they are identical.

5.3 Checking of Cryoflare Sleeves/Nuts for Warming (i.e., Premature “Shrinkage”)

5.3.1 Check each suspect Cryoflare sleeve/nut for warming as follows:

Step 1. Fill a suitable insulated foam tray with approximately 3" of liquid nitrogen.

Step 2. Cool transfer tools (e.g., tongs) in the liquid nitrogen in the insulated foam tray until boiling stops.

Step 3. Transfer the suspect sleeve/nut from the storage dewar to the liquid nitrogen in the insulated foam tray.

Step 4. Cool a length (6" approximately) of the appropriate tubing in the liquid nitrogen in the insulated foam tray until the boiling stops.

Step 5. Being careful to keep the sleeve/nut in the liquid nitrogen, insert the tube into the sleeve/nut. If the tube slips easily into the sleeve/nut to bottom at the stop of the Cryoflare installation package, then the sleeve/nut has not been warmed. If the tube does not fit into the sleeve/nut, it has been warmed. Return warmed Cryoflare sleeves/nuts to the manufacturer for re-expansion - **DO NOT DISCARD**.

5.4 Preparation of Tubing

5.4.1 Except when the Cryoflare sleeve/nut is to be installed in-situ (i.e., on a tube already installed in the aircraft), cut the tube to length according to PPS 6.01. If the Cryoflare sleeve/nut is to be installed in-situ, cut the tubing to length using a chipless tube cutter as follows. In either case, cut the tube end square to within ±1/2° of the tube centre line.

Step 1. Loosen the drive screw on the chipless tube cutter using a suitable hex wrench and locate the cutter head on the tube in the desired cutting position (see Figure 4).

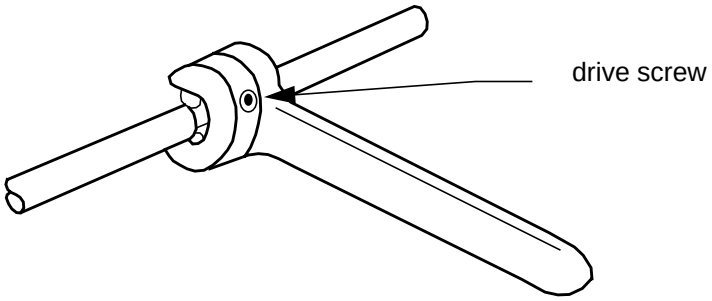


Figure 4 - Chipless Tube Cutter

Step 2. Tighten the drive screw until the cutter wheel lightly contacts the tube, then tighten 1/4 of a turn.

Step 3. Rotate the tool handle back and forth around the tube until there is no resistance.

Step 4. Tighten the drive screw a further 1/8 to 1/4 turn and rotate.

Step 5. Repeat the operation until the cut is complete.

5.4.2 For tubes cut to length according to PPS 6.01, deburr the tube ends according to PPS 27.05. For tubes that have been cut to length using the chipless tube cutter, deburr the ends as follows. Do not chamfer tube ends. Ensure tube ends are free from nicks, dents and scratches.

Step 1. Select the correct size stem assembly shown in Table 3 for the tube size used and assemble it in the tool body.

Table 3 - Deburring Tool

TUBE SIZE	WALL THICKNESS	TOOL BODY	STEM ASSEMBLY
-03	0.030"	Use D10210 complete tool	
-04	0.016" - 0.028"	D9851-14	D9851-13-04
	0.028" - 0.050"		D9651-13-03
-06	0.016" - 0.035"		D9851-13-06
	0.035" - 0.058"		D9851-13-07
-08	0.016" - 0.042"	D9850-14	D9850-13-08
-10	0.016" - 0.058"		D9850-13-10
-12	0.016" - 0.065"		D9850-13-12
-16	0.020" - 0.083"	D9849-15	D9849-13-16
-20	0.024" - 0.065"		D9849-13-20
-24	0.028" - 0.083"		D9849-13-24

Step 2. Depress the tool plunger to extend the plug and insert it into the tube until the cutters contact the tube end (see Figure 5).

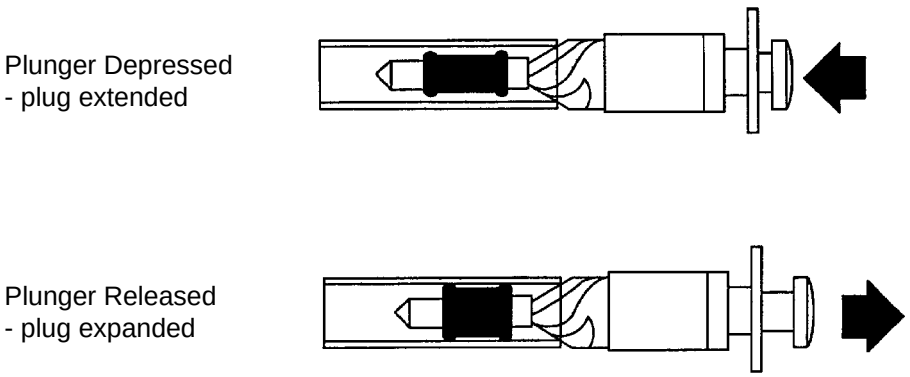


Figure 5 - Use of Plunger Type Deburring Tools

Step 3. Release the plunger to expand the plug in the tube.

Step 4. Apply a light pressure to the knurled body and rotate the tool against the tube end. Do not deburr excessively.

Step 5. Without depressing the plunger, withdraw the tool to the first bulge of the plug and wipe off the chips. Do not depress the plunger before withdrawing the tool or chips of metal will enter the tube.

Step 6. Completely withdraw the tool.

Step 7. Solvent clean the tube according to PPS 31.17 to remove dust and chips from the tube surface. 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 8. Strip any primer or surface finish, other than chemical conversion coating, a minimum distance of 2" from the tube end according to PPS 31.07. On aluminum tube end surfaces, chemical conversion coating (e.g., alodine) is acceptable. Do not mechanically remove the primer or surface finish.

Step 9. Remove the sharp outer edge left by the cutter by polishing the outer edge with a 3M Scotch-Brite pad. Remove all scratches, gouges, etc., by polishing in a circumferential direction only. Tubes that have scratches, gouges, etc., that cannot be removed by polishing are not acceptable.

Step 10. Ensure that the tube surface is free of dirt, grease, etc., for at least 4" from the tube end. If necessary, solvent clean the tube end 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.

5.5 Preparation of Cryoflare Sleeves/Nuts for Installation

5.5.1 If the storage location of the Cryoflare sleeves/nuts is some distance away from the installation area, transfer the required number of Cryoflare sleeves/nuts from the storage dewar to an insulated transport box as follows:

Step 1. Fill a transport box approximately half full with liquid nitrogen.

Step 2. Fill an insulated foam tray with approximately 3" of liquid nitrogen. Allow the bubbling to cease before proceeding. The insulated foam trays must be large enough to allow adding the half-trays and/or canisters without overflowing.

Step 3. Remove the storage half-tray or canister from the storage dewar and place it in the insulated foam tray. For sleeves/nuts in canisters, remove the shop towel from the mouth of the canister and place the shipping canister on its side so that the entire canister will be covered with liquid nitrogen. Place storage canisters on their sides so that the entire canister will be covered with liquid nitrogen. After placing storage canisters in the liquid nitrogen, remove Cryoflare sleeves/nuts by lifting the shipping canister and allowing the fittings to slide into the insulated foam tray without leaving the liquid nitrogen.

Step 4. Cool the tongs to be used for transfer of the Cryoflare sleeves/nuts in the liquid nitrogen in one of the foam trays until bubbling stops.

Step 5. Using the cooled tools, transfer the Cryoflare sleeves/nuts from the storage half-tray or canister to the transport box.

Step 6. Return the storage half-tray or canister to the storage dewar.

5.5.2 If the Cryoflare sleeves/nuts are stored in close proximity to the installation area, it is acceptable to install the Cryoflare sleeves/nuts from an insulated foam tray. In this case prepare the Cryoflare sleeves/nuts as follows:

Step 1. Fill an insulated foam tray with approximately 3" of liquid nitrogen.

Step 2. Remove the storage half-tray or canister from the storage dewar and place it in the insulated foam tray. Place storage canisters on their sides so that the entire canister will be covered with liquid nitrogen. After placing storage canisters in the liquid nitrogen, remove Cryoflare sleeves/nuts by lifting the shipping canister and allowing the fittings to slide into the insulated foam tray without leaving the liquid nitrogen.

Step 3. After installing the Cryoflare sleeves/nuts, return the storage half-tray or canister to the storage dewar.

5.6 Installation of Cryoflare Sleeves/Nuts

5.6.1 Install Cryoflare sleeves/nuts onto prepared tube ends as follows:

Step 1. Cool transfer tools (e.g., tongs) in the liquid nitrogen in the insulated foam tray or transport box until boiling stops.

Step 2. If possible, cool tube ends by immersing them in the liquid nitrogen in the insulated foam tray or transport box until boiling stops.

Step 3. If possible, hold or position the tubes vertically so that the Cryoflare sleeves/nuts will not shift or move after being placed on the tube ends.

Step 4. Using only cooled tools, remove the Cryoflare sleeves/nuts from the insulated foam tray or transport/work box and install them on the cooled tube ends. Install one Cryoflare sleeve/nut at a time and do not delay between removing the Cryoflare sleeve/nut and placing it on the tube end. Ensure that the tube end bottoms against the stop in the Cryoflare installation package of each Cryoflare sleeve/nut.

Step 5. Allow each Cryoflare sleeve/nut to warm on the tube end undisturbed for at least 30 seconds. If it was not possible to hold or position the tubes vertically, manually maintain the Cryoflare sleeve/nut in the correct position after installation until it has warmed (i.e., resumed its pre-cooling shape and strength).

5.7 Removal of the Installation Package

5.7.1 It is recommended to leave the plastic installation package on the tube end to protect the sleeve and act as a dust cover until ready to mate with the fitting.

5.7.2 To remove the plastic installation package, unscrew the nut (Fig. 6-A) and remove the plastic package (Fig. 6-B) as shown in Figure 6.

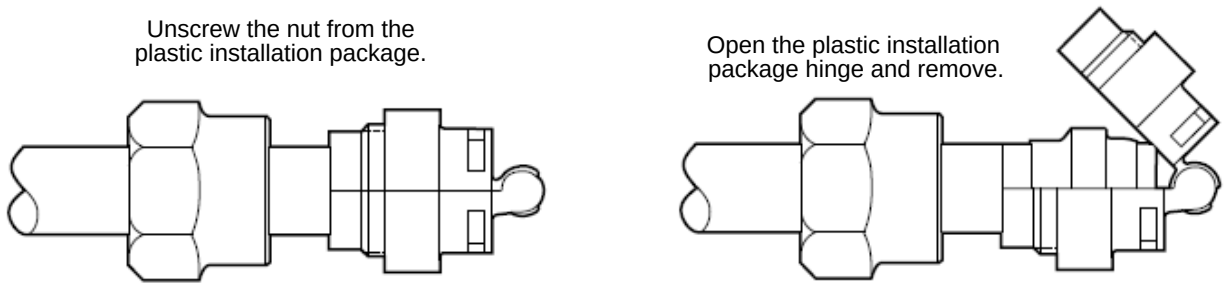


Fig. 6-A Fig. 6-B

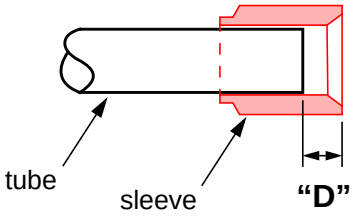
Figure 6 - Removal of the Installation Package

6 Requirements

6.1 Ensure that the depth of the tube end within the Cryoflare sleeve meets the requirements specified in Table 4.

Table 4 - Required Tube Depth

TUBE SIZE	"D" TUBE DEPTH
04 (0.250")	0.100" - 0.140"
06 (0.375")	0.126" - 0.166"
08 (0.500")	0.165" - 0.205"
10 (0.625")	0.174" - 0.214"
12 (0.750")	0.180" - 0.220"



Note 1. If available, use of a suitable check gauge or similar inspection aid is recommended.

7 Safety Precautions

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

7.2 Liquid nitrogen will displace oxygen in confined spaces. Its volume expansion from liquid to gas at standard conditions is 1 to 696 (i.e., as a gas the nitrogen will expand to fill a volume 696 times as great as it occupied as a liquid). Evaporation of large amounts of liquid nitrogen in unventilated or confined spaces could cause suffocation. Therefore, working areas (e.g., storage, transfer, filling, installation, etc.) must be provided with adequate ventilation.

7.3 Liquid nitrogen, at -320°F (-196°C), can cause frostbite or "burn" if it comes into contact with human skin or tissue for more than a few seconds. Brief contact with the liquid due to accidental splashing will not cause harm, however, care must be taken to avoid trapping spilled liquid against the skin. Wear loose fitting clothing and ensure that pants are long enough to overlap shoes.

7.4 Always wear thermal gloves when handling tooling, tubes and Cryoflare sleeves/nuts cooled by liquid nitrogen.

7.5 Pour liquid nitrogen in small quantities to avoid splashing, thermal shock and rapid build-up of pressure.

7.6 In the case of a large spill of liquid nitrogen:

- **stay clear of the liquid nitrogen and allow it to evaporate with adequate ventilation.**
- **immediately remove any clothing or shoes which may have been saturated with liquid nitrogen. Flush skin with cold tap water if "burned".**

7.7 If any prolonged contact of liquid nitrogen with skin or eyes occurs, immediately flush with water and obtain medical attention.

7.8 Always wear splash goggles during bulk transfer of liquid nitrogen.

7.9 Always use tongs to remove cryoflare sleeves/nuts from a work box, tray or dewar. Never reach in with a gloved hand. A thermal glove will become saturated and trap liquid nitrogen against the skin causing frostbite or "burn".

8 Personnel Requirements

8.1 Personnel responsible for installation of Cryoflare sleeves/nuts must have a good working knowledge of the applicable procedure and requirements as specified herein and must have exhibited their competency to their supervisor.

9 Storage of Cryoflare Sleeves/Nuts

9.1 Cryoflare sleeves/nuts can be stored in liquid nitrogen indefinitely, provided care is taken to ensure that the liquid nitrogen level is not permitted to drop below the top of the sleeves/nuts. The liquid nitrogen level in a 40 litre dewar drops approximately 1 inch per day. The level should be checked at least twice a week and replenished as required. For long term storage, use of an automatic system to control the liquid nitrogen level is recommended.

9.2 If there is reason to believe that a Cryoflare sleeve/nut has been warmed (such as from a low liquid nitrogen level in the dewar) check the inside diameter as specified in section 5.3. Return pre-maturely warmed Cryoflare sleeves/nuts to the manufacturer for re-expansion - **DO NOT DISCARD**.