



Work Instruction

Boxfish 2.7mm & 4.3mm Fibre Optic Tether Termination

Release History

Doc Revision	Prepared by	Date	Change description
1	CB	180322	Created
2	CB	080922	Updated seal info



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1 Safety Warning

Fibre optic shards are sharp and easily penetrate skin. They can be extremely dangerous. Treat these with the same precautions as would be the case with needles, blades, or broken glass.

Please follow all safety instructions listed below.

- Keep all food and beverages out of the work area. If fibre particles are ingested, they can cause internal injury.
- Always wear safety glasses. Treat fibre optic splinters as you would glass splinters.
- Never look directly into the end of fibre cables.
- When using an optical fault indicator, look at the fibre at an angle at least 20cm away.
- Wash hands after working with fibre optics.
- Put all cut or broken fibre pieces in a labelled sharps container.
- Do not wipe hands across work surface until the surface has been wiped.

Thoroughly clean your work area when work is complete.

2 Important Note

These instructions apply to the Boxfish **2.7mm** and **4.3mm** diameter tethers. This procedure will not work for other sizes. Please contact Boxfish Support if any clarifications are required.

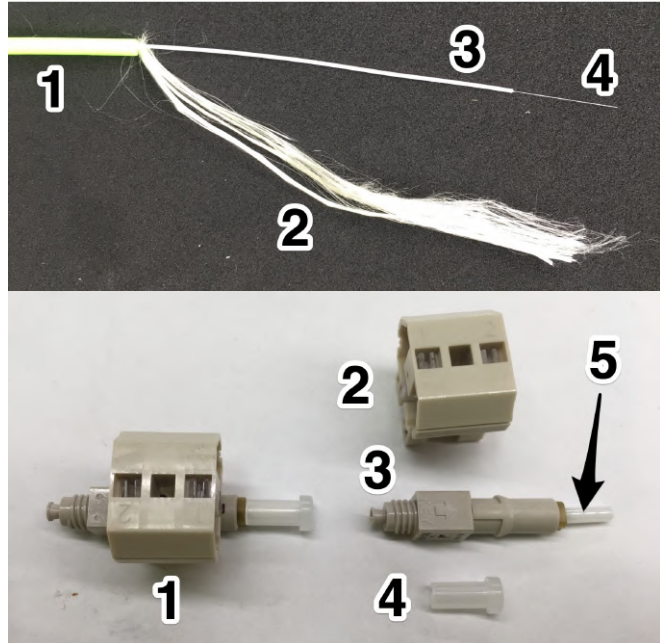
3 Fibre Construction

Tether

1. Tether jacket
2. Strength members
3. Tight Buffer
4. Bare fibre

Fibre termination

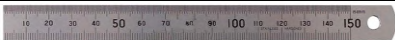
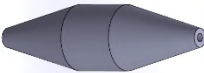
1. **FAST-ST-SM** assembly
2. Wedge clamp tool
3. ST fibre termination
4. Dust cap
5. Ferrule – 2.5mm



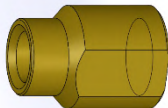
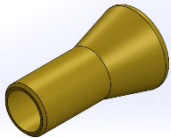
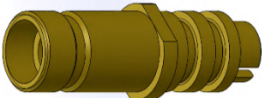
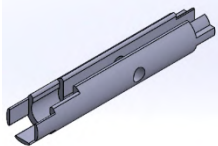
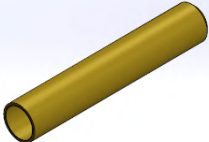
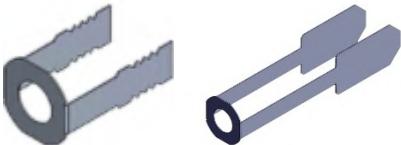
4 Boxfish Tether Termination Tool Kit

<u>ITEM</u>	<u>QUANTITY</u>	<u>IMAGE</u>
Safety glasses	1	
Kevlar Shears	1	
Fibre optic strippers	1	
Alcohol wipes	20	
Wire hook (rigidity like solder)	1	
Silicone lubricant	1	
12mm spanner/wrench	1	
14mm spanner/wrench	1	
Fibre optic cleaver	1	
Optical Fault Indicator	1	

Boxfish Tether Termination Tool Kit Contents, continued.

<u>ITEM</u>	<u>QUANTITY</u>	<u>IMAGE</u>
150mm steel rule	1	
Heat shrink – 8mm (4:1) glue-lined	100cm	
Heat shrink 8mm (4:1) standard (white or blue or yellow)	10cm	
Heat shrink – 1.5mm (2:1)	100cm	
PTFE Tubing 900µm	1m	
Fibre Compression Seal	6	
Sharps Disposal Box	1	
Razor Blade	6	
Permanent Marker	1	

5 Boxfish Tether Termination Mechanical Parts (optional)

<u>ITEM</u>	<u>QUANTITY</u>	<u>IMAGE</u>
Part A Compression fibre penetrator nut	1	
Part B Tether fibre retainer	1	
Part C Strength member spreader	1	
Part D Fibre Compression Seal	1	
Part E Penetrator nut	1	
Part F Compression Fibre Penetrator	1	
O-rings 8.73 x 1.78	2	
O-rings 12 x 1.5	1	
Part G Tether fibre guide Spacer	1	
Part H Penetrator Guide Sleeve	1	
Part J Tether Reinforcement Clip	1	

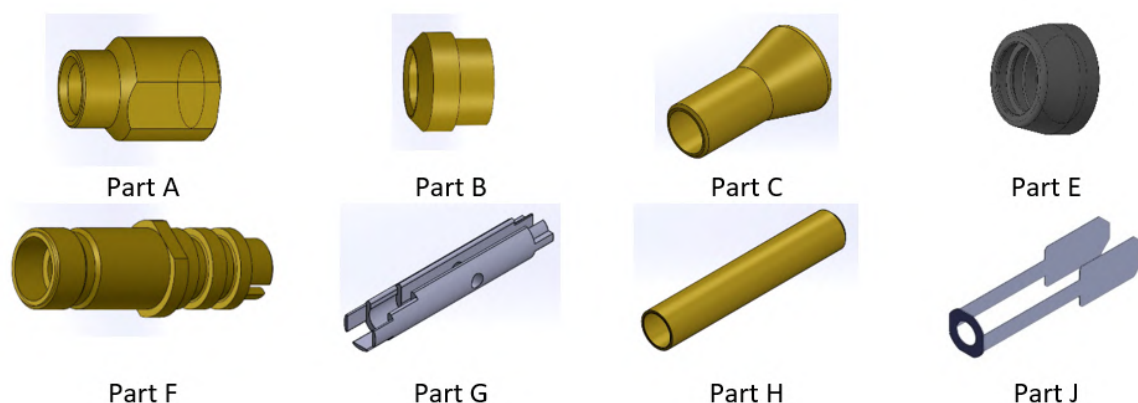
6 Terminating Tether

These instructions consist of three main sections:

- 1) Recovery of parts from an existing damaged tether for use in a new termination.
- 2) Practice steps for aiding improving skills.
- 3) Final tether termination

The practice step is highly recommended if this has not been performed before.

Please refer to the below illustration and the tables above to aid in Part Identification.



6.1 Recovery of parts

Follow this step to retrieve parts from a disused termination for use in a new termination.

1. Cut the tether back to the desired re-termination position.
2. Slice the heat shrink to remove **Part J**.
3. Unscrew **Part H** (Penetrator guide sleeve).
4. Remove **Part 1 (FAST-ST-SM)** from **Part G** (tether guide spacer).
5. Remove **Part G** from **Part F** (compression fibre penetrator).
6. Cut the fibre jacket anywhere along its length.
7. Discard **Part 1 (FAST-ST-FM)** and fibre tail.
8. Unscrew **Part A** (compression fibre penetrator nut) from **Part F**.
9. Pull **Part D** (fibre compression seal) away from **Part C** (strength member spreader).
10. Pull **Part F** and off the tether.
11. Pull **Part A** up and off the tether.

6.2 Practice Termination

1. Strip 120mm of the outer tether jacket. To do this, use the largest slot on the strippers and either make a cut at 120mm and slide the outer jacket off by hand, if this doesn't work strip in 20-30mm increments.
 - NOTE: Cut through the jacket from two angles that are 90° apart.
 - Strip by loosening grip on tool and pulling with slow, constant tension until the section releases.
 - If difficult to strip, joining the cuts with a razor blade and removing the sections may be required.



1. Trim back the strength members and mark 50mm from the end of the white fibre with the masking tape.



2. Strip the fibre back to this mark in 10mm sections using the middle slot of the fibre strippers.

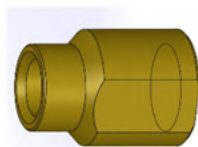


3. Repeat this step several times until confident with the ability to consistently strip the white fibre without it breaking.
 - If the fibre appears uneven or rough, clean the remaining cladding from the fibre using the smallest notch on the cutters.

- Immediately place any broken pieces of fibre in the sharps container for safe storage and later disposal.
- 4. Try removing the clear coating (the Cladding) that is on the fibre, this requires using the smallest slot of the strippers. This will appear like clear/white shavings.
- 5. Try the same process but this time shrink 45mm of 1.5mm (2:1) heatshrink (at 210°C, apply heat for approximately 15-20s) onto the white tight buffer and attempt to strip 40mm, make sure to line the fibre up with the slot through the heat shrink. Repeat this several times until consistent. This should remove the Cladding, check this using the smallest slot on the strippers.
- 6. Cut the exposed tether and place into the sharps container.
- 7. Cut the end of the tether clean to start the final termination.

6.3 Final Termination

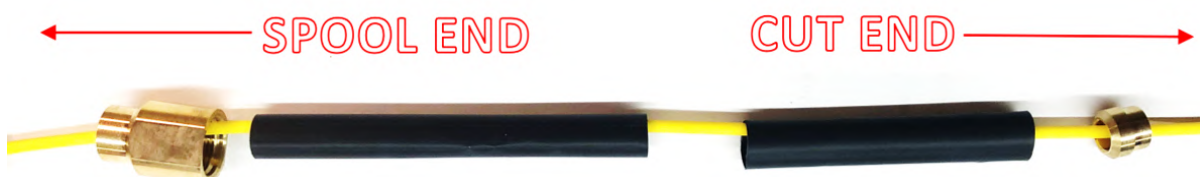
2. Cut 8mm (4:1) adhesive-lined heat shrink sleeving to:
 - 80mm +/- 2mm
 - 60mm +/- 2mm
 - 40mm +/- 2mm
3. Cut 1.5mm (2:1) heat shrink to:
 - 10mm +/- 1mm
 - 85mm +/- 1mm
4. Cut 10mm (4:1) heat shrink to:
 - 10mm +/- 2mm
5. Thread the following onto the end of the tether **in specified order**, taking particular attention to the orientation of the parts.
 - **Part A** (Compression Fibre Penetrator Nut).
 - 80mm 8/2 black heat shrink.
 - 60mm 8/2 black heat shrink.
 - **Part B** (Tether Fibre Retainer (note direction in image)).



Part A



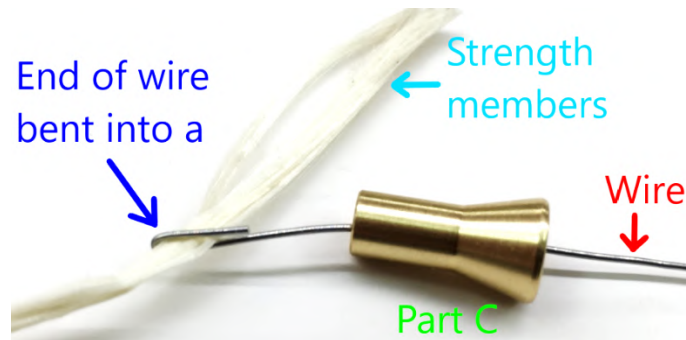
Part B



6. Strip 120mm [+/- 1mm] of the outer tether jacket. To do this, use the largest slot on the strippers and either make a cut at 120mm and slide the outer jacket off by hand, if this doesn't work strip in 20-30mm increments.
 - NOTE: Cut through the jacket from two angles that are 90° apart.
 - Strip by loosening grip on tool and pulling with slow, constant tension until the section releases.
 - If difficult to strip, joining the cuts with a razor blade and removing the sections may be required.



7. Separate the Kevlar strands using a hook or a pin and pull at the weaving a little bit at a time until its unravelled back to the jacket. If the Kevlar becomes hard to pull, pause and try again from a different angle, continuing to pull can cause the Kevlar to become tangled and difficult to work with. Try not to fray the strands.
 - *Note: Using the blunt end of a tool, such as a crochet needle is effective.*
8. Insert the hook wire through **Part C** (Strength Member Spreader), and then bend the end over into a hook.



9. Insert a bundle of strength members into the hook and squeeze tight. Then, pull the bundle through the Strength Member Spreader until all the strength members are through.
 - *Note: Do one or two bundles at a time, do not try to do too many at once.*
10. Carefully insert the fibre itself through the strength member spreader.
11. Move the strength member spreader snug onto the outer jacket of the tether until it is fully seated with a couple of millimetres inserted into the strength member spreader.



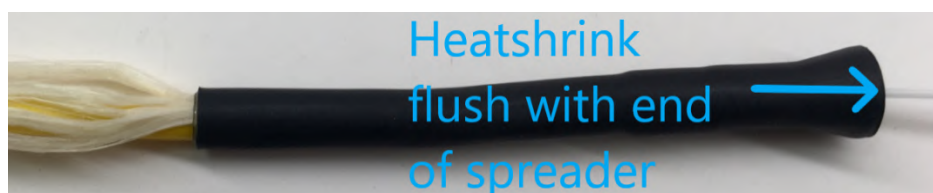
12. Pull the bare strength members back away from the end of the tether and spread the strength member elements evenly over the spreader as shown.



13. Carefully distribute the strength members around the cone of the strength member spreader as evenly as possible.
14. Slide the 10mm (4:1) heat shrink over the strength member spreader to just beyond the end of its metal part.
15. Using a hot-air tool, shrink the heatshrink (150°C) onto the tether jacket, hard up against the strength member spreader end to hold the Kevlar tight.



16. Check the distribution of strength members on the spreader and adjust if required. The fibres should be evenly spread around the cone of the strength member spreader as shown in the example above. They should not wrap around the fibre in the centre.
17. Install the 40 mm heatshrink (150°C) over the strength member spreader & strength members. The end should be flush with the widest part of the strength member spreader.
Note: When shrinking the longer lengths of adhesive lined heat shrink:
 - i) **Ensure that you begin at one end and work down towards the other.** This is to prevent air from becoming trapped inside the heat shrink resulting in poor bonding.
 - ii) Make sure liquid adhesive can be seen at the ends of the heat shrink during the heating process.
 - iii) *Be careful when positioning heat shrink against recently heated brass components. These will be hot and can cause the heat shrink to be placed improperly.*



18. Trim the strength members back to the edge of the heat shrink.



19. Slide **Part B** back down over the heat shrink and hard against **Part C**. Note **Part C** is hidden under the heat shrink.



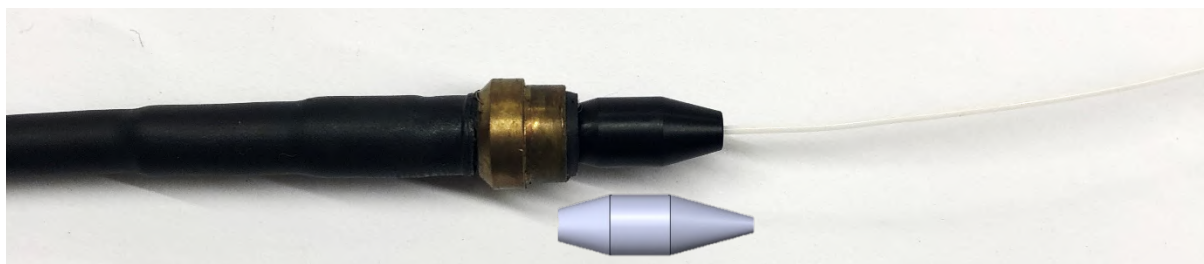
20. Slide the 60mm black heat shrink back up the tether and hard up against **Part B**.
 21. Hold in place to maintain some tension onto it so that heat shrink splays out onto **Part B**.



22. Apply hot air to the heat shrink sleeve to fully shrink to the parts beneath it.
 23. Slide the 80mm black heat shrink over the tether end and back up hard up against **Part B**.
 24. Hold in place to maintain some tension on it so that heat shrink splays out onto **Part B**.
 25. Heat to 150°C to fully shrink starting from the termination end and working down towards the spool end.

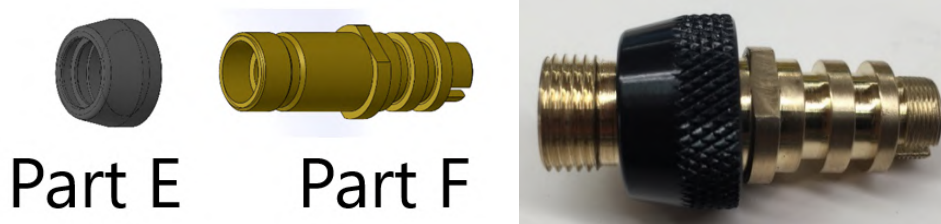


26. Slot Part D over the tight buffer and as far into the spreader as possible. Truncated end first if only one side is truncated. If Part D has one long conic side and one short conic side, the short side should be inside the spreader. See figure.



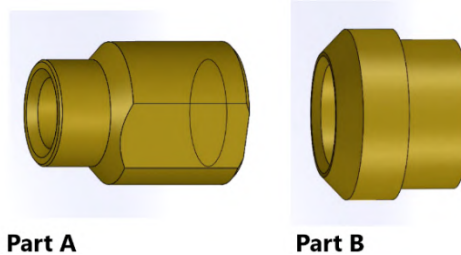
27. Insert 12 x 1.5 O-ring into **Part E** if this was not recovered.

28. Insert **Part E** over **Part F**.



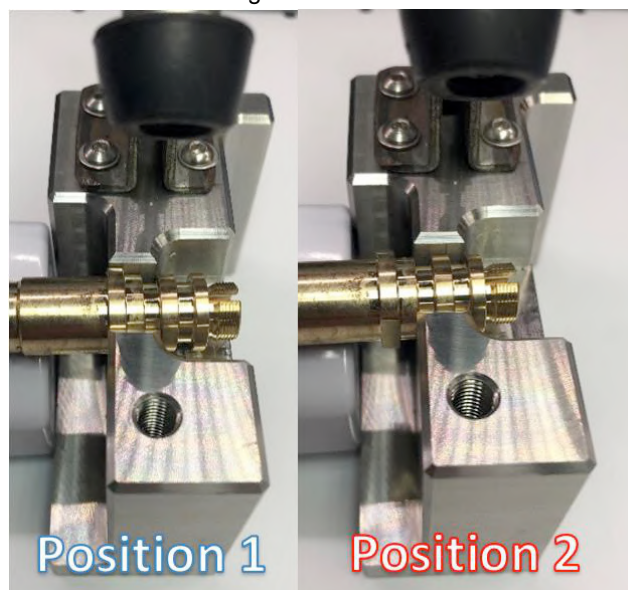
29. Apply a thin smear of silicone grease to the black heat shrink where it touches **Part B**.

30. Move **Part A** onto **Part B**. It may be necessary to 'screw' **Part A** into place, however this should be avoided, if possible, to minimise damage to the heat shrink.

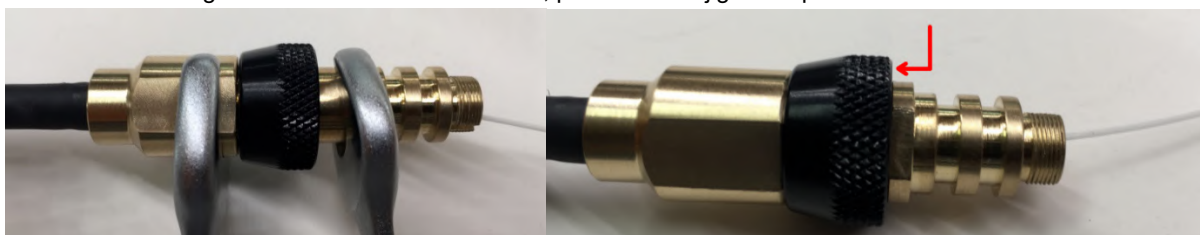


31. Thread the fibre carefully through **Part F**.

32. Thread **Part A** onto **Part F**. Continue using the 12 & 14mm spanners until the flats on **Part F** are flush with the large end of **Part E** when **Part E** is against **Part A**.

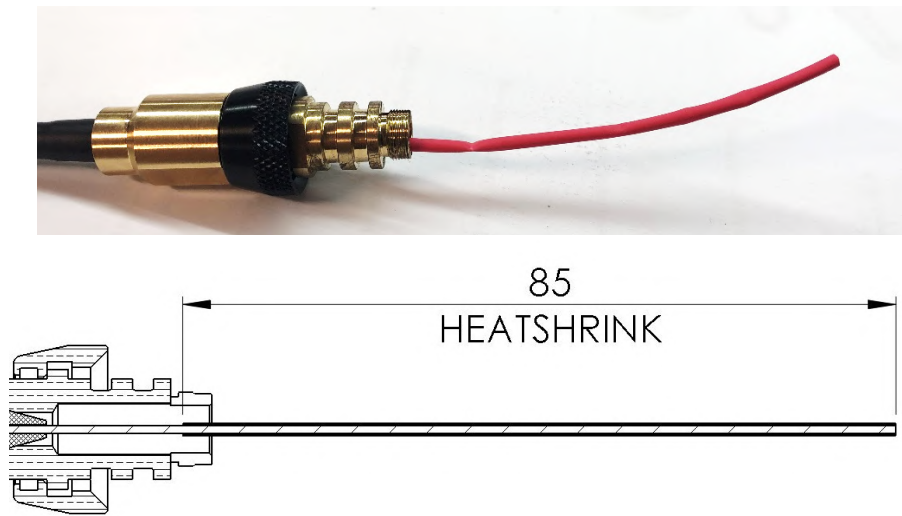


33. 38. If using the Tether Termination Holder, place into the jig in the position 1 of the Holder.

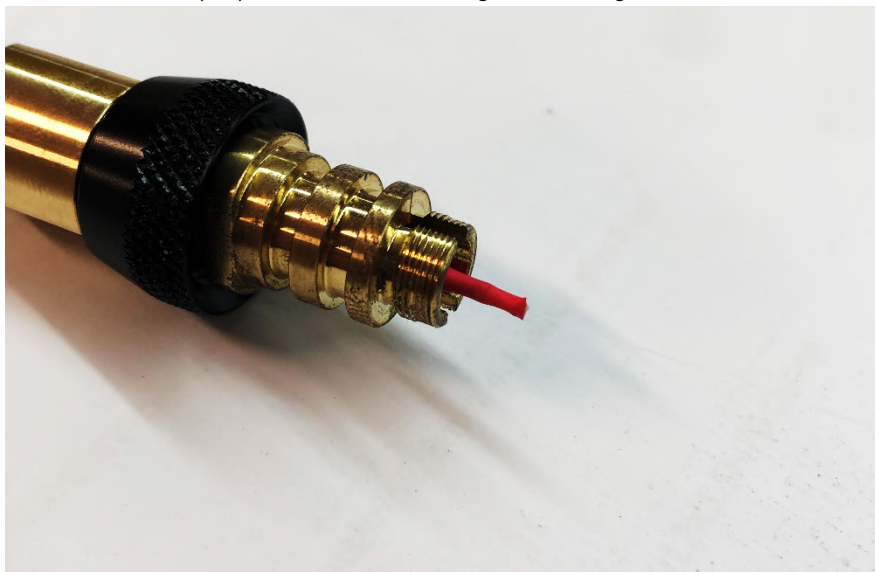


34. 39. Tighten until a firm stop is reached. The top edge of feature shown should be flush with the bottom of **Part E** or against the Holder if using. Check the Nut can be rotated if using the Holder, if it is tight removal from the Holder will be very difficult without damaging the termination assembly.

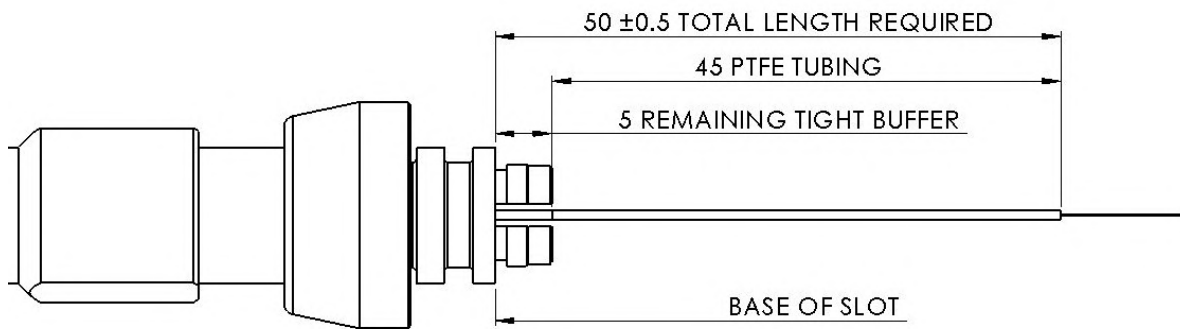
If using the Holder, back Part A off until the Nut can just be rotated, and so removed from the Holder.



35. Place the 85mm 1.5mm (2:1) heat shrink over the tight buffer, align the end with the end of the tight buffer.



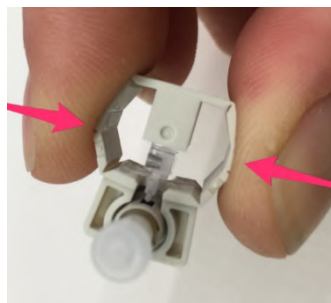
36. Shrink the heat shrink 45mm at a time with the heat gun set to 210°C (make sure it is up to temperature before starting!). Maintain the heat for 15-20s. Once this has occurred, very quickly strip the tight buffer using the middle slot. Be very careful to make sure the fibre is in the centre of the slot so as not to cut through the fibre, as this requires starting again. Repeat this process as close as possible to the end of **Part F**.



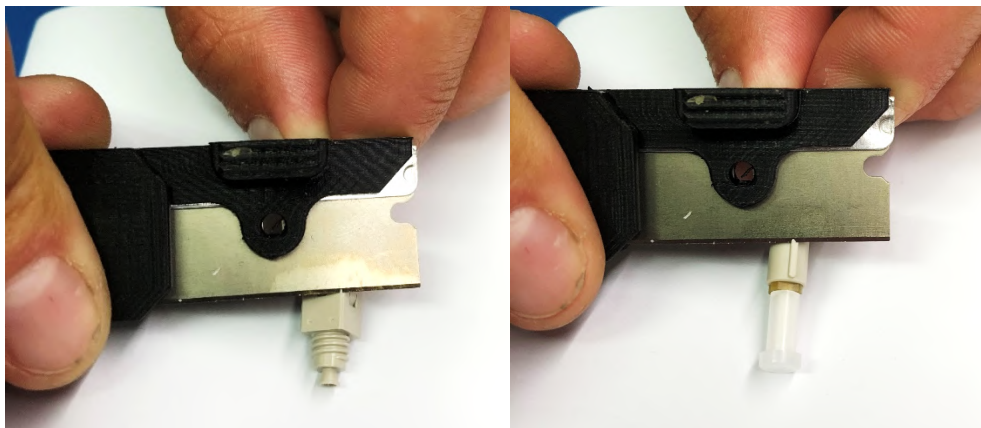
Example showing a 45mm length of PTFE tubing required to make 50mm $\pm$ 0.5mm.



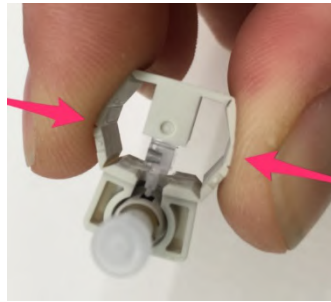
37. The PTFE tubing must reach 50mm $\pm$ 0.5mm from the base of the slot in **Part F**. To calculate how much is required, subtract the length of buffer between the base of the slot and the start of the fibre from 50mm. Cut this length of tubing and slide to meet the tight buffer. Check the length is within 50mm $\pm$ 0.5mm.
38. Ensuring the PTFE tubing remains stationary, slide the 10mm 1.5mm (2:1) heat shrink until it bridges the tight buffer and the PTFE tube. Apply heat (150°C) to lock everything in place. Recheck the positional accuracy (50mm $\pm$ 0.5mm).



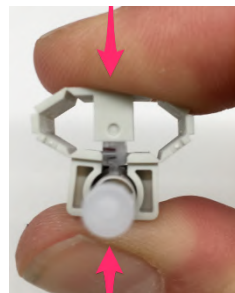
39. Remove the **FAST-ST-SM** connector from the wedge clamp tool by squeezing as shown.



40. If this has not been done on the already, trim the following areas (highlighted in images):
- The four edges using a razor blade to reduce the cross-corner dimension.
 - The raised ridge on the connector (as shown above) down to approximately flush. This is best done with repeated light passes than in one.
 - The sides of the conical section to flatten the two cylindrical sections, do this on the sides either side of the arrow.
 - Ensure plastic shavings do not enter the two rectangular slots in the connector.
41. Reinstall the **FAST-ST-SM** connector to the Wedge Clamp Tool.
42. To ensure that the connector is in the released state, squeeze the sides of the wedge clamp tool. If the wedge is engaged (clamp open) a sound will be heard, and if the wedge is not engaged, there should be no sound.



43. Squeeze the wedge clamp tool between thumb and forefinger firmly until it clicks to open the fibre clamp ready to receive the fibre.



44. If no fault indicator is available, continue with all other steps, otherwise, remove the dust cap and place the **FAST-ST-SM** connector onto the visual fault indicator being careful not to touch the end of the ferrule.



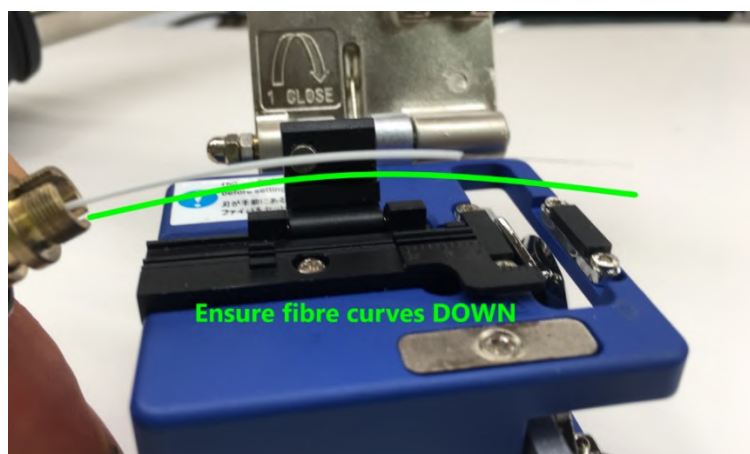
45. Turn on the visual fault indicator ready for use in the next steps.
 46. Clean the bare fibre end several times with alcohol wipes until it is free from any debris. Ensure that the wiping action is towards the end of the fibre, as indicated below.



NOTE: Next steps must be carefully followed with accurate measurements for proper function.

- a) Open sharps container and place it close by.

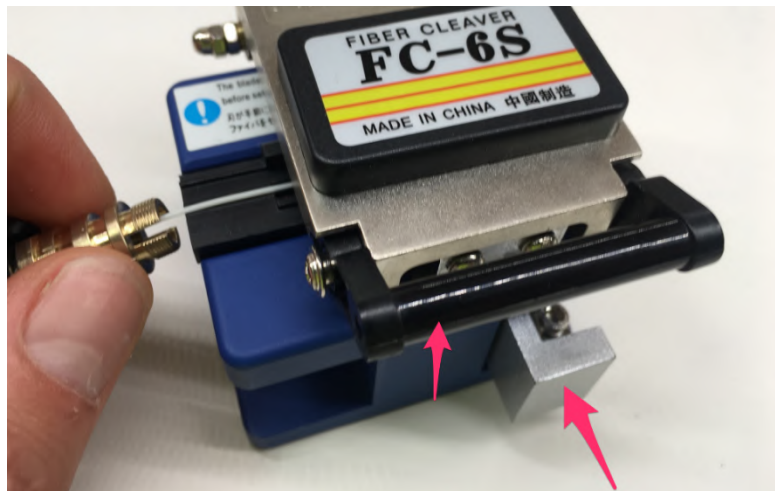
- b) Note the curvature in the fibre and rotate it so that the end of the fibre is curved down. This can be achieved whilst using the holder by moving the Termination to position 2.



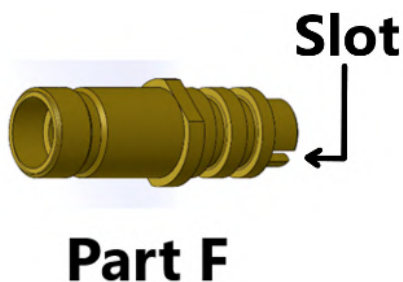
- c) Open the cleaver and the fibre clamp tab.
 d) Carefully place the fibre into the cleaver, in the slot shown. Align stripped jacket at 10.5mm on the cleaver.
 i. *Note: This is not marked, so align halfway between 10 & 11mm.*
 ii. Press the fibre into the slot to ensure it is sitting flat on the bottom of the groove.



- e) Close the black plastic fibre clamp flap. Again, press the fibre down into the groove, ensuring that the bare fibre is resting on the rubber pads on both sides of the blade.
 f) Close the fibre cleaver. Do not hold the lid down.
 g) Push the cutter slide in until it clicks.



- h) Lift the cleaver lever to open.
 - i. If the fibre remains uncleaved, it may be that the clear cladding is still on the fibre. Check this has been removed by using the smallest slot on the stripper. Then wipe the fibre with the alcohol wipe and repeat the cleaving process.
- i) Carefully remove the glass shard and place in sharps container.
- j) Remove the cleaved fibre and carefully insert into the **FAST-ST-SM** connector. Rotate the fibre in **FAST-ST-SM** so that slot in **Part F** is aligned with the fibre clamp, in other words, parallel with the top surface of the clamp (see image).

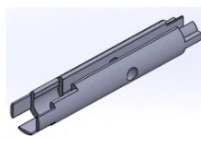


- k) Carefully apply just enough pressure to put a small bend into the fibre and observe the light dimming in the window on the wedge clamp tool.
- l) Squeeze both sides of the fibre clamp tool all the way together to set the wedge clamp.
- m) Carefully remove the fibre clamp tool.
- n) Remove from the optical fault indicator.
- o) Turn off the optical fault indicator.
- p) Reinstall dust cap.





Part F

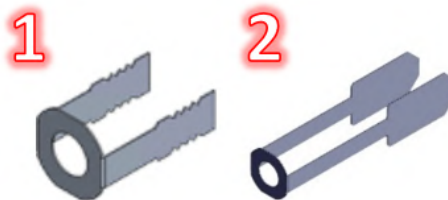


Part G



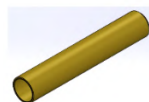
47. With the fibre & newly terminated connector moved off to the side, insert **Part G** (may be white or black) into **Part F** with the opening in the far end facing the **FAST-ST-SM** termination.
48. Gently move the **FAST-ST-SM** towards the tether fibre guide spacer. Check if the arrow on the termination is facing out. If not, **STOP!** Remove **Part G** from **Part F**, rotate 180°, then reinstall.

Before continuing with assembly, test the tether using a Fibre Optic Light Source and an Optical Power Meter if available. Any value between -0.5 to -1.5dBm/km is acceptable. This is to be measured from the Termination to the other (fusion spliced) end of the tether.



If the Tether Reinforcement Clip you are using looks like '1' in the figure above, continue, if '2', skip to the section labelled 'Tether Reinforcement Clip - Style 2'.

Tether Reinforcement Clip – Style 1:



Part H



49. Carefully slide **Part H** over the end of the assembly and screw into place.

Before continuing with assembly, test the tether using a Fibre Optic Light Source and an Optical Power Meter if available. Any value between -0.5 to -1.5dBm/km is acceptable. This is to be measured from the Termination to the other (fusion spliced) end of the tether.



50. If the reinforcement clip legs are not bent as shown above, use needle-nosed pliers to bend the legs of this clip at the line between the hub and the legs if not already bent (see image).

51. Place the tether reinforcement clip over the ferrule on the end of the **FAST-ST-SM** connector so the legs point down towards the tether.
52. Place a 4mm length of glue lined heat shrink over the legs and heat to bond in place.

Tether Reinforcement Clip – Style 2:



53. If the reinforcement clip legs are not bent as shown above, use needle-nosed pliers to bend the legs of this clip at the line between the hub and the legs if not already bent (see image).
54. Remove the cap, slide the reinforcement clip over the ferrule and reinstall cap. Tuck the legs of the clip into the 'wings' of **Part G** as shown in images.



55. Carefully slide **Part H** over the end of the assembly and screw into place. Be careful not to 'drag' the Reinforcement Clip legs round.

Instructions Continue:

56. Place a 4mm length of glue lined heat shrink over the legs and heat to bond in place.
57. Install 2 x lightly greased 8.73mm x 1.78mm O-rings.



58. Check the optical transmission using an optical fault finder. The light should glow brightly at the opposite end of the tether.

Test the tether using a Fibre Optic Light Source and an Optical Power Meter if available. Any value between -0.5 to -1.5dBm/km is acceptable. This is to be measured from the Termination to the other (fusion spliced) end of the tether. It can be useful to note this down for later reference.

The 2.7mm/4.3mm tether is now ready for use.