

FOA Reference Guide For Fiber Optics



Virtual Hands-On Fusion Splicing



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This FOA virtual hands-on (VHO) tutorial on fiber optics covers fiber optic cable splicing using a typical portable fusion splicer. It is copyrighted by the FOA and may not be distributed without FOA permission.

This VHO covers similar material to the videos on YouTube.

Safety Rules

- Read and follow rules in lab manual
- Wear safety glasses
- Dispose of fiber scraps carefully
- Careful with chemicals
- No eating, drinking or smoking
- Splice in well-ventilated areas where no flammable gasses are present!
- ***DO NOT OPERATE THE FIBER CLEAVER OR FUSION SPLICER UNLESS YOU HAVE BEEN PROPERLY TRAINED!***



The lab manual has several pages of rules for safety in fiber optic labs. Each student should be familiar with them and follow them carefully. Instructors must follow them too!

Wear safety glasses whenever doing hands-on exercises

Dispose of fiber scraps carefully in a closable, disposable bin, preferably like deli soup containers with a lid.

Be careful with chemicals. Alcohol is highly flammable and some chemicals are not good to breathe so work in well-ventilated spaces.

No eating or drinking, smoking either.

A note on fusion splicing: The electric arc used to splice fibers can cause explosions if flammable gasses are present! Splice in well-ventilated areas where you are positive that no flammable gasses are present!

**DO NOT OPERATE THE FIBER CLEAVER OR FUSION SPLICER UNLESS YOU
HAVE BEEN PROPERLY TRAINED**

Fusion Splicer - Sumitomo Type 36

- Electrical arc fusion
- Automatic programs
- 25 second splice time
- 2-axis optical core alignment
- Average <math><0.02\text{ dB}</math> loss
- AC or 12V operation



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The fusion splicer shown is the Sumitomo Type 36. It features:

Electrical arc fusion

Automatic programs stored for different types of fibers

Approximately 25 second splice time

2-axis optical core alignment using a CCD camera

Average <math><0.02\text{ dB}</math> loss on typical singlemode fiber

AC or 12V operation for lab or portable use

Splicer Operation - Power Panel

- AC operation - attach AC power cord
- 12 VDC operation - attach cord from 12V supply
- Turn on by setting the AC-OFF-DC switch to the appropriate position
- Allow the unit to initialize



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Splicer Operation - Refer To Power Panel

AC operation - attach AC power cord

12 VDC operation - attach cord from 12V supply

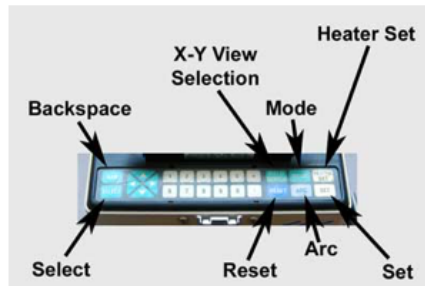
Turn on by setting the AC-OFF-DC switch to the appropriate position

Allow the unit to initialize

Graphic from Sumitomo manual

Keyboard Controls

- Set - starts splice operation
- Reset - aborts splicing
- Mode - opens mode selection menu screen
- Select - chooses highlighted item
- X-Y View- chooses fiber view
- ARC - manual arc control
- Heater set - starts heater
- Backspace - returns to previous menu



Before starting use of the splicer, it is important to understand the keyboard controls:

Set - starts or continues the programmed splice operation

Reset - aborts splicing, resets the splicer to the beginning menu screen

Mode - opens mode selection menu screen, refer to manual for options, not normally used in labs, as splicer will be preprogrammed for fibers used in exercises

Select - chooses highlighted item

X-Y View- chooses fiber view - X direction or Y direction

ARC - manual arc control

Heater set - starts heater for heat-shrink protection sleeve

Backspace - returns to previous menu

Graphic from Sumitomo manual

Sumitomo FCP-22L Cleaver

- Precisely cleaves fibers for splicing
- Strip fiber to 40 mm (about 1-1/2")
- Insert in holder
- Cleave to 16-18 mm (about 3/4")
- Insert in splicer immediately



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Cleaving the fiber

Precisely cleaves fibers for splicing

Strip fiber to 40 mm (about 1-1/2")

Insert in holder

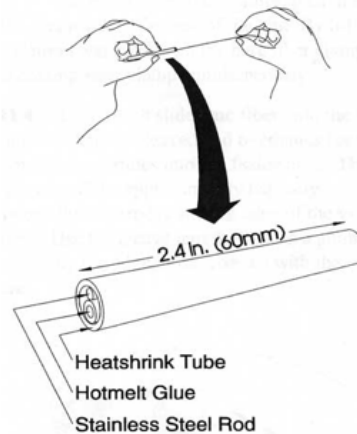
Cleave to 16-18 mm (about 3/4")

Insert in splicer immediately

Graphic from Sumitomo manual

Splice Sleeve

- The first step is to install a splice protection sleeve on one of the fibers to be spliced
- Before stripping or cleaving
- Will be heated to seal fibers and splice after splicing



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The first step is to install a splice protection sleeve on one of the fibers to be spliced
Do this before stripping or cleaving!
The splice protection sleeve will be heated to seal the fiber splice after splicing is completed

Graphic from Sumitomo manual

Splice Sleeve - FIRST!

- Remember to install the splice protection sleeve before stripping or cleaving
- Will be heated to seal fibers and splice after splicing



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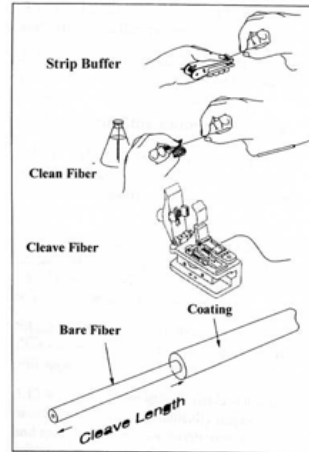
8

Remember to install the splice protection sleeve before stripping or cleaving! It is practically impossible to install after the fiber is stripped without damaging the fiber. The splice protection sleeve will be heated to seal the fiber splice after splicing is completed

Graphic from Sumitomo manual

Preparing The Fiber

- Strip fiber buffer coating
- Strip fiber to 40 mm (about 1-1/2")
- Clean the fiber thoroughly
- Cleave fiber



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Preparing the fiber for splicing

Strip fiber, down to the bare glass, Strip fiber to 40 mm (about 1-1/2")

Clean the fiber thoroughly using lab grade isopropyl alcohol

Cleave fiber - this is the most critical phase, as a poor cleave will always yield a poor splice!

Graphic from Sumitomo manual

Stripping Fibers

- Most critical phase of splicing where fiber damage is most likely
- Try to avoid nicks or cuts as it weakens fiber
- Strip 900 micron buffer first, then 250 micron
- Be careful cleaning and placing fiber in holders on cleaver or splicer too



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Stripping fibers is the most critical phase of splicing where fiber damage is most likely to occur.

Try to avoid nicks or cuts as it weakens fiber and can cause long term reliability problems

Strip 900 micron buffer first, then 250 micron, both in one step. To minimize fiber nicks, strip in one step instead of little bites as done with connectors.

Be careful cleaning the fiber and placing it in holders for cleaving or splicing too

Cleaning Fiber

- Clean fiber
 - Wipe with lint-free wipe and isopropyl alcohol
 - Careful - do not break fiber!



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Place an alcohol pad (or lint-free wipe with pure isopropyl alcohol) between your thumb and forefinger, and wipe the fiber between them.

Careful- do not break the fiber!

Cleaving -1

- Open the two clamps on the cleaver
- Make sure it is completely clean



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Cleaving - Step 1

Open the two clamps on the cleaver

Make sure it is completely clean

Cleaving -2

- Gently lay the fiber into the left side of the cleaver
- End of the buffer should be at 16 mm



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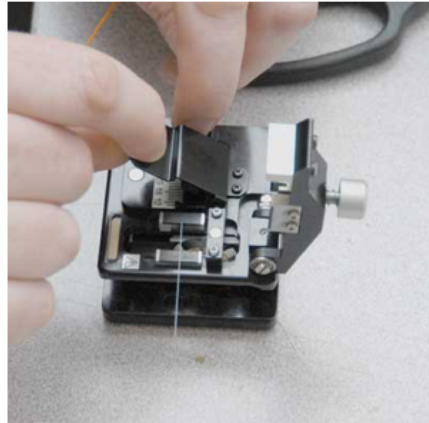
Cleaving -Step 2

Gently lay the fiber into the left side of the cleaver

End of the buffer should be at the 16 mm mark

Cleaving - 3

- Close the clamp to hold the fiber buffer in place



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Cleaving - Step 3

Close the clamp to hold the fiber buffer in place

Cleaving - 4

- First check to see the fiber is straight and in the middle of the pad indicated by the arrow
- Move the scribe wheel to the front of the cleaver
- Gently close the right clamp to hold the fiber



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Cleaving - Step 4

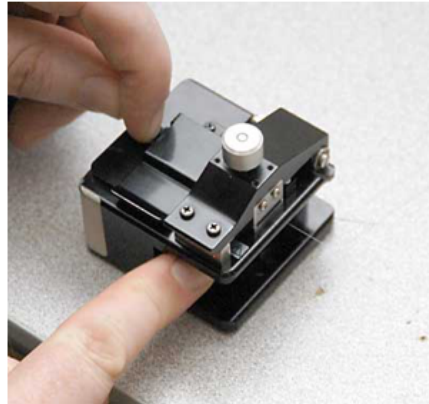
First check to see the fiber is straight and in the middle of the pad indicated by the arrow

Move the scribe wheel to the front of the cleaver

Gently close the right clamp to hold the fiber

Cleaving - 5

- Push the button on the front of the cleaver to slide the cleave wheel to the rear, which will scribe the fiber



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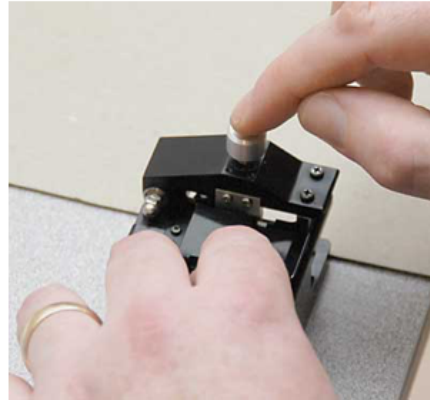
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Cleaving - Step 5

Push the button on the front of the cleaver to slide the cleave wheel to the rear, which will scribe the fiber

Cleaving - 6

- Push the button on the top of the cleaver to cleave the fiber



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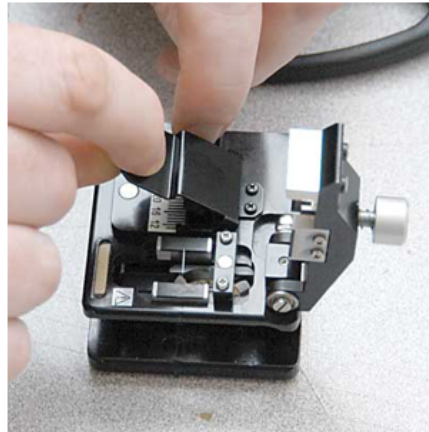
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Cleaving - Step 6

Push the button on the top of the cleaver to cleave the fiber

Cleaving - 7

- Open the right cleaver clamp to remove the fiber scrap
- Pick up the fiber scrap with tweezers and dispose of properly
- Open the left clamp and remove the fiber



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Cleaving - Step 7

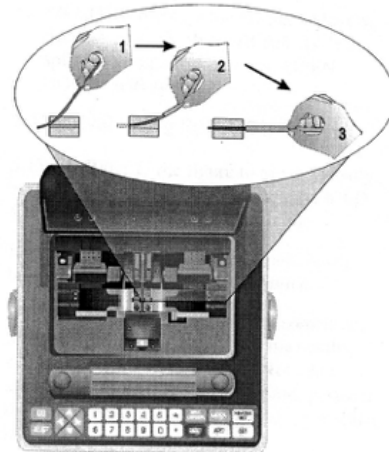
Open the cleaver clamp to remove the fiber

Pick up the fiber scrap with tweezers and dispose of properly

Open the left clamp and remove the fiber

Inserting Fibers In Splicer

- Raise splicer hood
- Release both fiber clamps
- Lower fiber gently into V-grooves
- Close clamps GENTLY



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Inserting Fibers In Splicer

Strip fibers and cleave first

Raise splicer hood located in the middle of the top of the unit

Release fiber clamps by pushing the activators toward the rear of the unit. Lift the clamp lever to raise both the bare fiber clamps and the coated fiber clamps simultaneously

Lower fiber gently into V-grooves so the cleaved end overhangs the V-groove and protrudes into the fusion area. The fiber end should be about halfway between the end of the V-groove and the electrodes. Align the end of the buffer coating on the fiber with the cleave length mark on the unit.

DO NOT SLIDE THE FIBER IN THE V-GROOVES OR ALLOW THE FIBER END FACE TO TOUCH ANYTHING AS THIS CAN CONTAMINATE THE FIBER OR DAMAGE IT.

Close clamps GENTLY by pushing the clamp lever down. First press the clamp lever to lower the fiber coating clamp and press it down until it locks. Then gently lower the bare fiber clamp to properly seat the bare fiber in the V-groove.

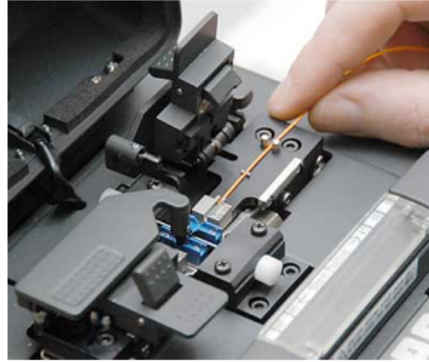
The fiber should now be resting in the V-grooves. Repeat for the other fiber.

Close the hood and you are ready to splice.

Graphic from Sumitomo manual

Loading Fibers - 1

- Gently lay the fiber in the guides on the splicer
- Note the position of the end of the buffer coating - at the 16 mm mark
- Check the position of the fiber end - should be near the electrodes



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Loading Fibers - Step 1

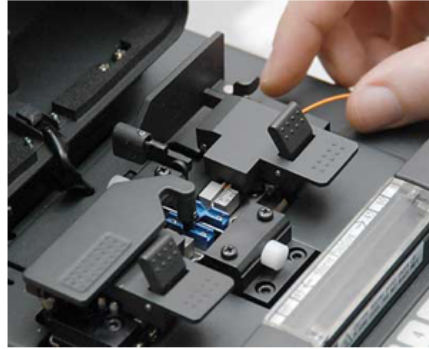
Gently lay the fiber in the guides on the splicer

Note the position of the end of the buffer coating - at the 16 mm mark

Check the position of the fiber end - should be near the electrodes

Loading Fibers - 2

- Gently lower the first clamp to hold the buffer coating in place
- Make certain the fiber is still in position in the v-groove near the electrodes



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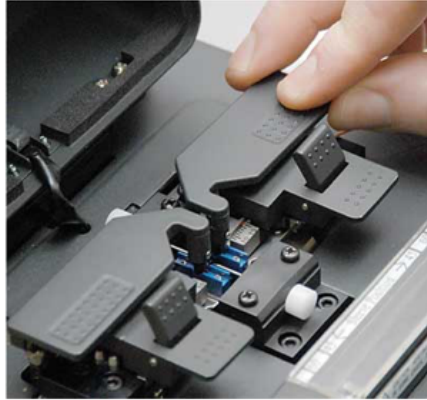
Loading Fibers - Step 2

Gently lower the first clamp to hold the buffer coating in place

Make certain the fiber is still in position in the v-groove near the electrodes

Loading Fibers - 3

- Check again that the fiber is in the V-groove and the end is near the electrodes
- Close the clamp that holds the fiber



Loading Fibers - Step 3

Check again that the fiber is in the V-groove and the end is near the electrodes

Close the clamp that holds the fiber

Loading Fibers - 4

- Repeat for the other fiber being spliced



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Loading Fibers - Step 4

Repeat for the other fiber being spliced

Run Splicer Program - 1

- Close hood on fibers
- Display should show “SPLICE MODE MENU” and “AUTOMATIC MODE”



Run Splicer Program - Step 1

Close hood on fibers

Display should show “SPLICE MODE MENU” and “AUTOMATIC MODE”

Run Splicer Program - 2

- Press “SET” to begin splicing
- Splicer will move fiber into place and show fiber on screen



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Run Splicer Program - Step 2

Close hood on fibers

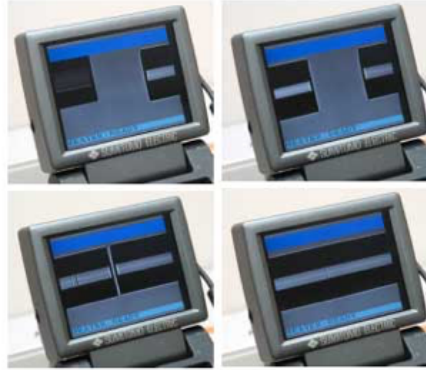
Display should show “SPLICE MODE MENU” and “AUTOMATIC MODE”

Press “SET” to begin splicing

Splicer will move fiber into place and show fiber on screen

Run Splicer Program - 3

- During the process, screen will show fiber placement and messages will display to show progress



Run Splicer Program - Step 3

Splicer will move fiber into place and show fiber on screen

During the process, screen will show fiber placement and messages will display to show progress:

GAP ADJUST - the splicer is setting end gap

FOCUS - adjusting the camera focus

SPLATTERING - pre-fusing the fibers to polish the fiber ends

FIBER END CHECK - checks the cleave angle and cleanliness

FIELD CHANGE - changes from X to Y image

CORE ALIGN/DIAMETER ALIGN - aligns the fibers according to the chosen program

ARC FUSION - fuses the fibers by heating the ends in an arc and feeding them together

INSPECTION - High-resolution Direct Core Monitoring (HDCM) to evaluate the splice quality using the camera

ES LOSS - displays the estimated loss in dB and any observed defects

Run Splicer Program - 4

- When finished running program, splicer will show splice loss estimate at top of screen and say “OPEN HOOD”
- The splicing process is finished



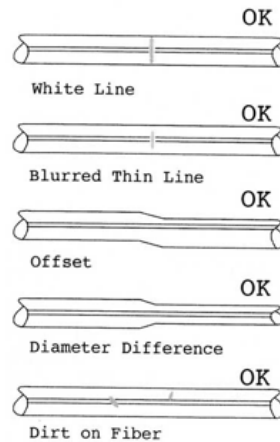
Run Splicer Program - Step 4

When finished running program, splicer will show splice loss estimate at top of screen and say “OPEN HOOD”

The splicing process is finished

Acceptable Splices

- Visually inspect splice
- Use both X and Y views (FIELD CHANGE)
- Some flaws that do not affect optical transmission are acceptable, as shown
- Some fibers may cause white or black lines in splice region



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Visually inspect splice

Use both X and Y views (FIELD CHANGE)

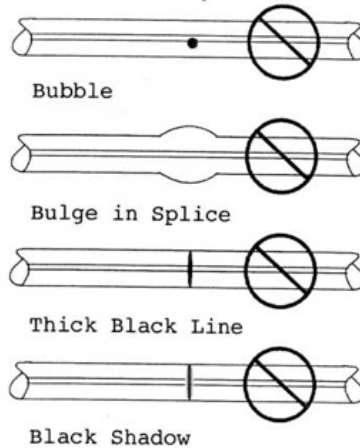
Some flaws that do not affect optical transmission are acceptable, as shown

Some fibers (e.g. fluorine-doped or titanium coated) may cause white or black lines in splice region that are not faults

Graphic from Sumitomo manual

Bad Splices

- Some flaws are unacceptable
- Some, like black spots or lines, can be improved by repeating the ARC step
- For large core offsets, bubbles or bulging splices, always redo



Some flaws are unacceptable and require starting the splicing process over
Some, like black spots or lines, can be improved by repeating the ARC step, but never more than twice
For large core offsets, bubbles or bulging splices, always redo

Graphic from Sumitomo manual

Install Splice Protective Sleeve

- Open splicer hood and remove spliced fibers
- Slide protective sleeve over fiber and center it
- Pull fiber gently to get straight inside sleeve



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Install Splice Protective Sleeve

Open splicer hood and remove spliced fibers

Slide protective sleeve over fiber and center it

Pull fiber gently to get straight inside sleeve

Sleeve Heater - 1

- The heater for the sleeve is at the front of the splicer
- Open heater clamps on both sides
- Center sleeve in heater chamber
- Lower fiber into heater
- Close doors and secure magnetically



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The heater for the sleeve is at the front of the splicer
Open heater clamps on both sides
Center sleeve in heater chamber
Lower fiber into heater
Close doors and secure magnetically

Sleeve Heater - 2

- Center sleeve in heater chamber
- Lower fibers and sleeve into heater
- Close doors and secure magnetically



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Center sleeve in heater chamber

Lower fiber into heater

Close doors and secure magnetically - NOTE: When using 900 micron buffered fiber, do not snap heater doors closed, just shut gently, since they can damage fibers if snapped shut!

Once heater cycle is started, you can begin another splice while it is operating.

Sleeve Heater - 3

- Press HEATER SET to start heater cycle
- Beep after about 90 seconds indicates cycle is completed
- Lift open both clamps
- Removed splice while pulling gently on fibers to keep straight
- Careful - sleeve is hot!



Press HEATER SET to start heater cycle

Beep after about 90 seconds indicates cycle is completed

Lift open both clamps

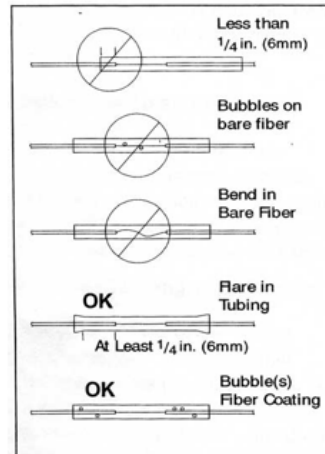
Removed splice while pulling gently on fibers to keep straight

Careful - sleeve is hot!

Once heater cycle is started, you can begin another splice while it is operating.

Acceptable Sleeves

- Inspect sleeve carefully as this is protection for the splice
- Must have at least 6 mm (1/4 inch) of buffer inside sleeve
- No bubbles near fiber
- No bend in bare fiber



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Inspect sleeve carefully as this is protection for the splice and will greatly affect splice reliability

You must have at least 6 mm (1/4 inch) of buffer inside sleeve

No bubbles can be near fiber

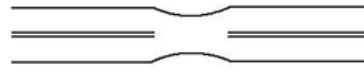
No bend is allowed in the bare fiber in the middle of the splice sleeve

Graphic from Sumitomo manual

Splice Troubleshooting - Constriction

- Current too high
- Feed rate too slow
- Prefusion time too long
- Prefusion current too high
- Gap too wide
- Contaminated electrodes

Constriction



Constriction

Current too high

Feed rate too slow

Prefusion time too long

Prefusion current too high

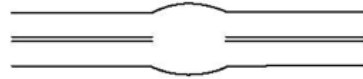
Gap too wide

Contaminated electrodes

Splice Troubleshooting - Enlargement

- Autofeed too fast
- Incorrect current

Enlargement



Enlargement

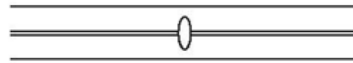
Autofeed too fast

Incorrect current

Splice Troubleshooting - Bubbles

- Contaminated fiber end faces
- Poor cleave
- Fusion current too high
- Prefusion current or time too low

Bubble or inclusion



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Bubble or Inclusion

Contaminated fiber end faces

Poor cleave

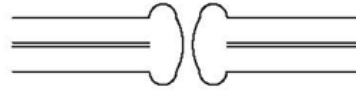
Fusion current too high

Prefusion current or time too low

Splice Troubleshooting - Matchheads

- Contaminated electrodes
- Fusion current much too high
- Prefusion time much too long
- Prefusion current much too high
- Autofeed too small
- Gap too large

Matchheads



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Matchheads

Contaminated electrodes

Fusion current much too high

Prefusion time much too long

Prefusion current much too high

Autofeed too small

Gap too large

Splice Troubleshooting - Not Fused

- Fusion current too low
- Prefusion time too short

Not fused through



Not fused through
Fusion current too low
Prefusion time too short

If the fibers look like this, recleave!



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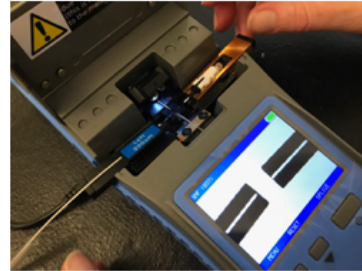
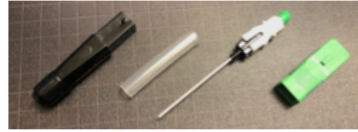
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If the fibers look like this, recleave!

These fibers were not cleaved properly and the splicer will not try to splice them.

Fusion Splice-On Connectors (SOCs)

- Some fusion splicers can splice connectors directly onto fiber
- See the FOA VHO on Prepolished/ Splice Connectors



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Some fusion splicers can splice connectors directly onto fiber using a factory-made connector with a short fiber pigtail.

See the FOA VHO on Prepolished/ Splice Connectors for details on this termination method.

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