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.
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 gases 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**
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 <0.02 dB loss on typical singlemode fiber
- AC or 12V operation for laboratory 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

Graphic from Sumitomo manual
Before starting use of the splicer, it is important to understand the 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

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

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
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
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

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 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. 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!

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 - 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

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
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
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
Cleaving - 7

- Open the left clamp and remove the fiber.
- Pick up the fiber scrap with tweezers and dispose of properly.
- Open the right cleaver clamp to remove the fiber scrap.
Inserting Fibers In Splicer

1. Raise splicer hood
2. Release both fiber clamps
3. Lower fiber gently into V-grooves
4. Close clamps GENTLY

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

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 - 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 - 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 - 2

- Press “SET” to begin splicing
- Spicer 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:

  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
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

Graphic from Sumitomo manual

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

Graphic from Sumitomo manual

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

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
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

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
Splice Troubleshooting - 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

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
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!

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

Some fusion splicers can splice connectors directly onto fiber using a factory-made connector with a short fiber pigtai.
See the FOA VHO on Prepolished/Splice Connectors for details on this termination method.
FOA Guide - Virtual Hands-On

By

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