# Successful Splicing Made Easy

Years ago fiber splicing was a difficult and finicky process that was left to the fiber guru. The splicers were expensive and temperamental. Nobody wanted to be the person that held up a job because of splicing results that seemed to be random and they certainly did not want to be the person who “broke” this very expensive instrument.

The ever increasing demand for high bandwidth networks has created a need for qualified splicing technicians. Luckily today’s splicers are a lot easier to use and give much more repeatable and consistent results.

With proper training the technician can quickly become very proficient if they follow a few basic rules and understand some basic concepts.

**The Basics**

Over 90% of all fusion splicing issues can be attributed to not performing an ARC calibration or not properly cleaning the splicer.

The ARC calibration fine tunes the power delivered to the electrodes. Even though manufacturers state that the splicer has automatic ARC calibration, this process must be done to insure that the optimum fusing arc is applied to the fibers. This process should be done at the beginning of a splicing session, or if the splicing results have become irregular, or if the ambient conditions have changed. The ambient conditions include the elevation, humidity and temperature. Modern splicers have barometric pressure and temperature sensors built in for “automatic” compensation but the ARC calibration still needs to be performed for optimum results. Remember the barometric pressure can be very different from the basement to the top floor of a skyscraper!


The shape of the fiber ends is analyzed to determine if the optimum power is applied. The process is iterative and requires that the technician repeats the step until the splicer reports back that the ARC power was successfully adjusted.

Cleaning the splicer must be done to make sure that the splicer operates correctly. Dirt and other debris will interfere with the cameras and the optical feedback mechanism to accurately align the fibers. Not cleaning the mirrors, lenses and mechanical fittings will soon cause the fusion splicer to throw error codes. There is no substitute for cleaning and protecting your investment.

Some fusion splicer manufacturers show videos of splicing in the rain or in a sandstorm. Yes it will splice one time but it will also be the last splice when the windshield is opened and these contaminates make contact with the optical components. The splicer will most certainly have to be sent to a repair lab for refurbishing. Remember the fusion splicer is an instrument that needs to be protected from the elements due to the fragility of the fiber this instrument splices.

**Cleaving**

The most time consuming and critical step in fusion splicing is the actual fiber preparation. This makes the splicing time specification almost irrelevant since most manufacturers are in the seven to 11 second area and the fiber preparation time is significantly longer. The fiber needs to be stripped of the buffer and acrylic coating. If the technician is not careful they might scratch or score the fiber which could cause the fiber to fracture during the splicing process or at some time after installation. The fiber needs to be cleaned of contaminates with 99% pure isopropyl before cleaving so that the fiber is held securely. If the fiber moves during the cleaving process the resulting cleave might have a substantial angle thereby causing a poor splice to be formed.

**Core vs Cladding**

There are two types of fusion splicers; core alignment and cladding alignment. Core alignment fusion splicer's have lower splice losses than cladding alignment splicers because of the active alignment of the two fiber cores.

The typical splice loss for standard singlemode fiber using the 910FS Core Alignment splicer is 0.02dB whereas for a cladding alignment splicer it is 0.05dB. This is not a big difference but this specification for cladding alignment splicer's is met under ideal and 'new, out of the box' conditions.

Core Alignment fusion splicers employ a Core Detection System (CDS) which is also known as a Profile Alignment System (PAS). Essentially, light is shone into the fiber and embedded cameras are used to identify the core of the fiber by detecting the difference in the refraction of light caused at the core/cladding interface.

Core alignment splicers use six motors and two cameras to align the fibers in the X, Y and Z dimensions and are able to compensate for any misalignment of the fiber cores when held in the V-Grooves. The V-Grooves are actually moved so that the centers of the cores of the both fibers are precisely aligned. This is done in a dynamic feedback loop (PAS) methodology that automatically senses the active area of the fiber core and adjusts the alignment of the two cores to minimize splice loss.

Any misalignment of the fibers within the two V-Grooves due to fiber tolerances, contamination or damage to the V-Grooves is automatically compensated for resulting in repeatable, low loss splices.

That said, we must remind the splicing technician to be diligent with the care and maintenance of the splicer but the active alignment system allows the technician to use the splicer in real life situations while obtaining low loss splices quickly and reliably.

**Cladding Alignment (V-Groove) Technology**

While this technology is lower cost there are many compromises that reduce its effectiveness in the "real world". A cladding alignment splicer generally uses one camera and two motors and relies on the two V-Grooves to be perfectly aligned and the concentricity of the outside of the fiber cladding to align themselves in the X and Y axes before the motors bring the fibers together along the Z axis for splicing.

**Causes of Fiber Misalignment in V-Groove Splicers**

- The cores are not in the dead centre (Co-axial) of the cladding.
- Cladding diameter mismatch, especially from different fiber manufacturers and older fibers.
- Dirt in the V-Groove will misalign the fibers.
- Misalignment or damage of the V-Grooves themselves.

**Concentricity**

Single Mode Fiber (SMF) has a core diameter of between 8 and 10 microns but if the core is not in the geometric centre of the fiber cladding, a mechanical alignment of the cladding (in V-Grooves) can't optimally align the cores in the X and Y dimensions. This results in higher splice losses. This problem is further compounded when fibers from different manufacturers are spliced since the cores may be in slightly different positions.

## Cladding Diameter Tolerance

If the user is splicing fibers from two different manufacturers, the actual diameter of the fiber claddings may also be slightly different. The smaller diameter fiber will sit slightly lower in the V-Groove than the other resulting in further misalignment and therefore higher splice losses.

**Dimensional Specifications**

**Glass Geometry**

| | |
|---|---|
| Fiber Curl | ≥ 4.0 m radius of curvature |
| Cladding Diameter | 125.0 ± 0.7 μm |
| Core-Clad Concentricity | ≤ 0.5 μm |
| Cladding Non-Circularity | ≤ 0.7% |

**Coating Geometry**

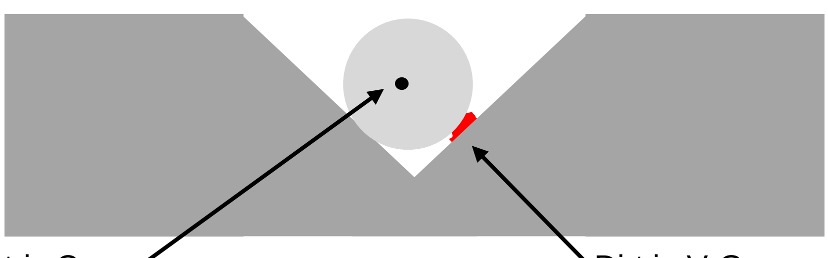
| | |
|---|---|
| Coating Diameter | 242 ± 5 μm |
| Coating-Cladding Concentricity | <12 μm |

Courtesy: Corning Inc

## Dirt and Contamination

Further compounding these problems is the fact that if the V-Groove is dirty or the cladding of the fiber isn’t fully cleaned then the fiber will not rest in the proper alignment position. If the fiber or the splicer is contaminated with dust or dirt, the resulting splice will be subject to higher losses or even failure for the splicer to complete the splice.

It is impossible to eliminate all dirt and dust where splicing is performed but the technician has a responsibility to clean and care for the splicer as recommended by the manufacturer. Doing so will yield lower splice losses and increase the lifetime of the splicer.




## V-Groove Misalignment

Should the V-Grooves become damaged (chipped or scored) over the course of time due to use, improper cleaning or neglect, the relative alignment of the V-Grooves may become compromised and higher splice losses will occur.

## Fusion Splicing Losses

The splice loss displayed on the 910FS screen after splicing is only an approximation and should be validated with an optical time domain reflectometer (OTDR) or optical loss test set (OLTS). The determining factors for the displayed loss are cleave quality, cleave axis and an analysis of the shape of the finished splice. Fusion splicer's quote the typical loss of a singlemode splice to be 0.02dB. This is always a cut and then re-splice of the same fiber. In the real world the technician will have to splice different types of singlemode fibers together.

Sometimes the fibers are old and have different geometries when compared to newer fibers. Different manufacturer's fibers can also have different geometries. Usually a core alignment splicer can accommodate these differences for single mode fibers but multimode fibers may require some of the splicer settings to be fine tuned from the standard splicing profiles.

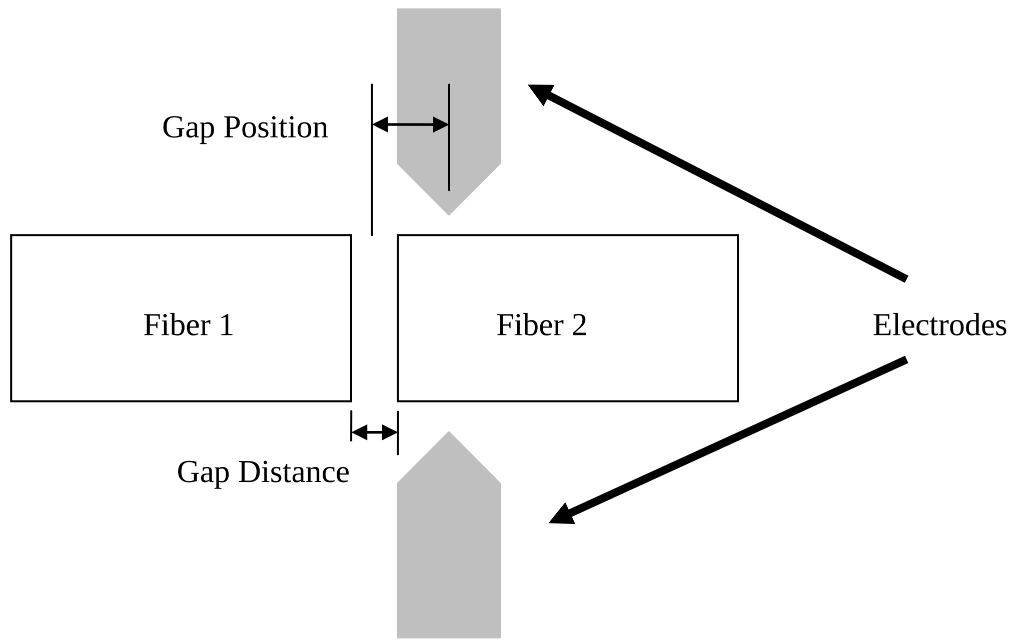
Older fibers have poor concentricity, varying core diameters and are made of different formulations of glass with different dopants. Graded index multimode fibers are prone to differences in geometries and are especially problematic. The typical multimode splicing problems are due to core diameter, numerical aperture and index of refraction mismatches. Fiber concentricity variations between the core and the cladding will compound splicing difficulty.

If the technician has trouble splicing due to fiber mismatch and concentricity issues, the manual modes of splicing must be used. The manual modes allow the technician to change the arc power, arc duration and splice position with respect to the electrodes.

## Adjust Gap Setting and Position

If one fiber is harder to melt than the other fiber the gap position can be changed so that more energy is applied to the harder to melt fiber and less energy to the softer fiber. The gap setting can also be increased or decreased so that the splice can be made faster by adjusting the arc power and or arc duration

*Fiber #1 melts easier so more energy is applied to Fiber #2.*

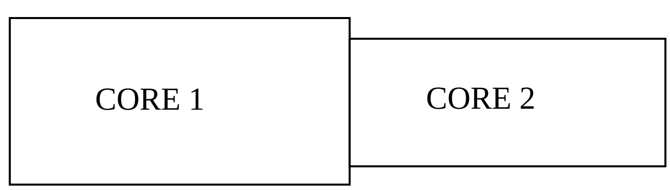



Arc power and duration allow the technician to apply varying amounts of power to the splice point. This may be necessary if the fibers are harder to melt and require more heat to melt the fibers. The arc power and duration can also be reduced to better control fiber melting.

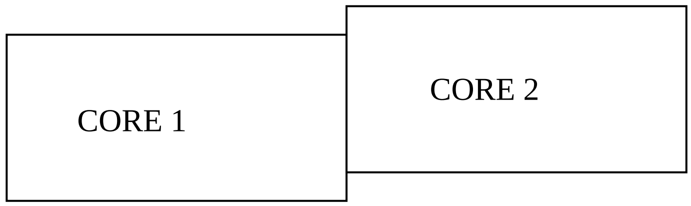
This is very much a trial and error process and requires careful experimentation by the technician. Consulting data sheets of the two fibers will simplify the process.

**Core Mismatch Losses**

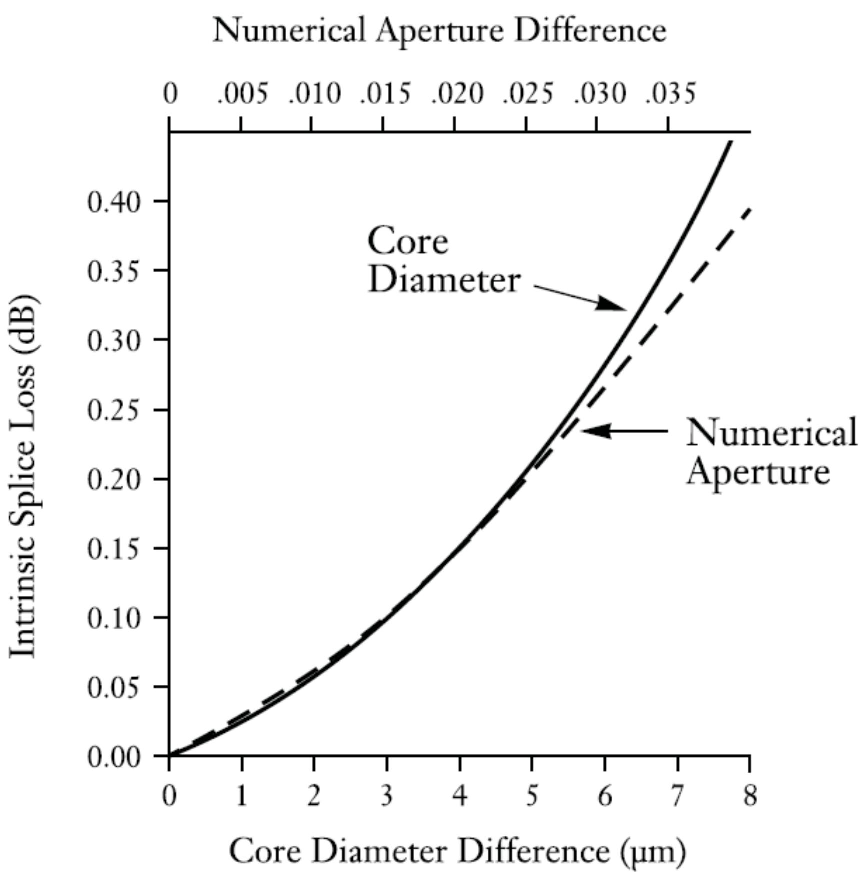
Splice loss will be higher for signals travelling left to right.
Return loss will be high especially for signals travelling left to right.



**Concentricity Losses**
Especially problematic for cladding splicers.




**Dissimilar Fibers – Numerical Aperture Differences**
When the technician is splicing two different fibers, chances are that the numerical aperture is also different. This can cause a higher insertion loss as characterized below.




*A core diameter mismatch of 5 microns can cause a 0.2dB loss.*

**Summary**

Fusion splicing has evolved and has been refined over the years so that it is commonly used in terminating fiber optic cables in many applications. The splicers available today are more robust and easier to use and will provide many years of service if they are properly cared for. Proper cleaning of the splicer will allow the technician to perform up to 150 splices a day for restoration projects or for terminating new FTTH customers on an as needed basis. The ARC calibration is needed to make sure that the splicer electrode power is set to the optimum value; this will allow the technician to make the lowest loss splice. Utilizing fiber tools that work cohesively together is also integral to successful fiber splicing.