Society of Cable Telecommunications Engineers

**ENGINEERING COMMITTEE**
**Interface Practices Subcommittee**

## AMERICAN NATIONAL STANDARD

# ANSI/SCTE 134 2012

# Fusion Splicing Equipment and Applications for the Cable/Broadband Industry

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## 1.0 PURPOSE, SCOPE AND DEFINITIONS

### 1.1 Purpose and Scope

This standard defines the equipment, methods, and practices used within the cable/broadband industry to obtain consistent low loss fusion splice connections between optical fibers.

### 1.2 Definitions and Acronyms

LID: Local Injection and Detection

L-PAS: Lens – Profile Alignment System

MFD: Mode Field Diameter

PAS: Profile Alignment System

## 2.0 FUSION SPLICING BASICS

Fusion splicing consists of aligning and permanently fusing together stripped, cleaned and cleaved optical fibers with a high temperature arc. It provides a fast, reliable, low-loss, connection by creating a transparent joint between two fiber ends. Fusion splices provide a high-quality joint with the lowest loss (in the range of 0.01 dB to 0.10 dB for single-mode fibers) and are practically non-reflective.

## 3.0 EQUIPMENT

### 3.1 Fusion Splicers

Fusion splicers are typically used in the field or within a Lab/OEM environment. While many splicers may be used in either environment, some splciers are designed for specific performance environments.

### 3.2 Alignment Methods

Two fiber alignment techniques are:

- Passive alignment (Single-axis)
- Active alignment (Multi-axis)

### 3.2.1 Passive

Passive alignment systems do not move the fibers in the x or y axes, the fibers are moved in the z axis only (single-axis).

This technique is used in fixed v-groove machines. Fiber alignment is dependent on how the fibers are positioned relative to each other in the precision cut grooves in the x and y axes. In order to achieve a good quality splice, the two fiber ends must be aligned correctly.

The cleanliness and good condition of the v-grooves are important to insure that the fibers are positioned in the v-groove to allow the proper alignment necessary for a good quality splice.

### 3.2.2 Active

Active alignment systems detect and compensate for any fiber misalignment, moving the fibers in the x, y and z axes (multi-axis).

Active alignment methods fall within one of the following categories:

- LID™ system (Local Injection and Detection)
- CDS (Core Detection System)
- L-PAS™ (Lens – Profile Alignment System)
- PAS (Profile Alignment System)

#### 3.2.2.1 Local Injection and Detection (LID)

The LID system aligns and monitors the fusion splice with an optical transmitter and receiver. This allows for the cores to be optimally aligned. A source (transmitter) injects a light signal into the fiber through a bending coupler and a power meter (receiver) measures the received light signal through another coupler. When the transmitted signal is at its maximum level, both fiber cores are perfectly aligned. The transmitted signal from the LID source is present throughout the process, allowing effective control of the splice process. The LID™ system provides a splice loss measurement after the splice is complete by comparing the post-splice light level to the pre-splice level.

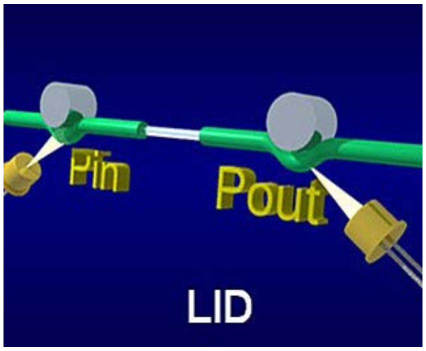


**Figure 2**

3.2.2.2 CDS

Another active alignment method, the Core Detection System (CDS) uses the luminescence properties of optical glass. The core and the cladding of optical fiber have different optical properties. Due to the different doping of the fiber core, it glows brighter than the cladding when an arc is applied to the fiber. To detect the core, a short arc is fired that allows the core-cladding-contrast to be detected.

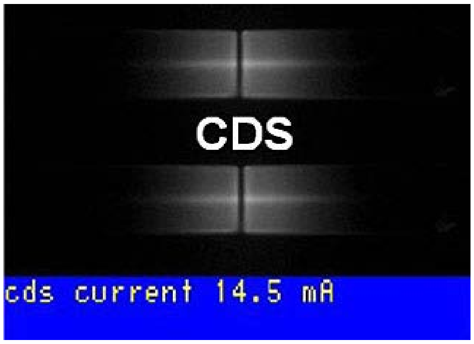


**Figure 3**

3.2.2.3 Lens – Profile Alignment System (L-PAS)

With an L-PAS alignment method, an optical system consisting of cameras, lenses, prisms and LEDs are used to make the fiber visible. The fiber image is generated by a backlit arrangement, using LEDs that shine through prisms which then project the shadow of the fiber through lenses, onto a camera. The fiber alignment is analyzed by comparing the positions of the two fibers.

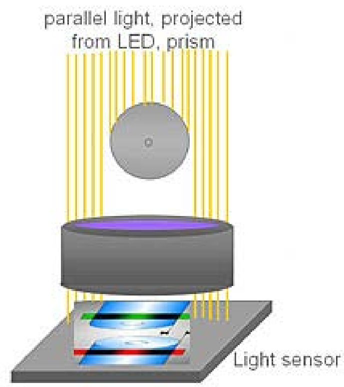


**Figure 4**

3.2.2.4 Profile Alignment System (PAS)

The Profile Alignment System works on the same principle as the L-PAS system with the exception that in addition to “seeing” and image of the cladding, focus lenses also allow an image of the core to be detected as well.

3.2.3 Considerations

When choosing the right fusion splicer a particular application it is important to take into consideration some of the following aspects:

- Loss requirements – Determine the loss requirement of the application. Active core alignment splicers provide more precise and lower loss results than passive alignment systems.
- Value – In general active alignment units are more expensive, however they provide lower splice loss and can be used wherever a passive alignment unit can. It is important to determine what application will be most often used and match those needs to the right fusion splicer.
- Features and ease of use are important when choosing the splicer; this increases productivity and allows various skill levels of personnel to use the machine.

## 3.3 Coating Strippers

In order to perform a fusion splice the optical fiber must be stripped down to the bare glass. The coating can be removed by a number of techniques:

- Mechanical stripping tool
- Thermal stripper
- Chemical stripping

The mechanical stripping tool is commonly used with single fiber splicing because it is fast, effective and inexpensive. The thermal stripper is normally used with multi-fiber splicing since up to twelve fibers are being stripped simultaneously.

Regardless of the method used to strip the coating, it is important to use the correct size tools and techniques to prevent damage to the bare glass. Ensuring the fiber is not damaged is critical to creating a low loss, strong splice.

## 3.4 Cleavers

### 3.4.1 Theory of Operation

To achieve good splice results, it is extremely important for the fiber ends to be properly cleaved. Consistent, good quality end faces can be only achieved if the cleaver is well maintained. Cleave angle deviations or chips and knicks in the end-face, can only be compensated for by using unusually high fiber feed during the fusion process. This can create a splice with an outer cladding that may look good but the actual loss could in fact be high due to core bending. For best results, the smaller the core, (for instance single-mode fiber), the lower the tolerance of cleave angle deviation.

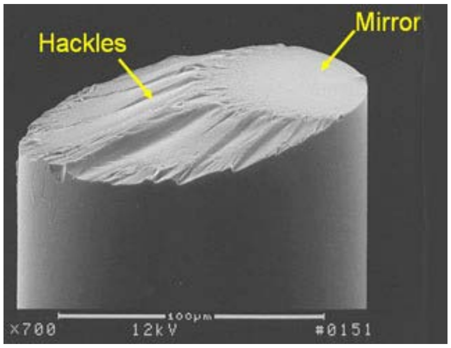

**Figure 5**

Various cleavers are available that operate in different ways but the general principles for cleaving the fiber are:

1. Score - A score is introduced into the glass
2. Bend - The glass is bent to propagate the score
3. Tension - Tension is applied to separate glass

3.4.2 Types of Cleavers

Single fiber cleavers

**Figure 6**

Single fiber cleaver are designed for cleaving one fiber at a time and providing a high quality end face angle that will lead to low loss splices.

Multi fiber cleavers

**Figure 7**

Most multi-fiber cleavers can cleave multiple or single fibers. In many instances a different handler or adapter may be necessary to accommodate single fiber cleaving.

3.4.3 Considerations

As with fusion splicers it is important to consider several aspects when choosing a cleaver for a particular application.

- Performance – A good cleave is essential to obtain good low loss splices.
- Usability – Ease of use is important for users and in obtaining consistent high quality results.
- Quality of cleave – In order to obtain quality cleaves from a cleaver it is important that the cleaver is:

  - Clean – fiber and cleaver

  - The blade is kept and maintained in good condition

  - Proper operating technique is followed

### 3.5 Splice protection

After the fibers have been successfully spliced together it is important to protect the joint. There are various options for splice protection. One of the most common techniques is a heat shrink sleeve. This sleeve is placed over the fiber prior to splicing and pushed down the fiber during preparation and fusing. After the splice is complete the heat shrink is placed over the splice point. It is then placed in a heat shrink oven, where the material is heated and shrunk down over the fiber, providing protection to the joint.

Clamshell type protectors are also available. These protectors commonly have a hinged joint that allows it to be placed on the splice point after completion of the splice. Most version use adhesive in a groove to hold the fiber while the other half of the “clamshell” is closed on the fiber holding and protecting the joint.

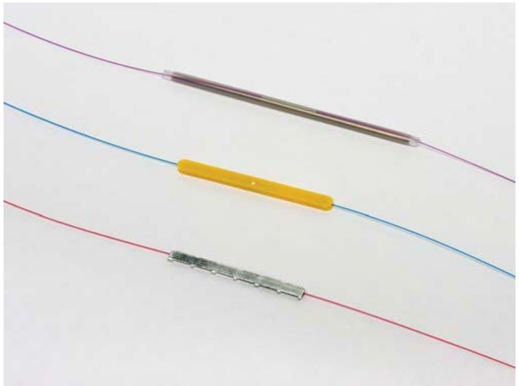

**Figure 8**

## 4.0 METHODS AND PRATICES

### 4.1 Generic Procedures – Single fiber splicing

The preparation process before inserting the fiber into the splicer is very important. Optical fibers must have the coating removed down to the bare glass. The fibers must be cleaned properly and must have a good quality cleave. It is important to be aware of and use the correct cleave length for the particular fusion splicer that is being used. This length varies with splicer manufactures, so it is recommended to consult the operating manual for the specific unit before beginning the splice process. The three main steps to preparing the fiber are:

**Step 1 - Strip**

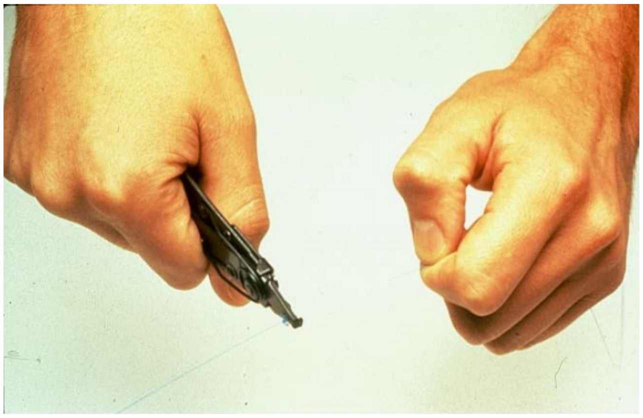

**Figure 9**

All coatings (900 µm and 250 µm) should be removed and bare glass exposed.

**Step 2 - Clean**

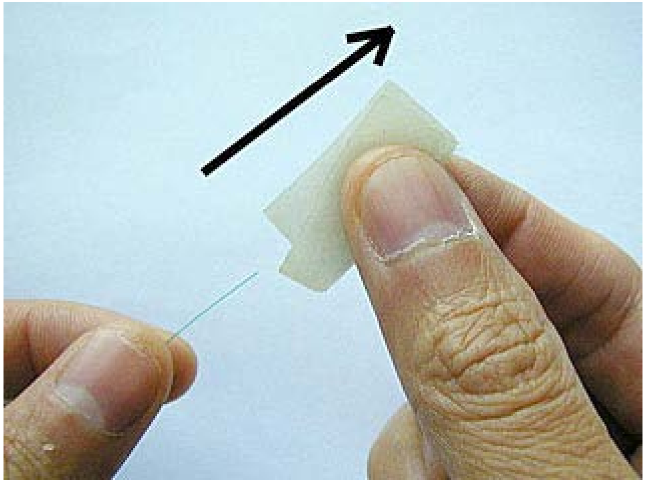

**Figure 10**

The bare glass should be cleaned to remove all contaminants. The most common cleaning method is to use a clean lint free wipe saturated with 99% isopropyl alcohol. This wipe is pulled over the bare glass removing any acrylate coating and other contaminant that may be on the bare glass. It is important to insure that the glass is not touched with the bare fingers or contaminated with anything after the cleaning step, as this can adversely affect the cleaving, alignment and fusion process.

**Step 3 - Cleave**

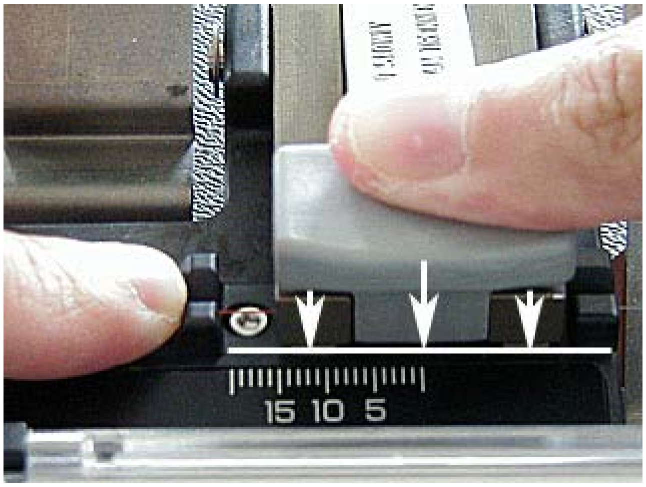


**Figure 11**

Cleaving of optical fibers involves several processes. The fiber is inserted into the cleaver after being cleaned with isopropyl alcohol. The cleave process is achieved through a combined movement of scoring and breaking. Both fiber ends can then be inserted into the splicer and are ready to be spliced together. The fiber's end face quality affects the final splice result. The better and cleaner the fiber end faces are, the lower is the splice loss that can be achieved

Basic Steps in Fusion Splicing Process

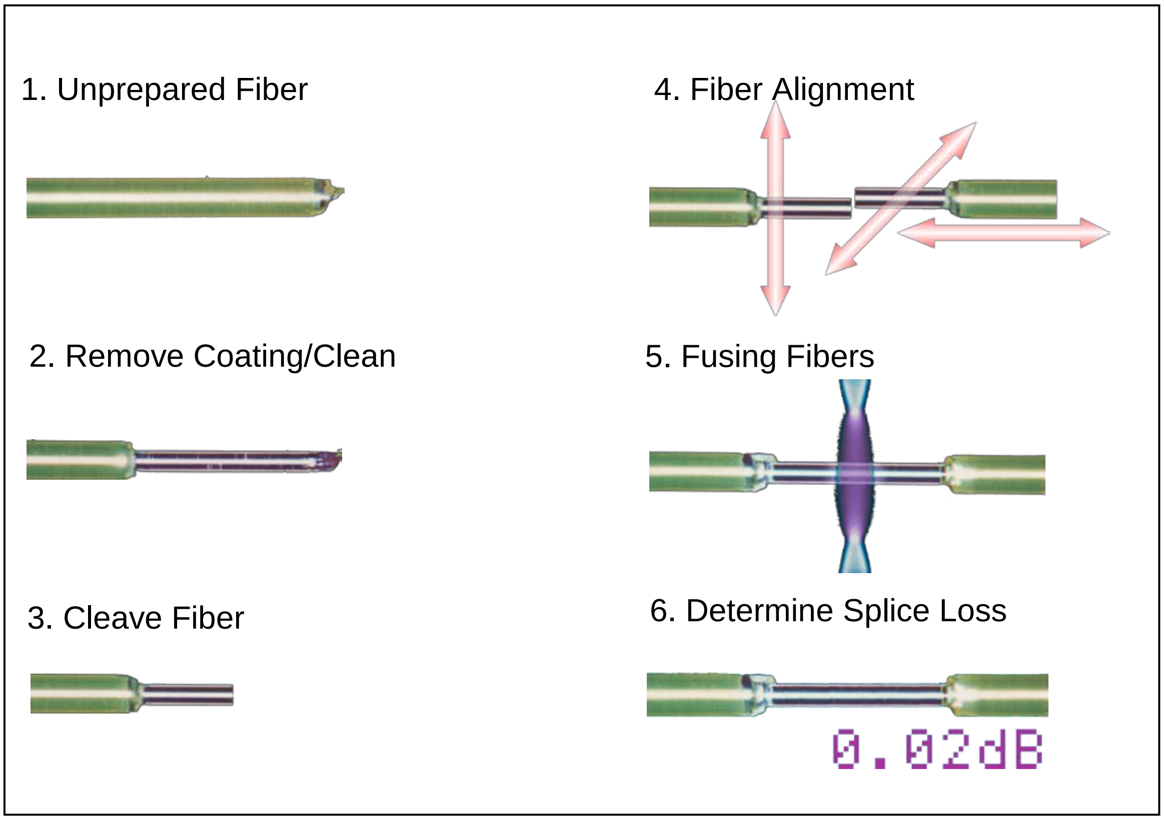


**Figure 12**

4.1.1 Factors that affect splice loss

4.1.1.1 Cleanliness: It is very important that the fibers and equipment are clean. Dirt and contaminants can cause (1) misalignment issues, (2) increased loss and (3) degradation of equipment.

4.1.1.2 Fiber Geometry: The position of the core relative to the center of the fiber will affect splice loss. If fibers with eccentricity offsets are being spliced, active core alignment units will provide the best splice loss results.

4.1.1.3 Equipment: It is important to use the correct equipment for the specific application and insure it is used and maintained correctly. Proper maintenance of mechanical and optical systems on fusion splicing equipment is necessary to insure it functions correctly and provides future use.

4.1.1.4 Training/skill level – Fusion splicing requires proper training and personnel development in order to obtain consistent good quality low loss splices.

4.1.2 Multiple Fiber (Mass splicing)

Multiple fibers may be spliced together simultaneously. This is commonly referred to as mass splicing. Mass fusion splicing is the same in principle to single fiber splicing. There are some differences in the process.

Mass fusion splicers use the passive alignment system with a fixed v-groove. The fibers can be in ribbon form or may be ribbonized by the craftsperson from 250 μm fibers. The ribbon fibers are stripped with a thermal stripper, cleaned and then the fibers are cleaved simultaneously to insure the fibers are the same length.

The fibers are inserted into the fusion splicer and the process is essentially the same as with single fiber splicing. The splice point can be protected with heat shrink sleeves.

## 5.0 LOSS VALUE

5.1 The most common standard used for splice loss values is 0.30 dB.

## 6.0 TESTING

6.1 Importance of Testing

It is important to test optical fiber systems in order to:

- Verify the system works correctly
- Insure splices are acceptable
- Identifies problems
- Provides baseline for maintenance and troubleshooting

## 6.2 Testing Methods

An optical fiber system can be tested using:

- Power meter/source
- Optical Time Domain Reflectometer (OTDR)

The meter/source method tests the entire system. It determines end to end loss including any components and fiber in the system. This is a good way to get actual values for the entire system; however it does not allow individuals splices or components to be singled out.

The OTDR operates on a principle known as Rayleigh backscatter. Light is input into one end of the system. A certain amount of light is reflected back from events. Events can be fusion splices, connectors, mechanical splices etc. The OTDR interprets these events and determines where they are located along the fiber and the attenuation value.

This can be used to verify specific splice loss values and where they are located in the system. This information can be saved for documentation proposes and validation of the system.