PANDUIT®

Technology Brief

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Panduit Fiber Splice-On Connectors

Understanding the application, termination, and best practices related to fusion splicing single-fiber discrete connectors

Introduction

Single-fiber splice-on connectors are an increasingly common technology used in today's fiber installations. These fusion-spliced connectors allow for rapid deployment of custom fiber links using high-performance field terminated connectors. Field termination allows for advantages over pre-terminated assemblies, such as eliminating the extensive planning and pre-work needed for fixed-length pre-terminated assemblies and eliminating the risk of cable excess or shortages.

This document will review the following:

- Differences between fiber splice-on connectors versus pigtail assemblies
- Differences between fiber splice-on connectors and other field terminable fiber connectors
- Important standards and industry best practices for terminating and testing splice-on connectors
- Recommendations for best results in these processes.

This document only covers single-fiber connectors. Multi-fiber connectors, such as MTP/MPO connectors, are not covered.

As the cost of fusion splice machines continues to decrease, the number of available manufacturers and versions of these machines continues to increase. These splice machines can vary from simple passive alignment machines to complex active alignment machines, with a wide array of settings and options in between. The settings and best practices discussed here may not be available on every machine but are important to consider when they are available.

What is a Splice-On Connector?

Pigtails versus Splice-On Connectors

When looking at a fusion splice solution there are essentially two main options: splicing a pigtail assembly on to the fiber cable or splicing a discrete connector on to the fiber cable.

- A fiber pigtail assembly refers to a factory-polished and terminated connector on a length of tight-buffered cable, commonly 1-meter (~3-feet) in length.
- A splice-on connector is a type of discrete fiber optic connector that uses a fusion splice to terminate directly onto a field fiber in a similar manner to splicing a fiber optic pigtail on to field fiber.

The main difference with a splice-on connector is that it has just a few millimeters of bare glass that is enclosed within the connector assembly, rather than a length of buffered fiber.

When terminating either a pigtail assembly or splice-on connector:

- A specified length of the buffer is stripped back
- The fiber is cleaned and cleaved to a specific length
- Then it is fusion spliced directly onto the cable using any number of available splice machines.

With a pigtail, the following additional steps must be taken:

- A splice protection sleeve is then heat-shrunk over the splice point to provide stability and protection to the bare fiber section.
- This splice protection sleeve is then inserted into a splice tray to secure it in place.
- These splice trays are housed inside a fiber enclosure, and then stacked atop each other for higher fiber counts.

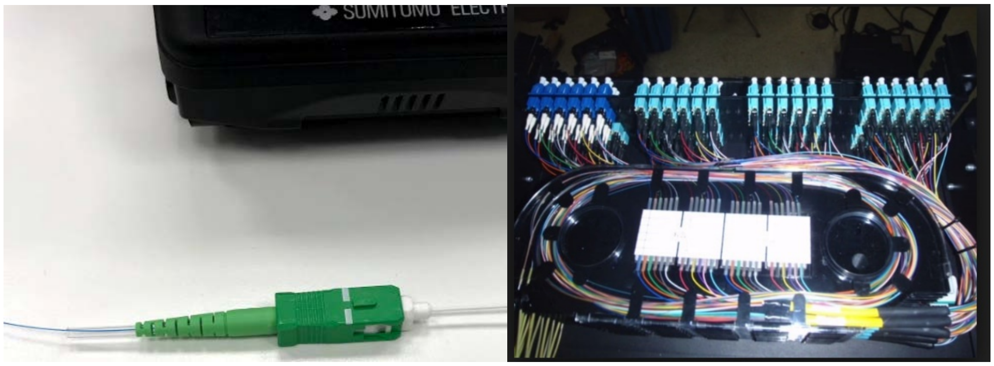

Figure 1: A splice-on connector on 250um cable (left) and a fiber splicing solution (right).

When terminating a splice-on connector, the connectors have integral splice management. This means they have a splice protection sleeve as part of the connector assembly, rather than requiring a tray to manage the splices and their splice sleeves such as is required when splicing fiber optic pigtails.

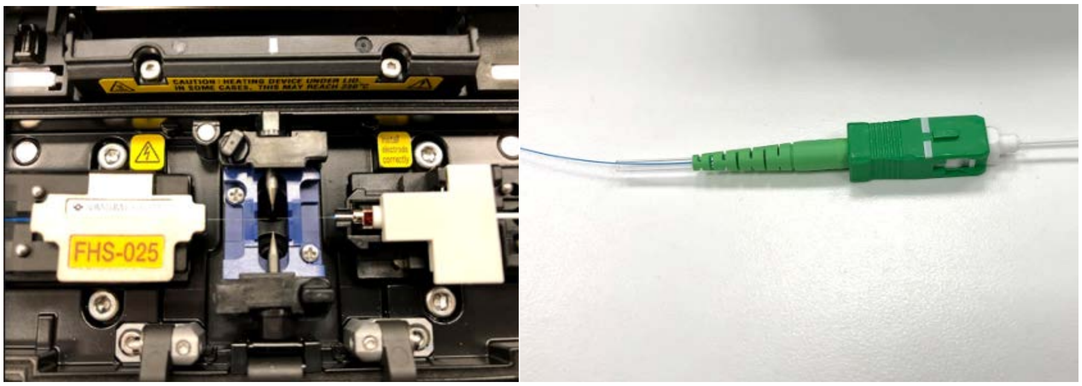

Figure 2: Field fiber being spliced to the connector ferrule (left) and the assembled connector (right).

“Cam” Style versus Splice-On Connectors

Splice-on connectors differ from more traditional mechanical splice connectors, often called “cam” style connectors, due to the nature of how they terminate on to the field fiber. Panduit OptiCam® products are an example of a mechanical splice connector. These mechanical splice connectors use mechanical means to hold the fiber inside the connector to facilitate the splice using index matching gel.

In a mechanical splice connector:

- The cleaved field fiber is pushed up against a pre-polished stub of fiber inside the connector
- An index-matching gel enables the transmission of light between the field fiber and the stub fiber

This type of joining contributes to insertion loss (IL) and optical return loss (RL) for mechanical splice connectors. Splice-on connectors, which are instead fused directly to the cable, make a more seamless splice and thus have improved IL and RL characteristics which may be needed in certain circumstances.

Panduit recommends using our mechanical OptiCam® connectors for most applications due to the:

- Quick and easy termination with performance approaching a splice-on connection
- Lower cost of tools needed for termination
- Ability to get an accurate calculated connector insertion loss with our OptiCam® 2 tool
- Ability to quickly re-terminate and fix a bad termination using the same OptiCam® connector
- Sufficient IL and RL for most applications

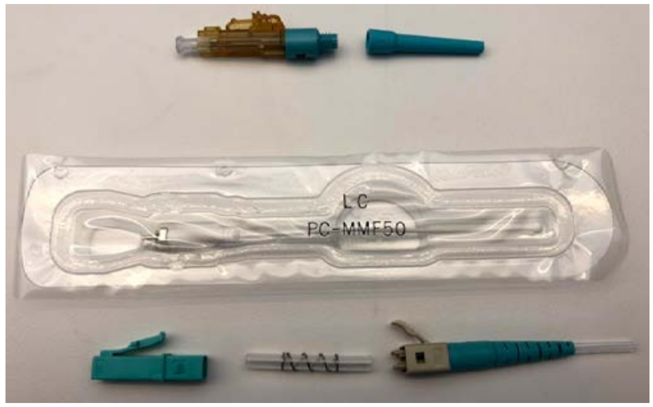

Figure 3: A mechanical splice OptiCam® connector (top) and the components of a splice-on connector (bottom).

Field Polish versus Splice-on Connectors

Splice-on connectors differ from field polish connectors in several ways. With a field polish connector:

- The technician pushes a length of fiber through the entire connector
- Cleaves off the end of the field fiber that protrudes beyond the ferrule tip
- Then manually polishes the endface until it is ready to be tested and installed

Since field polish connectors use a contiguous piece of the field fiber, they often have excellent performance in terms of IL and RL.

However, field polish connectors present several issues versus a mechanical or fusion splice-on:

- Field polish takes a significant amount of time for one connector through longer steps such as curing epoxy and endface polishing.
- There is a measure of skill required in the termination process to ensure proper performance of the connector through the testing and installation.

Mechanical and fusion splice-on connectors, on the other hand, can be done in just a few minutes and much of the process is validated by the termination tool or high-end splice machines.

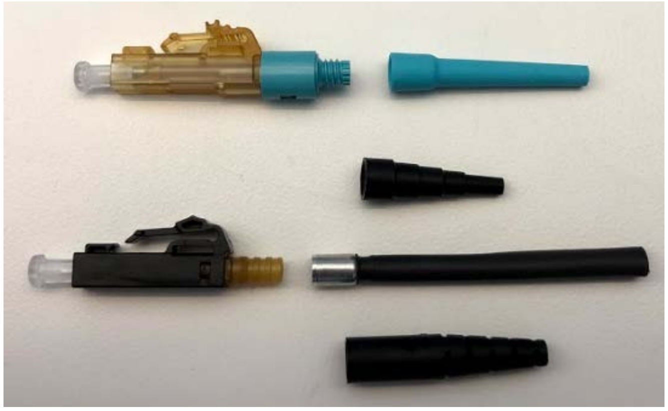

Figure 4: A mechanical splice OptiCam® connector (top) and the components of a field-polish connector (bottom).

Terminating Splice-On Connectors

When terminating fusion splice-on connectors, these are the most important considerations:

- Ensure the splice unit is on the correct settings
- Ensure the that the correct splice-on connectors are being used
- Understand the information provided by the splice machine
- Understand how splice-on connectors affect the loss budget

Setting the Correct Splice Machine Settings

The two primary settings to focus on for a splice machine are:

- Types of glass to be spliced
- Heat settings.

Depending on the type of splice machine being used, the complexity of these settings varies greatly but understanding the fundamentals is universal.

For example, if G.652.D singlemode glass is being spliced to G.657.A2 singlemode glass, the splice machine must be programmed to expect these two different types of glass. The different grades of glass have a different “profile” such as different numerical apertures, mode field diameters, core concentricities, et cetera.

Different grades of glass and even same grades of glass from different suppliers may appear different on the splice machine screen. Examples of differences can be one core appearing to be thicker than the other, or one fiber segment having a more well-defined transition between the core and cladding of the fiber. It is important to note that even though these fibers may appear different, they are still standards compliant. As an example, splicing a G.657.A2/B2 glass from one vendor to a G.657.A2/B2 glass from another vendor may look like the core sizes are different but they both have the same core diameter, the same cladding diameter, and so on. What is causing them to appear different is changes in how the glass was formulated.

Figure 5: G.652 singlemode fiber spliced to G.657.A2/B2 glass. Note the apparent difference in cores and defined splice event.

The other setting that is important to be aware of is the heat settings. This impacts the process in which the splice protection sleeve is heated up to enable the heat-shrink component to work properly and sufficiently protect the splice. If the heat is too high or too low, the sleeve will not shrink at the correct rate and can create failure modes such as blistering/bubbling of the sleeve or fiber jacket, excess shrinkage creating bends in the cable, or not fully adhering to the cable due to insufficient shrinkage. Blistering on the jacket and shrinkage causing bends in the fiber will have a direct impact on the performance of the cable, most likely resulting in higher attenuation.

Figure 6: Examples of incorrect heat settings - Overshrinking the shrink tube resulting in the strengthening rod protruding and potentially damaging other components (left); Blistering and charring of the buffer (right).

Choosing the Correct Splice-On Connector

Another important consideration is to make sure the connector matches the cable glass type and construction. This is a common mistake that people can make.

The first step is to ensure the connectors are designed for the glass being used in the cable. This means that one should use singlemode connectors for singlemode glass, and multimode connectors for multimode glass. Note that Panduit does not offer a 62.5um OM1 splice-on connector..

Next, ensure the connectors are designed for the construction of the cable they are being spliced to. As an example, note that Panduit's splice-on connectors are intended for cable with either a 250um coating (loose tube) or 900um (tight-buffer).

Do not use a 250um / 900um connector on a 2.0mm or 3.0mm jacketed cable.

Understanding the Information Provided by the Splice Machine

Most fusion splice machines will provide a loss value of the splice after the splicing is complete. The following should be noted about these values provided:

- Before performing the splice, some machines will display a value which is called the core offset. This number describes how far off-center the two cores are. Active alignment machines will easily resolve this misalignment during the splice, while v-groove machines may take some adjusting before the offset is within acceptable parameters.
- The machine is providing an estimation of the splice value based on its interpretation of the image of the splice on the screen. While these are accurate, they are a calculation based on the image, not actual performance.
- The insertion loss value shown is for the splice itself, not the connector.
- The connector will add additional losses.

Therefore, while the splice machine can provide information that is useful in indicating whether a splice was good or bad, it should not be taken as the actual value of the splice-on connector or used when considering the loss budget. The best way to determine the actual loss of the connector is through Tier 1 or Tier 2 link testing. Note that the splice estimation provided on the screen is part of the connector's overall loss and will not display separately.

Figure 7: The splice machine estimates the loss of this particular splice to be 0.01dB IL, which is included in the overall loss of the connector.

How Splice-On Connectors Affect the Loss Budget

Typical insertion loss for a fusion splice is less than 0.03dB IL, and the splice machine will provide values as low as 0.00dB with good splice practices. It is important to remember that this is the insertion loss of the splice itself, not the connector. The overall loss budget of the channel should plan on the loss of the connector, not just the splice. The total insertion loss of the connectors (including the splice) can be found on the Specification Sheet and Product Bulletin of the Splice-On Connector product offering. Typical losses for Panduit splice-on connectors are as follows:

- Singlemode splice-on connectors have an average insertion loss of 0.15db (including the splice) and a maximum insertion loss of 0.30dB (including the splice).
- Multimode splice-on connectors have an average insertion loss of 0.10dB (including the splice) and a maximum insertion loss of 0.25dB.

Unlike field terminated connectors, which rely on user skill for the insertion loss performance, splice-on connectors are factory-polished and are thus able to have a tighter range of insertion loss versus mechanical splice connectors.

Testing Splice-On Connectors

Testing links that include splice-on connectors is no different from links that include field polish or mechanical splice connectors. The maximum Insertion Loss allowed per the ANSI/TIA-568-D.3 is 0.75dB per connector pair. Panduit splice-on connectors have a maximum insertion loss value of between 0.25dB IL and 0.30dB IL as stated above.

Please review Panduit document PN445, the Best Practice for “Permanent Link Testing of Multimode and Singlemode Fiber Optic Cabling Systems” for a full breakdown of loss budgeting, testing, interpretation of results, and troubleshooting.

Panduit Recommendations

Panduit recommends using our OptiCam® mechanical splice connectors in most applications due to the simple termination method, lower cost tools, ability to easily re-terminate, and get accurate calculated insertion loss values with the OptiCam® 2 tool. These products provide a robust termination that can meet the application requirements in most scenarios.

In cases where the splice-on performance is needed, Panduit offers an industry leading splice-on connector. Panduit splice-on connectors are primarily intended to be used with Sumitomo splice machines. Within the range of splice machines, there are several different options available.

- For best results a core-aligning machine is recommended, as this type of machine will align the cores of the fibers to be spliced and are considered to have the highest degree of accuracy.
- A cladding-alignment machine is also acceptable. This type of machine, also an active alignment type of splice machine, aligns the 125um cladding of the fibers instead of the cores.
- The other type of splice machine available is called a v-groove style splice machine, which does not actively align the fiber. The fibers must be aligned manually which may increase the number of potential splicing failures.

Panduit further recommends using a precision style cleaver such as the Sumitomo FC-8R cleaver, into which the supplied holder is meant to fit. A good, even, 10mm cleave is essential to the performance of the splice.

Figure 8: The stripped and cleaned field fiber in the 900um holder, set into the cleaver.

It is also very important to read the instructions on the splice machine prior to performing splices, and following the steps as presented. Some important steps to remember are to perform the arc test before doing terminations, and not rolling or stressing the splice before the protection sleeve is applied.

Figure 9: Arc Test before (left) and after (right)

As previously mentioned, following Panduit's best practices regarding cleaning and testing fiber links is necessary for successful fiber terminations. The best practice is to:

- Inspect the endfaces of the components, ensuring that any lasers are turned completely off, to detect any debris or damage.
- If there is debris detected, a dry lint-free wipe should be used to clean the endfaces before inspecting again and repeating the dry clean if necessary.
- Stubborn debris may require the use of a cleaning solution applied to the wipes, and the endface should be inspected again to ensure cleanliness. Panduit recommends using dry, lint-free wipes with a measure of fiber optic cleaning solution added.
- Panduit "Permanent Link Testing of Multimode and Singlemode Fiber Optic Cabling Systems" is a best practice document that should be considered when installing and testing any fiber links.

Panduit now offers a full and complete range of industry leading fiber field termination products designed for almost any application.