

Pre-polished Connector Insertion Loss and Termination Yield

*Achieving High Termination Yields
And Low Insertion Loss Values*

White Paper – 1/2004



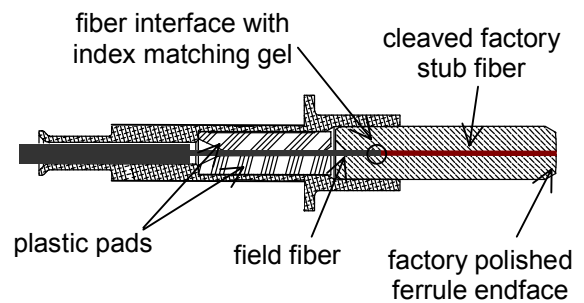
Executive Summary

Pre-polished connectors offer a quick and reliable alternative to field polish connectors for horizontal and backbone termination applications. With good installation practices and attention to detail, installers can expect high termination yields and insertion loss values similar to the more labor-intensive field polish connectors.

Introduction

Most pre-polished connectors incorporate a precision cleaved fiber stub installed into a ferrule with a factory polished endface (Figure 1). During installation, a cleaved field fiber is brought into contact with the cleaved stub endface and secured into place. Index matching gel is present at the fiber-to-fiber interface to eliminate air gaps and reduce insertion and return losses. Typically, the field fiber is held in place by compressing it between two plastic pads. Pre-polished connectors eliminate the need for adhesive and polishing in the field, which eases the termination and reduces installation time.

Figure 1: Typical Pre-polished Connector Design



Pre-polished vs. Field Polish Performance

For pre-polished connectors in general, one can expect higher connector insertion losses than field polish connectors due to the additional loss (~0.10dB) at the field fiber to stub fiber interface. However, improvements in fiber alignment and termination methods have brought pre-polished connector insertion losses closer to those of field polish connectors. Aside from the initial termination insertion loss, the performance of pre-polished connectors should be comparable to that of field polish connectors.

All connector products, including pre-polished connectors, are governed by TIA/EIA-568-B.3 specifications. 568-B.3 is an industry standard for optical fiber cabling which specifies certain environmental and mechanical tests and the associated minimum performance requirements for connectors in premise cabling environments. The environmental tests are intended to induce thermal stresses into the connector and expose any weaknesses that could cause product failure during normal operating environments over the connector life. Mechanical testing ensures that the connector can handle the mechanical stresses associated with typical patch cord installation and maintenance.

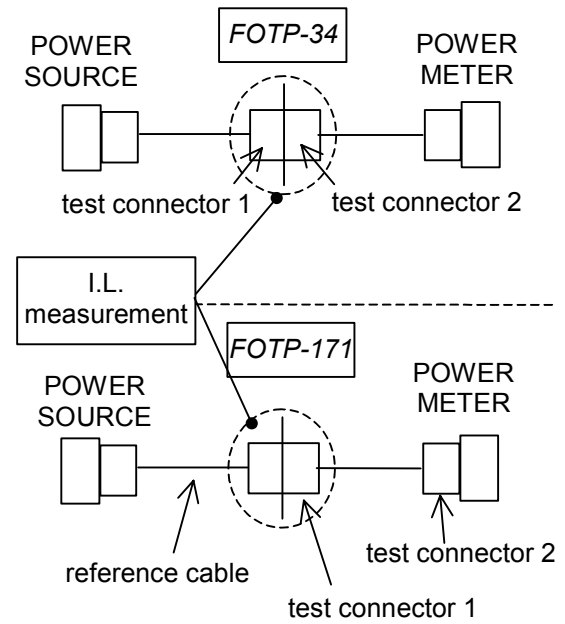
While all pre-polished connectors should, not all pre-polished connectors do meet the 568-B.3 requirements. Care should be taken when selecting a pre-polished connector to ensure that the product has met the industry standards.

Insertion Loss Testing

One parameter defined by TIA/EIA-568-B.3 specific to the field installation of connectors is the insertion loss. Insertion loss is a measure of the amount of optical power lost through a mated connector pair. The maximum allowable insertion loss is defined as 0.75dB per mated connector pair. A mated pair can be any combination of pre-polished and field polish connectors mated in an adapter. The connector insertion loss can be used with the cable length loss to determine the allowable loss budget for an installed link.

There are multiple methods for measuring the insertion loss of a connector. TIA/EIA 568-B.3 specifies using one of two methods for insertion loss testing: FOTP-34 (Fiber Optic Test Procedure) or FOTP-171. FOTP-34 measures the insertion loss of one test connector mated to another test connector while FOTP-171 measures the insertion loss of one test connector mated to a reference cable. Figure 2 illustrates the differences. FOTP-171 is typically used during the production of cable assemblies and patch cords and is similar to the testing that is done on installed cable links. FOTP-34, on the other hand, is more applicable to laboratory testing. However, with both methods, the maximum allowable insertion loss across the mated pair is 0.75dB.

Figure 2: Test Set-ups for Insertion Loss Testing



Termination Insertion Loss And Yield

Examples of pre-polished connector insertion loss performances of 50/125µm SC connectors are shown in Figure 3.

The two sample groups represented in the figure include *PANDUIT*® SC *OPTI-CRIMP*® Connectors and another leading manufacturer’s SC connectors (Manufacturer “A”). Manufacturer “A” samples were terminated per the manufacturer’s installation instructions; these instructions did not require the use of a visual fault locator (VFL) as is required by *PANDUIT*. However, to maintain an accurate comparison, the *PANDUIT* sample terminations did not use a VFL either. The data for the two groups is summarized in Table 1.

Figure 3: SC Pre-polished Connector IL – 850nm

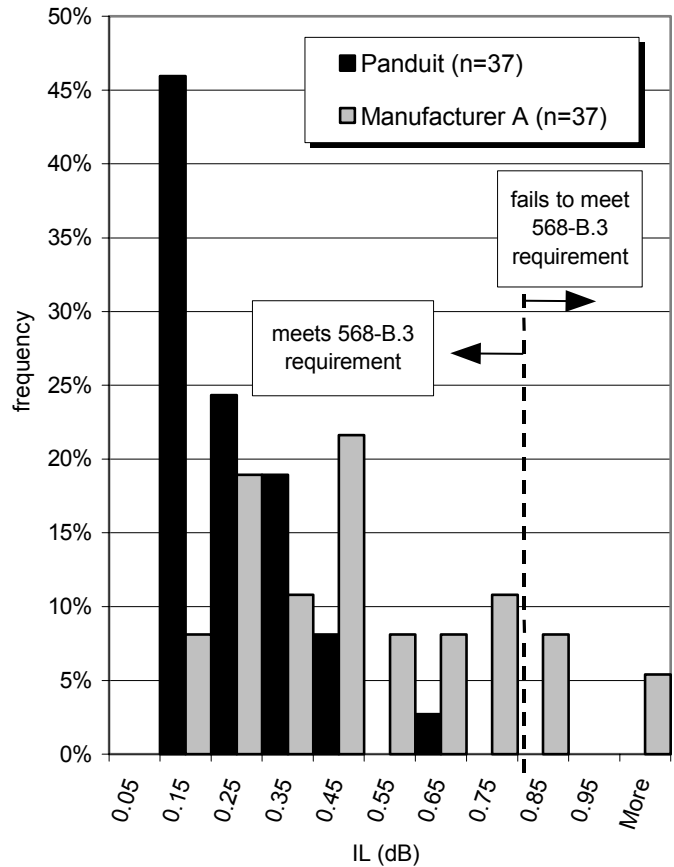


Table 1: 50/125µm SC Pre-polished Connector Termination Insertion Loss (dB) Results – 850nm

Data Type	SC <i>OPTI-CRIMP</i> Connectors	Manufacturer “A”
# of samples	37	37
# of passing samples (<0.75dB)	37	32
Termination Yield	100%	86%
Avg. IL (dB)	0.20	0.43*

* One sample was excluded because of high insertion loss measurement (~40 dB) that would have skewed the average to 1.7 dB.

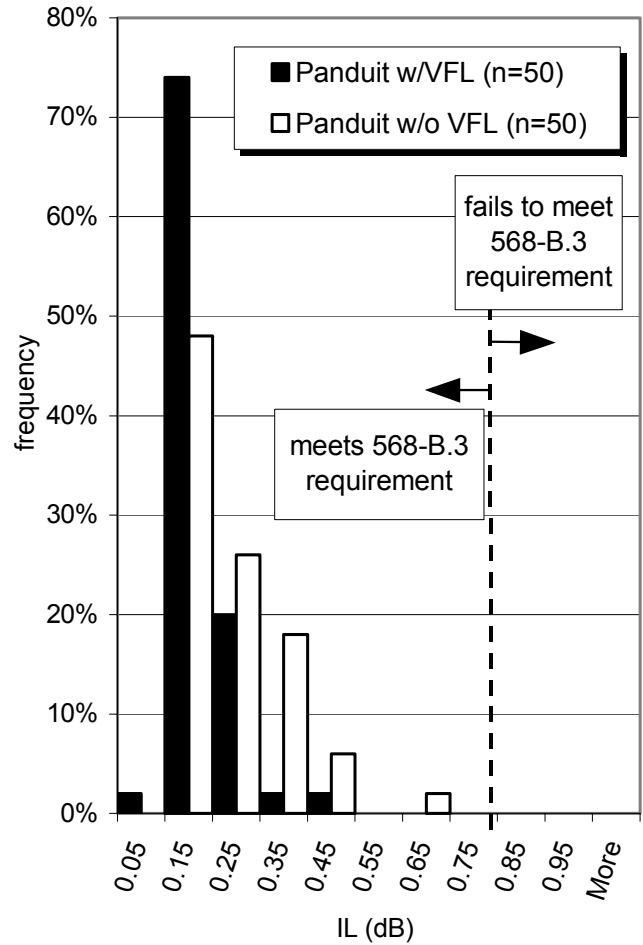
As previously stated, *PANDUIT* specifies the use of a VFL during the termination of *OPTI-CRIMP*[®] products. The VFL is used to help the installer to determine when the field fiber is in full contact with the stub fiber and to remove some of the subjectivity typically associated with pre-polished connector terminations. As can be seen from Figure 4 and Table 2, use of the VFL improves the quality (insertion loss) of the termination and reduces the variability. However, in both cases, the *OPTI-CRIMP* termination yield is 100%.

Table 2: 50/125µm SC OPTI-CRIMP Termination Insertion Loss (dB) Results – 850nm

Data Type	w/VFL	w/o VFL
# of samples	50	50
# of passing samples (<0.75dB)	50	50
Termination Yield	100%	100%
Avg. IL (dB)	0.13	0.19

For all the data presented in Figures 3 and 4, and Tables 1 and 2, insertion loss was tested per FOTP-34 and the mated sample pair was comprised of a pre-polished SC connector mated to a field polish SC connector. Termination yield was calculated as the number of passing samples (IL<0.75 dB) divided by the total number of samples terminated. All samples were terminated in a laboratory environment.

Figure 4: OPTI-CRIMP IL w/VFL and w/o VFL



Factors Affecting Yield

The data presented in the previous section reflects connectors that were terminated in a laboratory environment. The lab provides a well-lit, clean and spacious work area. This allows the capability of the pre-polished connector product to be characterized with minimal influence from external factors.

However, with all pre-polished connectors, there are certain external factors that contribute to the majority of the field problems related to connector insertion loss and termination yield. While the lab environment is not typical of field installation sites, results similar to those from the lab terminations can be realized with attention to the following factors.

Cleanliness

While cleanliness is always important when terminating fiber optic connectors, it is more critical when terminating pre-polished connectors than with field polish connectors. Field polish connectors have the advantage of being able to be cleaned after the termination is completed. However, with pre-polished connectors, any debris on the cleaved field fiber endface can become trapped between the field and stub fiber. Once terminated, this interface is inaccessible as only the factory polished ferrule endface can be cleaned.

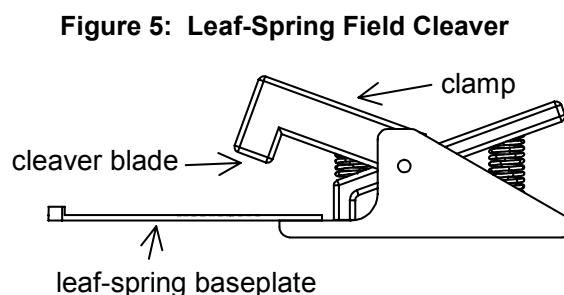
Ideally, it is best to terminate in a clean work environment. However, this is not always possible, with many installations taking place during building construction. In these cases, it is important to pay particular attention to the following steps. These steps should be taken during pre-polished connector termination to reduce the risk of contamination.

- Make sure that the cleaver is clean and free of dust and dirt prior to cleaving
- Wipe the field fiber with a lint free wipe and alcohol ($\geq 90\%$ concentration isopropyl) before cleaving
- Once the fiber is cleaved, install it into the connector and terminate immediately – avoid contact with the cleaved fiber end after cleaving

These steps are intended to minimize the amount of exposure that the cleaved field fiber has to the work environment. Given a clean fiber and cleaver, the newly cleaved fiber endface should be as clean as possible. Setting the cleaved fiber down before terminating or re-cleaning the cleaved endface offers the opportunity to introduce debris onto the cleaved end of the fiber. Often, installers use an assembly line type termination where all of the fibers are prepared (stripped and cleaved) at once and then all terminated. While this method works well for field polish connectors, with pre-polished connectors it is not a good idea to cleave multiple fibers ahead of time for the reasons mentioned earlier. If an assembly line termination method is desired, the jacket and buffer stripping steps can be performed in mass; but the fiber cleaning, cleaving, and terminating steps should be performed individually for each connector.

Cleave

The quality of the cleaved end of the field fiber is critical to the performance of the terminated connector. Most pre-polished connector termination kits include a hand held leaf-spring style cleaver (Figure 5) for performing the field cleave. The basic operation of the cleaver involves securing the fiber under a clamp, scoring the fiber with a ceramic blade, and breaking the scored fiber by bending the leaf spring baseplate. These cleavers advertise typical cleave quality at 90% of cleaves less than 1° and 99% less than 2° . While not as precise as the more expensive benchtop precision cleavers, a properly operated field cleaver is a cost-effective solution that is more than adequate for the field termination of pre-polished connectors.



However, there are some factors that can affect the quality of the cleave. These need to be considered when terminating pre-polished connectors using a leaf-spring style cleaver. Most importantly, the ceramic cleaver blade is designed only to score the field fiber, not to cut the field fiber. It is actually the bending of the baseplate that causes the scored fiber to break at the cleave location. With this in mind, the cleaver should not be used like a stapler with the blade pressed and held onto the field fiber. Instead, it is only necessary to touch the fiber with the blade in order to score it and then release the blade from contact with the fiber before breaking. When breaking the scored fiber, it is important not to over bend the baseplate. Over bending can cause the baseplate to become permanently damaged, resulting in poor cleave quality, and should be replaced. Another factor required to ensure a successful termination is proper cleave length. Most cleavers have a scale printed on the baseplate; before cleaving, the buffer should be lined up and held in place at the correct marking for the required cleave length.

Fiber End Face Contact

Endface contact between the cleaved field fiber and factory stub fiber is necessary for a successful termination. A gap between the endfaces can occur because either the length of the cleaved fiber is too short or the field fiber did not maintain contact with the pre-polished factory fiber throughout the termination. In order to ensure endface contact during termination, the field fiber should be pushed forward to create a bow in the buffered fiber behind the connector. This bow should be maintained during the termination to ensure endface contact. The bow serves two purposes: ensuring endface contact, and limiting the amount of pressure on the endface (which prevents fiber damage).

Experienced installers often develop a “feel” for termination and are able to incorporate the proper bow and pressure necessary to complete a successful termination. However, there are termination aids that can make the installation less subjective. An insertion mark on the buffer and a VFL (visual fault locator) are tools that can help the installer feel confident that the cleaved field fiber endface is in the correct location before the termination is completed.

Installer Experience and Training

While many of the cable preparation steps involved in terminating pre-polished connectors are familiar to most installers, each manufacturer’s pre-polished connector has a unique termination method with specific installation instructions that need to be followed. With practice and attention to detail, an installer can learn the technique and become proficient after only a handful of samples. However, when terminating any new product, it is important to be confident in the installation method prior to the actual on-site installation. Loss testing of practice pieces terminated during training provides instant feedback and is the only way to verify that the terminations are performed correctly.

Conclusion

Certain critical factors can affect the quality and success of pre-polished connector terminations. These include fiber cleanliness, quality of endface cleave, fiber endface contact, and installer training. Minimizing the effect of these factors can improve the termination yield of pre-polished connectors. Using good installation practices, testing has shown that pre-polished connectors such as *PANDUIT*[®] SC, ST AND FJ[®] *OPTI-CRIMP*[®] Connectors are capable of high termination yields and low connector insertion losses similar to field polish connectors with a less time/labor intensive termination.

PANDUIT develops and manufactures fiber optic connectors, patch cords, optical component modules, enclosures, and cable management. *PANDUIT* supplies connectors and patch cords that include FJ *OPTI-JACK*[®] Modules and Plugs, SC, LC and ST connectors. *OPTI-CRIMP* FJ Jack Modules, SC and ST connectors are also available for pre-polished crimp termination.