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Bend Insensitive Multimode Fiber: A new twist for high bandwidth fibers

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Bend Insensitive Multimode Fiber: A new twist for high bandwidth fibers

Technical advancements in the production of multimode optical fiber hold the promise of easier installation and cable management for 50/125 fiber cables through improvements in bend insensitivity. But before adopting a new technology, rigorous testing must be conducted in order to ensure the long-term viability and implications of the improvements. To that end, the Nexans Data Communications Competence Center independently tested a variety of 50/125 BIMMF.

Before reviewing the Nexans testing results, a review of the subject of bend sensitivity will help to explain why bend-insensitivity is a positive advancement for multimode fiber.

WHAT IS BEND INSENSITIVITY?

An optical fiber is comprised of a core and a cladding. While both of these regions are made from glass in telecommunications grade fibers, these two regions differ from each other in significant ways. The properties of each region are designed to capture light within the core and transmit it to the opposite end of the fiber.

In traveling from one end of the fiber to the other, the light follows many paths. Some of the light travels straight down the central axis of the fiber and some of the light bounces off of the boundary between the core and cladding of the optical fiber. Depending on the angle at which the light hits the

boundary, it is either reflected back into the core, or it gets lost into the cladding. Light losses during transmission result in a weaker optical signal at the receiving end.

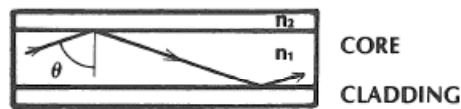


Figure 1: Light travelling through a straight fiber

When a fiber is bent, the angle at which the light hits the cladding changes and some light which had been contained in the core in a straight fiber will now escape and result in power loss. Various attributes in the fiber determine when this occurs. The relative ease with which this happens is known as bend sensitivity.

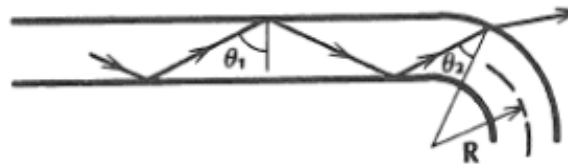


Figure 2: Power loss from bending.

It has long been known that some multimode fibers have a higher degree of bend sensitivity than others. For example, traditional 62.5/125 fiber has much lower bend sensitivity than traditional 50/125 fiber. Or, in other words, 62.5/125 is more bend *insensitive* than 50/125. This means that 62.5/125 fiber can be bent more tightly without additional optical signal power loss. This was one of the reasons it gained popularity in premises networks in the 1980's and 90's – it was viewed as a more robust fiber.

Those familiar with installing multimode fiber are aware that when compared with 62.5/125 optical fiber cables, traditional 50/125 fiber optic cabling requires some additional care. This is not related to the strength of the optical fiber or the cable designs. Rather, traditional 50/125 fiber is a more bend sensitive fiber and suffers additional power loss when compared to 62.5/125 fiber.

In short, bend insensitivity is a positive feature that can provide for additional robustness and simplify installation.

However, there has always been a trade-off for bend insensitivity. Specifically, while the relative bend insensitivity of 62.5/125 fiber is desirable, it is not able to support the high bandwidth needs of today's networks. With 50/125 fiber, the opposite has been true: it has outstanding bandwidth support, but bend sensitivity that can interfere in certain installation environments. The ideal solution is therefore clear; add bend insensitivity capabilities to high bandwidth 50/125 fiber.

Bend Insensitive Multimode Fiber (BIMMF)

Several optical fiber vendors have released 50/125 multimode fiber products with a minimum bend radius of 7.5mm, which compares very favorably to the 30mm bend radius traditionally specified. To achieve this, an optical “trench” is added to the cladding area outside of the fiber core. This trench retains more of the light that would have escaped the core of a traditional multimode fiber.

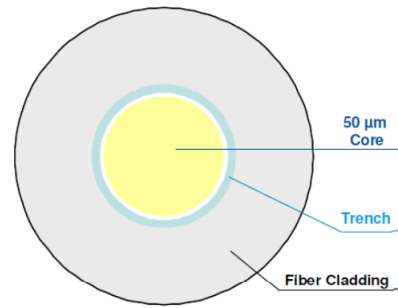


Figure 3: Cross-sectional view of a BIMMF 50/125 fiber.

Requirements for a tighter bend radius have been developed based primarily on factors in the fiber-to-the-home (FTTH) market. However, the benefits for premise markets have rapidly become apparent, particularly in data centers where more and more fibers are being installed in smaller areas. The expectation is that this new feature can enable deployment of multimode fibers in higher densities.

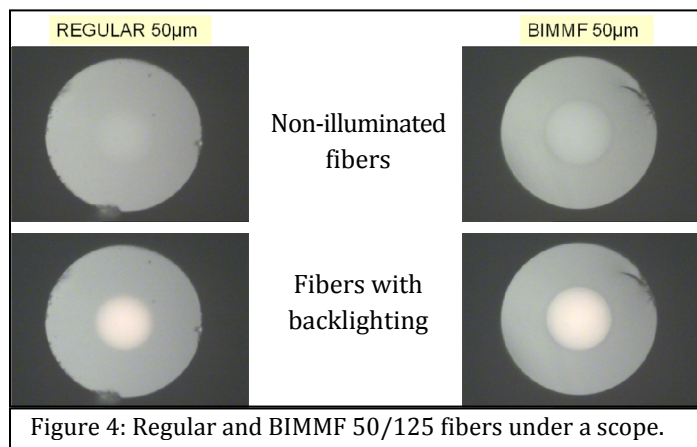


Figure 4: Regular and BIMMF 50/125 fibers under a scope.

DOES BIMMF ACTUALLY WORK?

New attributes are commonly added to cabling components. Innovations in optical cabling have created increased bandwidth capacity, improved handling characteristics, and allowed for smaller cables. However, whenever a change is made to the operating properties of the transmission media, verification that the change does not cause compatibility problems with previously installed architectures is vital. Without this verification there is the possibility of creating compatibility problems with the many thousands of kilometers of 50/125 fiber that are already installed in LAN’s and data centers around the world.

To determine whether this new technology can be integrated with legacy installations and enable higher data rates, the Nexans Data Communications Competence Center (DCCC) conducted a study to answer several important questions:

1. Do the fibers work as advertised? (i.e. limited attenuation in tight bending situations.)

2. Are the fibers backwards compatible with existing standard fibers? (i.e. can they be interconnected with acceptable connection loss?)
3. Do the fibers support advanced applications? (i.e. acceptable bit error rate (BER) for 40 and 100 Gb Ethernet transmission)

Active Testing

BIMMF fiber was obtained from several different manufacturers, cabled to a standard construction, and used to make multiple assemblies in various configurations (see Appendix A). The DCCC performed loss and active network testing with a BER of 10^{-12} threshold for qualification. For testing, link set ups included both all BIMMF channels and mixed links using a combination of BIMMF assemblies and standard non-BIMMF assemblies.

10G and 40G testing used full duplex traffic with two transceivers. The 100G tests used half duplex, on one transceiver. This approach was necessary since the trunk cables contained only 12 fibers and per the standard, full duplex traffic at 100G requires 20 fibers. The channel configurations for the various active tests are shown below.

10G Configurations

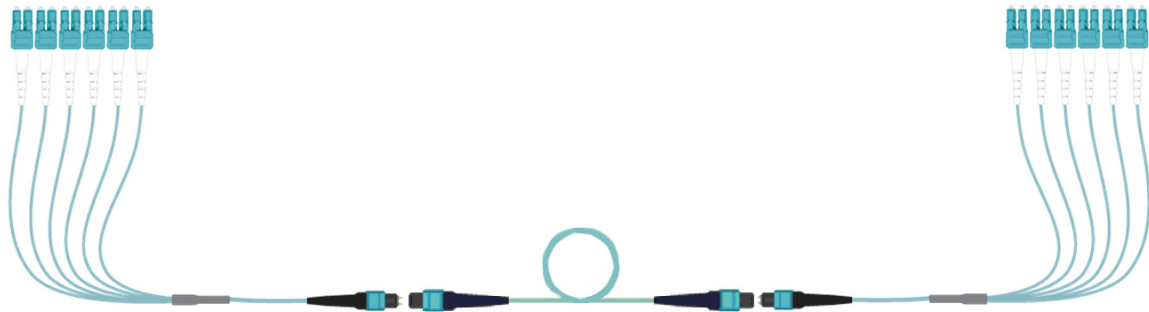


Figure 5 – 10G Test Set-Up: MPO-to-MPO trunk cables were mated to MPO-LC harnesses

40G Configurations



Figure 6 – 40G Test Set-Up: MPO-to-MPO trunk cables mated to MPO-to-MPO Patch Cords

100G Configurations

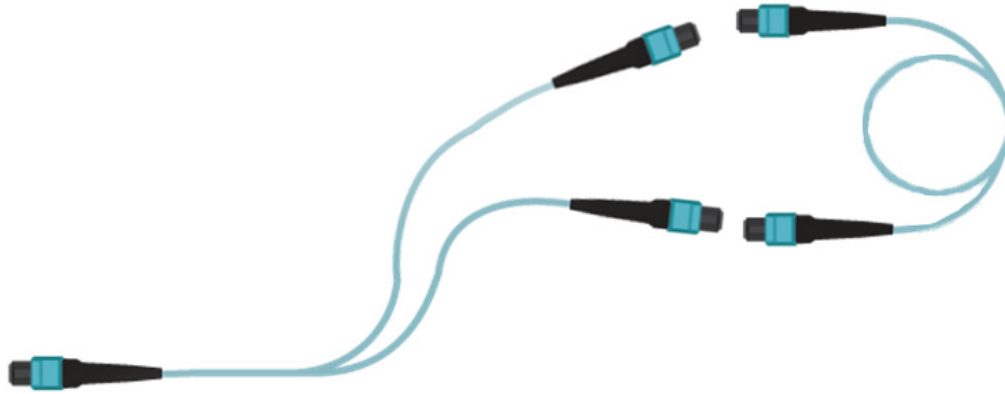


Figure 7 - 100G Test Set-Up: Half-Duplex over MPO-to-MPO trunk and 12F MPO-to-24F MPO Patch Cord

Insertion Loss Testing

Insertion loss (IL) testing was done in five different configurations, labeled C1, C2, C3, C4 and C5 in the figures below. The reference configuration for each setup is also shown.

Each test of configurations 1 through 4 used cords and trunks from a single vendor to determine if any performance variations were caused by combining standard and BIMMF 50/125 fibers in the channel.

In contrast configuration 5 (C5) mixed manufacturers in addition to combining standard and BIMMF fibers. This test was used to determine compatibility or possible performance degradation that might be seen when using BIMMF from different manufacturers within a single channel.

All cords used were BIMMF unless it is labeled 'Standard'. There were 10 three-meter duplex patch cords with LC connectors manufactured from various vendors.

Configuration C1: Single Vendor Mixed Channel Component Testing, Standard Launched to BIMMF

During test setup C1, the IL was measured at 850nm and 1300nm for cases with and without a mandrel on the standard cord.

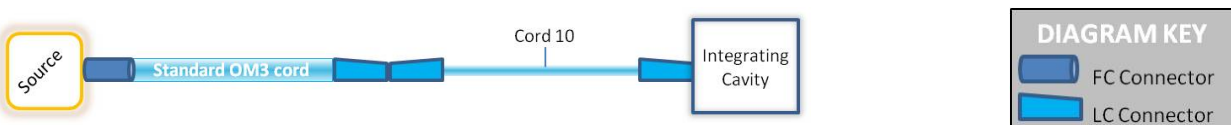


Figure 8: C1 Reference

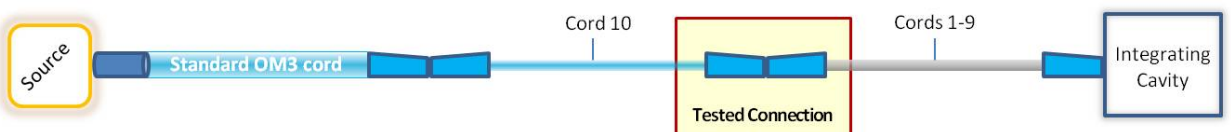


Figure 9: C1 Measurement

Configuration C2: Single Vendor Connector Insertion Loss Testing with BIMMF

Test C2 was similar to C1, except that the standard cord was removed from the setup. No mandrel was used during C2.

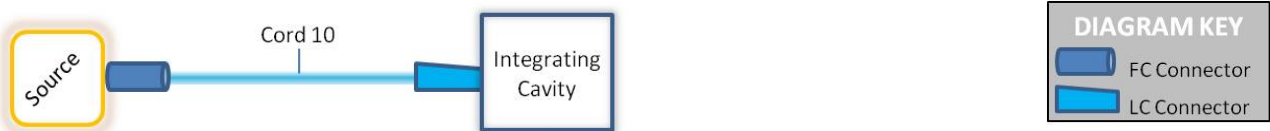


Figure 10: C2 Reference

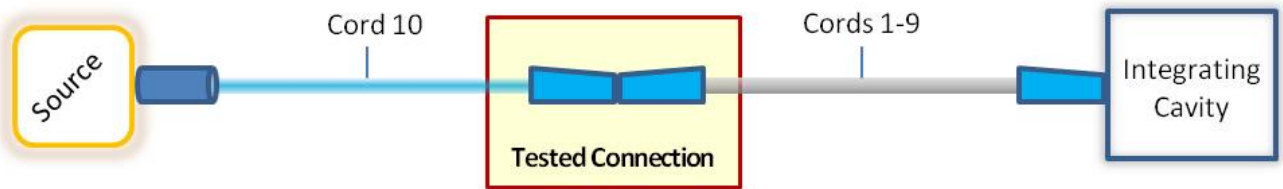


Figure 11: C2 Measurement

Configuration C3: Single Vendor BIMMF and Standard Patch Cord Compatibility

The C3 setup was used to test the direct compatibility between a patch cord made with standard fiber and one made with BIMMF. The test was done with and without a mandrel on the standard cord.



Figure 12: C3 Reference

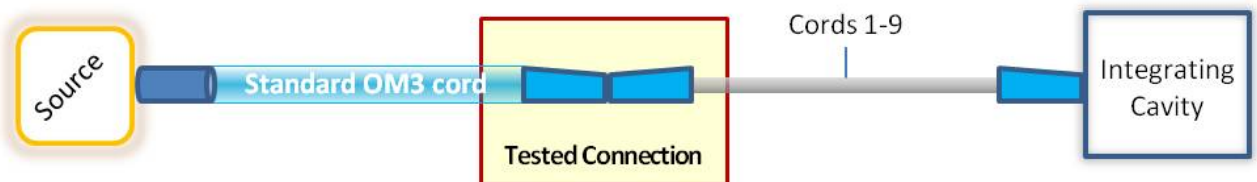


Figure 13: C3 Measurement

Configuration C4: Single Vendor Compatibility of Standard to BIMMF to Standard

The compatibility of launching from a BIMMF fiber into a standard fiber was tested using C4. The standard cord that was part of the reference measurement was wrapped around a mandrel.

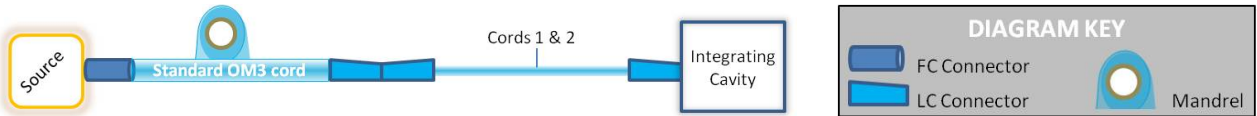


Figure 14: C4 Reference

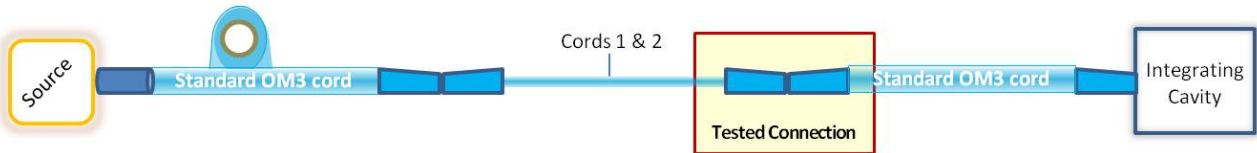


Figure 15: C4 Measurement

Configuration C5: Compatibility between BIMMF Manufacturers

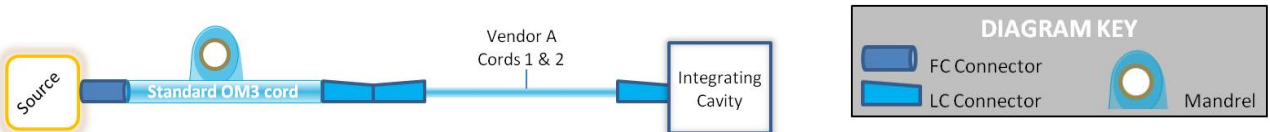


Figure 16: C5 Reference

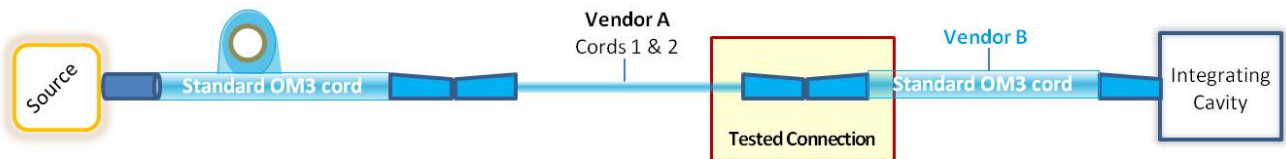


Figure 17: C5 Measurement

TESTING CONCLUSIONS

After many months of testing, the Nexans DCCC has determined that BIMMF can adequately address all of the stated concerns. To be clear, not every fiber manufacturer has performed acceptably, but BIMMF of a sufficient quality does combine the bend insensitivity of 62.5/125 fiber with the bandwidth capabilities of 50/125 optical fiber. To revisit the questions investigated in detail:

1. Do the fibers work as advertised? *Yes, the fibers exhibit limited attenuation increases in tight bending situations.*
2. Are the fibers backwards compatible with existing standard fibers? *All fibers passed the insertion loss experiments showing backwards compatibility and interoperability.*
3. Do the fibers support advanced applications? *Yes, fibers were shown to meet extended reach objectives, not just minimum compliance.*

By properly specifying important attributes, Berk-Tek can guarantee backwards compatibility and interoperability of new optical cables with previously installed standard 50/125 optical fiber cabling.

NEXT STEPS FOR BIMMF CABLES

Standardization

Since the addition of the trench around the optical core results in a change to existing standard geometry measurements, the current standards need to be updated to include BIMMF performance parameters. Berk-Tek, a Nexans Company, is working within TIA to standardize these attributes.

At a high level, there is general agreement as to the desired outcome and it is anticipated that these features will be part of the TIA standards in 2013. While two additional years for standardization sounds like a somewhat drawn out timetable, the process will allow more manufacturers to refine their processes and bring products to market that meet all of the above criteria.

Additionally, this effort will provide added assurance of the future capability and reliability of the BIMMF. While there has already been significant adoption, the final release of a standard typically increases the overall acceptance of a new technology.

TekFlex

To provide customers with the combined benefits of bend insensitivity and high-bandwidth, all standard products from Berk-Tek are now being supplied with this advanced technology. Berk-Tek GIGAlite™ fibers with TekFlex are certified to meet all of these requirements.

Legacy installations utilizing GIGAlite fibers, including GIGAlite-10 and GIGAlite 10-XB, have been specified for many years for installations where high bandwidth and low insertion loss were needed. Now these same fibers are available with the TekFlex bend insensitivity feature. These fibers are fully compatible with each other and with traditional fibers that may have been installed. Most importantly, these high bandwidth fibers can be confidently installed with a variety of installation methods and in the increasingly high-density application spaces of today's data center.

CONTACT INFORMATION |

Corporate Headquarters

132 White Oak Road
New Holland, PA 17557
USA

TEL: 717-354-6200

TEL: 800-237-5835

FAX: 717-354-7944

www.berktek.com

In Canada, please contact:

Nexans Canada Inc.
140 Allstate Parkway
Markham, Ontario
L3R 0Z7 Canada

TEL: 905-944-4300

TEL: 800-237-5835

FAX: 905-944-4390

www.berktek.com