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FIBER FAQs

Bend-Optimized Fiber

Technical Resource:

David Mazzarese
Technical Manager,
Fiber Systems Engineering

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As today's FTTx networks push optical fiber to single-family homes and multiple dwelling units (MDUs), they require smaller distribution cabinets and compact fiber management systems, where fiber is subject to a greater degree of bending. These conditions have put more stringent demands on the bend performance of single-mode fibers than ever before. However, the need to maintain a very high degree of mechanical reliability hasn't changed. An understanding of the design and performance of bend-optimized single-mode fiber will help the user make a more informed decision in specifying a fiber that can support tighter bends but still be very reliable.

What is "bend-optimized" fiber?

Bend-optimized fiber is designed for use in FTTx and enterprise applications to minimize the effects of increased attenuation resulting from macrobends and microbends in single-mode fiber. Optimized bend performance is valuable in many cable and connectivity applications including low-count cables, small enclosures, or any application where small bend radii may be encountered. Bend-optimized fiber like OFS' AllWave® *FLEX* and AllWave *FLEX+* fibers can be coiled into a 7.5 mm radius loop with < 0.1 dB incurred loss at 1625 nm and < 0.5 dB incurred loss at 1550 nm - five times better bending performance than conventional single-mode fibers. These fibers also help improve cable performance in high-stress and low-temperature environments by providing double the microbending performance of conventional single-mode fibers.

What's the difference between macrobending and microbending?

Optical fibers would not be practical if they needed to be kept perfectly straight to guide light. However, deviations from a straight path ("bends") can cause light to scatter from the core of the optical fiber. Bends fall into two categories: macrobends are bends that are large enough to be seen by the human eye, and microbends are microscopic deviations along the fiber axis. An example of a macrobend is the routing of a jumper in a patch panel; a microbend could be caused if the fiber coating squeezes a fiber as it contracts at very low temperatures. Both types of bends can result in increased attenuation that can degrade system performance.

A bend-optimized product such as AllWave *FLEX+* Fiber excels in both types of bend performance, enabling smaller enclosures and novel cable designs. The macrobend performance of AllWave *FLEX+* Fiber is more than twice as good as that of standard single-mode fiber (for the most demanding cable designs and environments, the microbend performance is even better). This improved performance is ideal for ultra high-density cables, the last mile of FTTx, and connectivity applications.

For bend-sensitive applications, are there factors beyond bend optimization that must be considered?

Bend performance is just one of several parameters that must be considered when designing an optical fiber for bend-sensitive applications; other key parameters include bandwidth, reliability, and compatibility with the installed base. In a well-designed fiber product, these properties must be balanced to create a fiber that will provide the most value to the end user.

Most important is that the bend-optimized single-mode fiber is based on a proven design that is fully compliant with International Telecommunications Union (ITU) standards including G.652.D for outside plant applications and G.657 for the access network. This ensures that the fiber will work with existing transmission equipment. Also important are low polarization mode dispersion (PMD), excellent attenuation from 1260 nm - 1625 nm even in tight bends, and Zero Water Peak (ZWP) performance to ensure that the product is ready for any future bandwidth upgrades. Very low splice loss when splicing either to itself or to the existing fiber base is also critical.

The mechanical reliability of the fiber under reduced bends is also very important. Be wary of any bend-optimized fiber whose design allows for bends that are so tight that they threaten the mechanical reliability of the fiber, unless the fiber is protected by a rugged cable design that preserves reliability. Low loss in a very tight bend (say, 5 - 7 mm in radius) may look like good performance during installation, but this tight bend is only recommended for in-building applications in cable designs that preserve reliability.

Has the industry developed a new standard for bend-optimized single-mode fiber?

Yes, the ITU is updating the G.657 standard to clarify the use of single-mode fibers with improved bending performance suitable for use in access networks. The standard describes two categories of fibers. Category A fibers are suitable for use from 1260 - 1625 nm and are a subset of G.652.D (low water peak fibers). Their main attributes are tighter dimensional requirements and improved bending loss to improve connectivity. The attributes and values of these Category A fibers are optimized to minimize macro-bending loss in access network installation, while the recommended values for the other attributes still remain within the range recommended in the ITU-T Rec. G.652.D. (AllWave *FLEX* Fiber exceeds the Class A Standard). Category B fibers are optimized for even lower macrobending loss, and therefore are capable of operating at very low bend radius values. These fibers are for short distances (less than 100 meters) at the end of FTTH networks, particularly inside or near buildings (e.g., in outside building riser cabling). They are suitable for use throughout the 1260 - 1625 nm range. Category B fibers are not necessarily compliant with ITU-T G.652.D; however, they are *system-compatible* with G.657.A and G.652.D access fibers in FTTH networks.

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Can I splice a bend-optimized fiber like AllWave *FLEX* Fiber to an existing outside plant base composed mostly of matched cladding fiber?

Yes. AllWave *FLEX* Fiber was designed for excellent splice performance both to itself and to the embedded base of single-mode fiber (using standard single-mode splice procedures, recipes and equipment to ensure no additional field challenges during deployment or repairs). Because this is probably users' biggest concern , we developed bend-optimized single-mode fibers with excellent geometric attributes designed to yield consistently low splice loss.

OFS conducted a massive splice study with over 1500 splices among AllWave, AllWave *FLEX*, and AllWave *FLEX*+ fibers, and with other standard single-mode fibers. The results, shown in the table below, illustrate the average bi-directional OTDR loss measured for each combination of fibers. One important observation: the nominal mode field diameter (MFD) of AllWave *FLEX* Fiber is slightly smaller than that of standard AllWave ZWP Fiber. As with any single-mode fiber, this difference in mode field diameter can lead to one-way OTDR artifacts that are larger than what would be observed if only one fiber type was used. True splice loss is the average measurement of the OTDR taken from each direction, not what is observed on a unidirectional measurement.

	AllWave Fiber	AllWave *FLEX* Fiber	AllWave *FLEX*+ Fiber	Competitive Fiber C	Competitive Fiber D
AllWave Fiber	0.02	0.03	0.03	0.03	
AllWave *FLEX* Fiber	0.03	0.02	0.02	0.03	0.04
AllWave *FLEX*+ Fiber	0.03	0.02	0.02	0.03	

When should I consider using bend-optimized single-mode fiber in my network?

There are many situations in which a bend-optimized single-mode fiber can improve system performance. Some examples:

- Low count cables: As the fiber count within cables decreases, they are more likely to have bends on the order of 30 mm radius or less.
- High density connectivity: The improved microbending and macrobending performance and full spectrum capability of products like AllWave *FLEX*+ Fiber make them an ideal choice for patchcords in demanding applications such as central office and distribution cabinets.
- Small enclosures: Tighter enclosures for FTTx applications have been made possible by the improved macrobend performance of these fibers, specifically the ability to have bends with radii as small as 10 mm.
- Low temperature applications: The improved microbending of bend-optimized fiber boosts the performance of patch cords and cables at temperatures as low as -40 degrees Celsius.
- Compact cable designs: The use of bend-optimized fibers results in low attenuation after cabling in the small-diameter designs of today's premises cables and blown fiber units.

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What are the key parameters to specify in a bend-optimized single-mode fiber?

The best value in a system is a fiber that has optimized bend performance at high levels of mechanical reliability. There are several key design features that need to be considered:

- good bend performance (without jeopardizing long-term reliability)
- low-loss splice compatibility
- high mechanical reliability
- Zero Water Peak performance
- low PMD
- G.652.D compliance (for the outside plant)

I've heard there are different designs of bend-optimized single-mode fiber. Which is best?

To select the best fiber, it's important to match the properties of each bend-optimized fiber to the application being considered for the access network. For example, in most outside plant applications, where a 10 mm minimum design radius is sufficient, a G.657.A1 fiber is recommended (this includes high-density cables and low fiber-count cables). Connectivity applications are more demanding; here, a G.657.A2 fiber, with its 7.5 mm bend radius, is recommended. For in-building applications where single subscribers are being connected, there may be value in considering a G.657.B3 fiber.

There are many designs available for achieving improved macrobend performance. When choosing these products, be sure to consider the compatabiltiy of the fiber with the embedded base of single-mode fibers. The optimum choice will provide full-spectrum performance and seamless plicing to the existing infrastructure with no additional reliability risk.

For more information, visit our website at www.ofsoptics.com/fiber or call 1-888-fiberhelp.

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