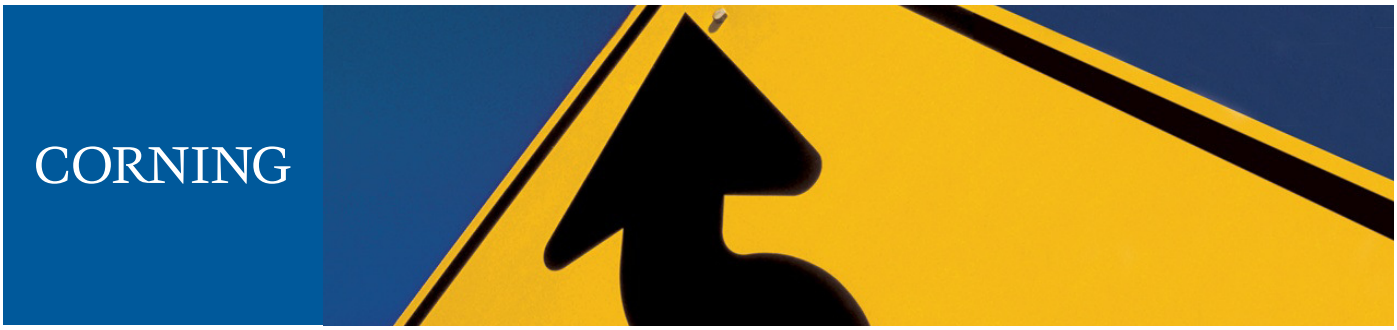
Corning® ClearCurve™ Optical Fiber



The fastest route is not always a straight line

Corning once again pushes standard single-mode fiber performance to new levels, introducing Corning® ClearCurve™ optical fiber, a fiber with hundreds of times better macrobend performance than other standard single-mode fibers to address key technical challenges for carriers installing fiber-to-the-home networks in apartment buildings and condominium complexes. This vastly improved macrobend performance allows carriers to design optical fiber into much more challenging installation environments.

Market Overview

Service providers continue to drive fiber closer to the end user. Increasingly, network operators are leveraging the near infinite information carrying capacity of fiber, as well as the lowered operating costs of optical networks. Fiber-to-the-home (FTTH) deployments continue to grow across the world and as fiber gets closer to end-users, the demands on fiber-based networks will continue to increase. Limited facility space and installers' ability to deploy quickly are driving smaller designs and more strenuous deployment conditions. The latest opportunity is bringing optical networks to and within apartment homes and condominium complexes or multiple dwelling units (MDUs). There are approximately 680 million MDU units around the world and nearly 30 million in the United States alone. For carriers, accessing a high density of households can reduce the capital costs per subscriber. The potential is great, but the challenges of these installation environments are significant: space limitations, tight bends, and a perception of fiber as "sensitive" all represent hurdles to installers' goals of cost savings, installment time reduction, and more aesthetic designs.

Standards Organizations Respond

Recognizing the change in macrobending performance requirements for FTTH networks, the ITU published Recommendation ITU G.657 in December of 2006. This standard, summarized below, describes characteristics of bend-enhanced single-mode fibers for access networks.

Table 1: Summary of Bend Performance Specifications of ITU-T G.657 Tables A and B

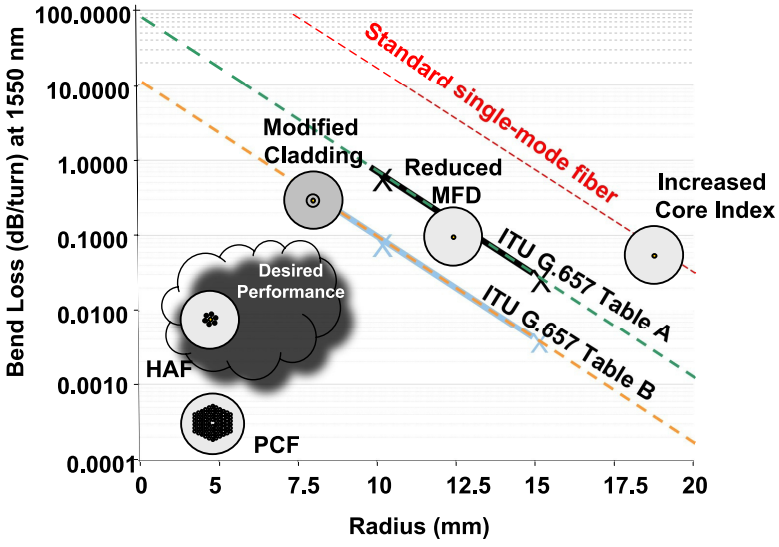
Parameter	ITU-T G.657 Table A	ITU-T G.657 Table B
Primary intent	Maintain backwards compatibility	Maximize bend performance
ITU-T G.652.D compliance	Required	Not required
1 turn x 7.5 mm radius @ 1550 nm	Not specified	≤ 0.5 dB
1 turn x 7.5 mm radius @ 1625 nm	Not specified	≤ 1.0 dB
1 turn x 10 mm radius @ 1550 nm	≤ 0.75 dB	≤ 0.1 dB
1 turn x 10 mm radius @ 1625 nm	≤ 1.5 dB	≤ 0.2 dB
10 turns x 15 mm radius @ 1550 nm	≤ 0.25 dB	≤ 0.03 dB
10 turns x 15 mm radius @ 1625 nm	≤ 1.0 dB	≤ 0.1 dB

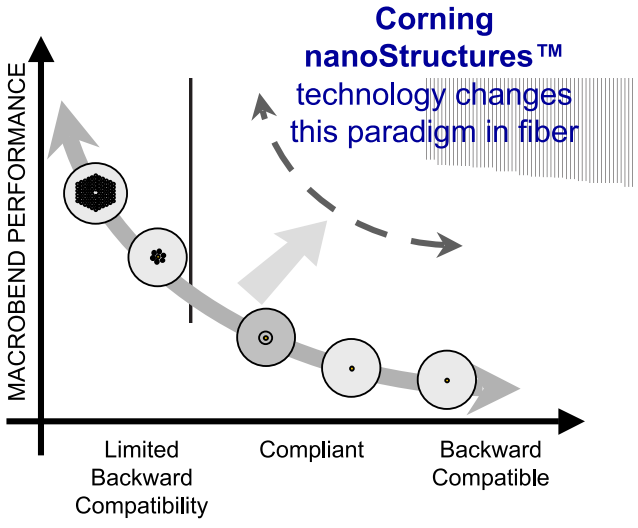
The Bending Problem

It has long been understood that an inherent limitation of optical fiber is the increased attenuation due to macrobending. Put simply, installers experience moderate signal loss with large diameter bends and increased loss with tighter bends. The focus on this limitation has increased as optical networks continue to move closer to where people live and optical cables encounter tight bend scenarios, space constraints, unique installation practices, and the requirements that the network equipment and cable be smaller and less noticeable to meet higher aesthetic standards of a living environment.

The Design Challenge: Optimize Bend Performance and Compatibility

There have been other technologies and technical solutions, such as hole-assisted fibers (HAF), photonic crystal fibers (PCF) and fluorine-doped fibers, all which aimed at solving the bend problem. However each of these technologies has struggled to overcome the fundamental performance to compatibility trade off. That is, HAF and PCF technologies were successful in meeting bend loss requirements, but they were not compatible with the installed base of fiber. While fluorine-doped fibers are backward compatible but do not meet the desired macrobend performance levels. As a result, it became obvious that a new solution was required that could break this performance/compatibility tradeoff. Corning researchers focused their efforts on developing a solution to the bend problem that successfully balanced the need for improved macrobend performance with the equally important need to have an optical fiber that is compatible with the installed base.



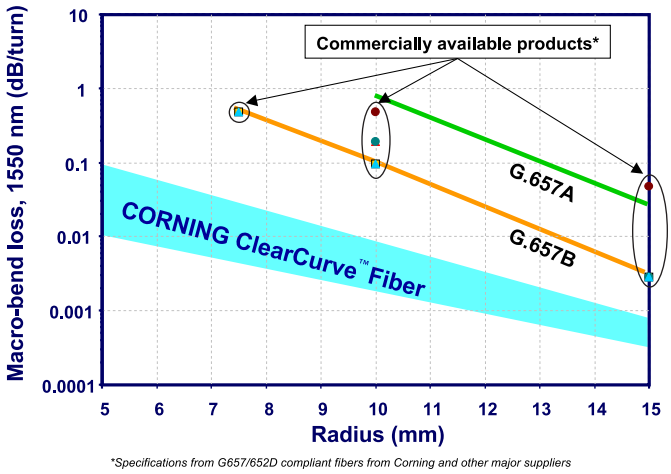


Enter Corning® ClearCurve™ Optical Fiber

In July 2007, Corning announced the development of a new nanoStructures™-based optical fiber design that can handle tight bends with virtually no signal loss. This technology enables optical fiber that is fully compliant with ITU-T G.652.D while also exceeding the bend requirements established in ITU-T G.657.B by an order of magnitude. The result, ClearCurve™ fiber, is the industry leader in macrobend performance which allows network planners to design optical fiber into much more challenging installations and environments such as FTTH network installations in apartment units and condominium complexes.

Corning® ClearCurve™ Fiber

- Industry leader in macrobend
- Multiple standards
  - ITU G.652.D
  - ITU G.657.A
  - ITU G.657.B
- Compatible with established field handling procedures and OEM processes



*Specifications from G657/652D compliant fibers from Corning and other major suppliers

Understanding Mechanical Reliability

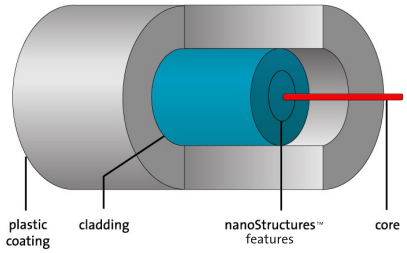
With the trend toward increasingly tighter bends in access and FTTH networks it is very important to understand the reliability performance of optical fiber under tight bend scenarios. Understanding the strength and fatigue behavior of optical fiber and developing the associated lifetime models has been a primary focus for Corning over the past 30 years. Also, supplying reliable fiber and utilizing our world-class manufacturing process continues to be Corning's highest priority. We demonstrate that the reliability of fiber in FTTH installations can be assessed by combining a relevant fiber strength distribution, knowledge of fiber fatigue behavior, and possible bend scenarios into Corning's reliability model. The full details of this work are available in the white paper titled, "The Mechanical Reliability of Corning Optical Fiber in Small Bend Scenarios" available on our website at: www.corning.com/clearcurve/resources.htm. Corning has a proven track record in engineering reliability solutions for optical fiber. A sampling of our fiber reliability publications are available at: http://www.corning.com/opticalfiber/technical_library/fiber_mechanical_reliability/basics.aspx

What is nanoStructures™ Technology?

To improve bend performance in optical fiber, one must lower the refractive index which basically means that we need to change the composition in portions of the fiber. This can generally be done by changing the materials (new chemical dopants) or the material location/distribution. In our analysis, we found that using dopants did not deliver enough bend performance benefit, while hole-assisted designs have too many compatibility and complexity concerns.

Our solution employs engineered nanoStuctures features into a controlled mesh configuration within the fiber cladding to deliver dramatic improvement over dopant designs, without all the significant compatibility tradeoffs. Essentially, it is a way to "trap" the light into the core of the fiber, where it is supposed to travel, by defining an additional level of barrier to prevent light from escaping the fiber when it is bent.

nanoStructures™ Optical Fiber



Performance and Specifications

		ITU G652A	ITU G652D	ITU G657A	ITU G657B	ClearCurve™ Fiber
	Functional Radius Limit*	30 mm	30 mm	10 mm	7.5 mm	5 mm
Bend Performance (Loss - dB for 1 turn at 1550 nm)	10.0 mm radius	n/a	n/a	0.75	0.1	✓++
	7.5 mm radius	n/a	n/a	n/a	0.5	✓++
	5.0 mm radius	n/a	n/a	n/a	n/a	0.1
Attenuation at 1310 nm		✓	✓	✓	✓	✓+
Attenuation at 1383 nm			✓	✓		✓+
Attenuation at 1550 nm		✓	✓	✓	✓	✓+
Attenuation at 1625 nm		✓	✓	✓	✓	✓+
Dispersion		✓	✓	✓	✓	✓+
PMD			✓	✓		✓+
Geometries		✓	✓	✓+	✓+	✓+
Comprehensive Environmental Specifications		✓	✓	✓	✓	✓+
Backward Compatible with G.652D			✓	✓		✓
Compatible with standard field procedures		✓	✓	✓		✓
Suitable for large-volume manufacturing processes		✓	✓	✓		✓

* Functional radius = radius at which 1 turn ≤ 0.1 dB of loss

Conclusion

Since introducing the first low loss optical fiber in 1970, Corning has led optical fiber innovation focused on market trends and customer needs. The leading carriers around the world have indicated that multiple-dwelling units are the next big challenge for access networks. In our work to solve that challenge we identified the traditional trade-offs between bend performance and backward compatibility as the technical challenge to solve. The result, Corning's nanoStructures™ technology, breaks that tradeoff paradigm and solves the bending problem with Corning® ClearCurve™ optical fiber, a truly bend-insensitive fiber that can withstand the unique installation requirements of fiber-to-the-home installation in multi-dwelling units.

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