200 Micron Fibers – Optical and Mechanical Resilience of Reduced Coating Diameter Fibers

Application Note

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Introduction

Miniaturization of cables and associated hardware is a major trend in the optical fiber cable telecommunications industry. This is born out of a necessity to improve installation efficiency and accelerate penetration of fast optical fiber-based bandwidth service coverage to subscriber areas which are difficult to reach or costly to service. Urban areas can be especially challenging for network operators when trying to deploy high fiber count cables in underground duct infrastructure. Smaller diameter, high fiber-density micro cables offer several distinct advantages: lower duct utilization (cheaper rental costs calculated on a cross-sectional area basis) and easier handling and installation. Smaller and light weight cables can be deployed quickly and more efficiently by blowing into smaller duct sizes. Additionally, smaller form factor cable and hardware help to reduce packaging, storage, and freight. The new generation of micro cables requires small diameter optical fibers that occupy less space and offer greater optical transmission resilience in confined spaces. SMF-28® Ultra 200 fiber is Corning's newest single-mode fiber featuring a reduced coating diameter of 200 microns which is optimal for high fiber-density outside plant cabling (OSP) and provides 100% ITU-T G.652.D backwards compatibility [1]. This application note explains some of the key features of this fiber and shows how the mechanical and optical properties uphold continuity of ITU-T G.652.D single-mode fiber, which likely results in wider adoption of 200 micron fiber in miniaturized cables for OSP network infrastructure.

200 Micron Diameter Fiber Coating

Conventional single-mode optical fibers that have become the foundation of modern day optical telecommunication networks feature a protective coating layer that has a typical outside diameter of ~242 microns. Since Corning developed the first low loss fibers in the 1970s, optical fiber technologies have evolved tremendously. Enhancements in both glass and coating technologies have improved optical transmission capabilities and the protective qualities of coating that is designed to preserve the optical and mechanical properties of the fiber. Over time, geometrical tolerances of both the glass and coating have also improved, but the overall coating diameter has changed very little. For decades Corning's optical fibers have been mechanically durable and optically reliable across numerous outside cabling applications deployed worldwide. Corning has developed a fiber with a reduced diameter coating to enable the development of smaller diameter, high fiber-density cables [2]. This fiber has glass technology which helps to advance the optical performance levels of the fiber and an optimized coating which maintains its protective functions despite the reduction in coating radial thickness. As Figure 1 illustrates, Corning's dual layer CPC® protective coating performs two main functions: 1) The inner layer which has a lower Young's modulus and low glass transition temperature, preserves the fiber's optical performance properties during its operational lifetime, 2) the outer layer has a higher modulus and serves to protect the inner coating layer and the glass from mechanical damage during processing, installation, and expected service life. In this application note the optical and mechanical performance aspects of SMF-28 Ultra 200 fiber is presented and compared alongside ITU-T G.652.D fibers with conventional coating diameter.

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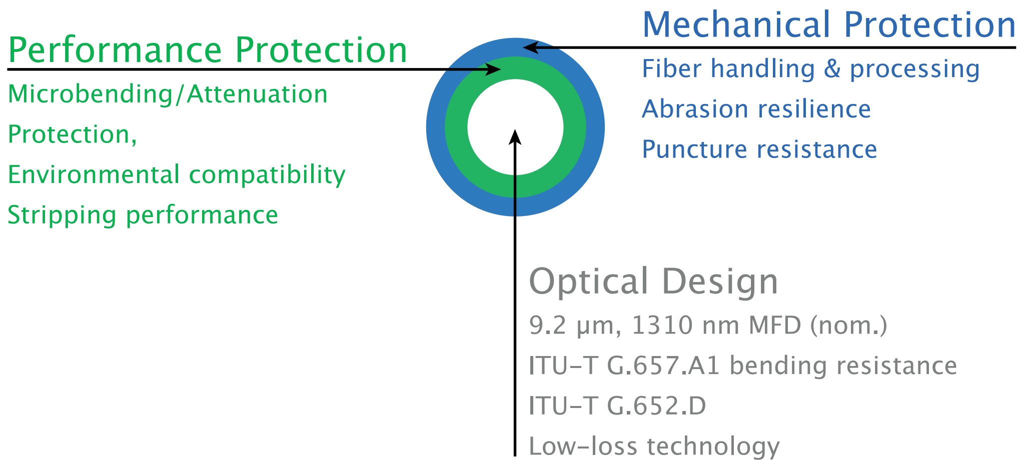

Figure 1 . Two main principle functions of the dual-layer Corning CPC® protective coating and key design aspects of the central glass fiber.

Mechanical Protection and Fiber Handling Properties

The mechanical protective qualities of the fiber coating are dependent on the properties of the outer coating layer. To achieve the desired levels of coating toughness requires the outer coating to have sufficient hardness or modulus and radial thickness to protect the glass from damage during handling and cable processing, and to remain effective during its operational lifetime. Resistance to mechanical stress or abrasion damage can be demonstrated through the use of coating puncture resistance testing. Corning developed a puncture resistance test in the 1990's to help quantify the mechanical resistance of the coating and its dependency on the properties of the coating and the radial thickness, or more specifically the cross-sectional area of the outer coating layer [3]. Figure 2 compares the results of the puncture load measured for a range of different coating diameters, all with a 125 micron glass cladding diameter.

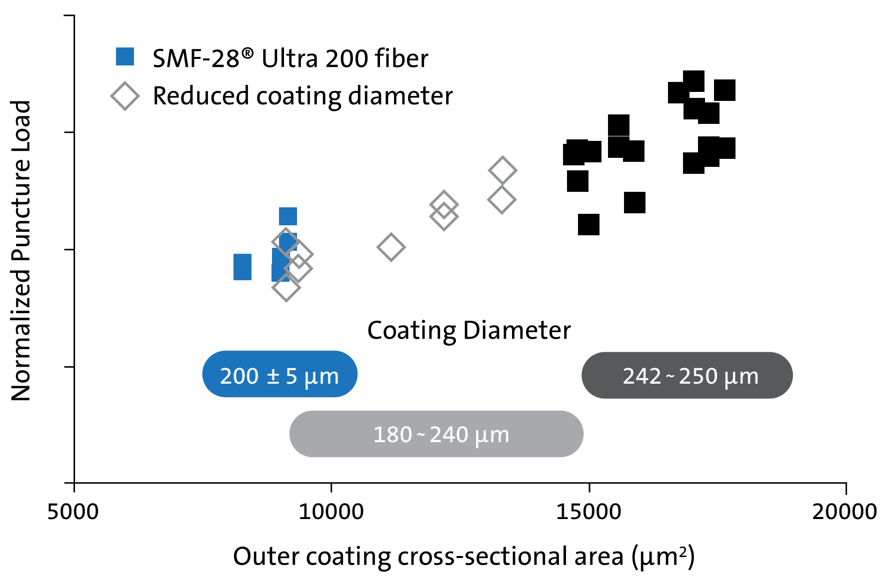

Figure 2. Puncture resistance testing for SMF-28® Ultra 200 fiber alongside legacy and conventional fibers.

Advances in coating technology since the mid-1990's help achieve similar levels of puncture resistance as conventional fibers, which have been proven to be effective for use in outside plant cables and even some harsh environments. In another study conducted by Corning to replicate high volume cable processing resilience, 200 micron fibers were subjected to several repeated mechanical proof test screening levels >100 kpsi. The results obtained were similar to previously Corning published data [4] for fibers with reduced coating diameter. Survival rates were well within expected limits and there were no signs of mechanical deterioration during microscopy inspection, nor was there any evidence to suggest coating ruggedness had been diminished.

Corning SMF-28® Ultra 200 fibers were also tested to measure coating strip force against existing requirements for conventional fibers in accordance with the sectional requirements of IEC 60793-2-50 for type B fibers [5]. Figure 3 shows the peak and average measured coating strip force for conventional coating diameter and 200 micron fibers using the same coating type. These two particular studies agree well with fiber and cable processing and handling trials, during which no changes to any fiber handling or fiber processing practices were deemed necessary, other than the required use of smaller sized machine tooling to make best use of the smaller form factor.

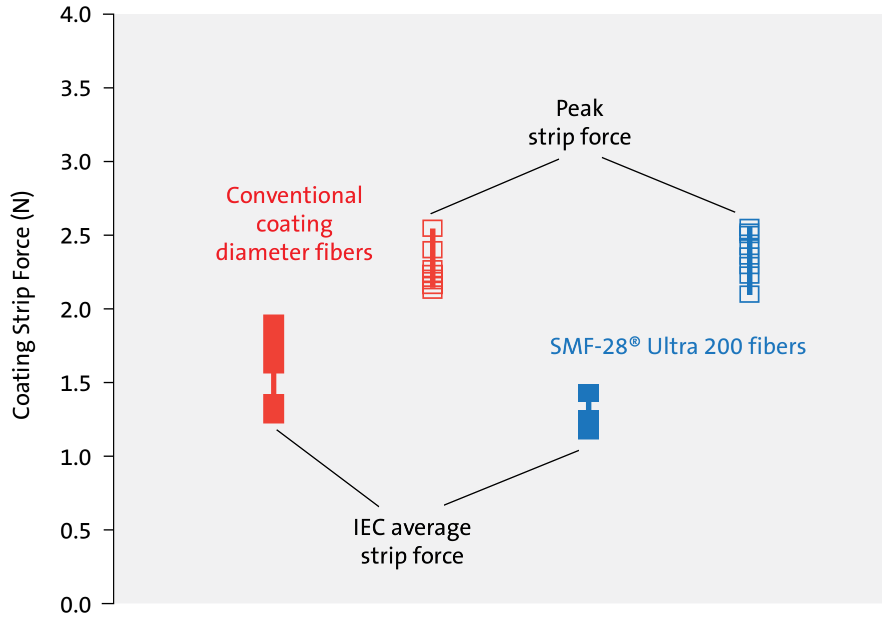

Figure 3. Comparison of coating strip force: Conventional coating diameter vs. 200 micron fibers.

As the tensile strength and mechanical reliability properties of optical fiber are determined by the glass and distribution of lower strength flaws present in the cladding surface, SMF-28® Ultra 200 fiber shares the same mechanical specifications as SMF-28e+® and SMF-28® Ultra fiber. Furthermore, fiber strength and reliability models developed by Corning continue to apply for SMF-28® Ultra 200 fiber. The applied stress guidelines that set out safe stress limits for tensile stress and bending stress applications that demand near zero failure risk or managed risk, continue to hold for Corning 200 micron fiber[6].

Fusion Splicing: Performance Compatibility

The fusion splicing performance of SMF-28 Ultra 200 fiber when spliced to conventional ITU-T G.652.D fiber types such as Corning SMF-28e+ fiber, is equivalent to same fiber splicing due to the same and shared MFD specifications of 9.2±0.4 microns at 1310 nm and 10.4±0.5 microns at 1550 nm. The adoption of ITU-T G.657.A1 fibers in high fiber count outside plant cables, which feature smaller mode-field diameters (MFD), has been deferred by some network operators due to perceived concerns over splice compatibility with the existing network installed base of legacy ITU-T G.652 fibers. Conventional ITU-T G.657 fibers derive some enhanced optical bending resistance from their smaller MFD, which is typically 8.6 ~ 8.8 microns, and is smaller than legacy ITU-T G.652 fibers that have a nominal MFD of 9.2 microns. SMF-28 Ultra 200 fiber specifications, while surpassing the requirements of ITU-T G.657.A1, are based on well-established industry international standards: ITU-T G.652.D and has a nominal MFD of 9.2 microns which maintains MFD consistency with legacy ITU-T G.652.D fibers to alleviate concerns over MFD compatibility during cable jointing and termination in the field.

During fusion splicing studies of Corning SMF-28 Ultra 200 fiber, using both core- and cladding-alignment modes and standard splicing recipes found on all the commercially available splicing machines tested, a typical splice loss of 0.02 ~ 0.03 dB was achievable. SMF-28® Ultra 200 fiber is identifiable as an ITU-T G.652.D single-mode fiber with all splicing machines tested – including independent studies conducted by a well-known fusion splicer equipment manufacturer. The results in Figures 4 and 5 are considered representative for SMF-28 Ultra 200 fibers.

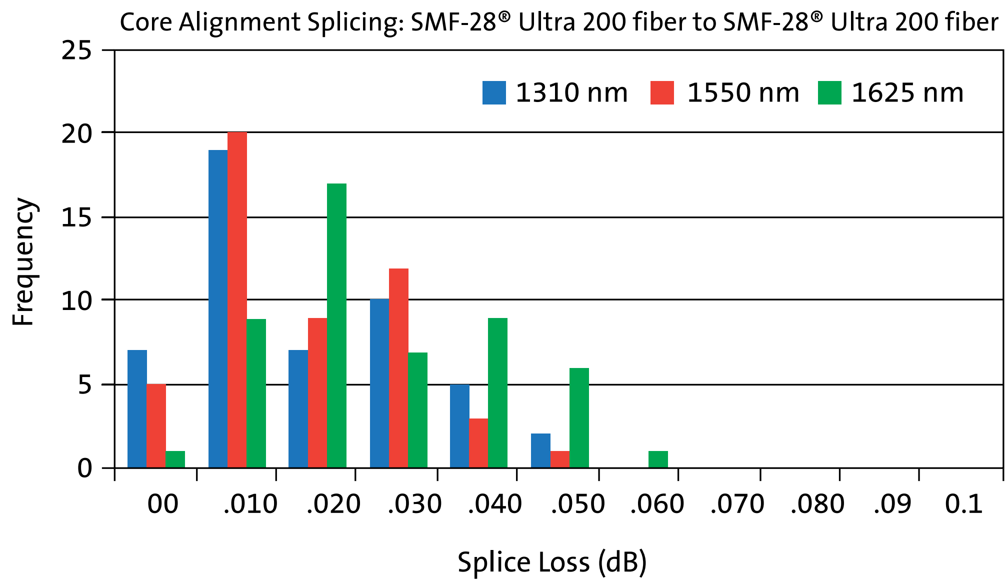

Figure 4. Representative splice loss of Corning SMF-28® Ultra 200 fiber spliced to itself.

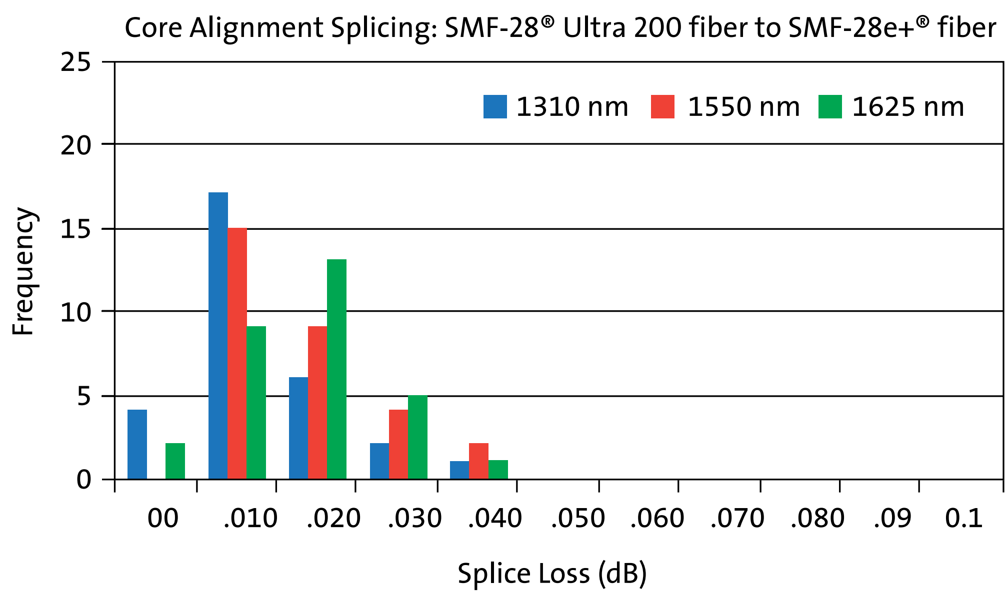

Figure 5. Representative splice loss of Corning SMF-28® Ultra 200 fiber spliced to SMF-28e+® fiber.

Enhanced Optical Bending Resilience

An improvement in the optical bending resilience derived from the glass design of the fiber is highly desirable, so that any decrease in the microbending cushioning effect of the coating, caused by the reduction in coating thickness, can be alleviated or eliminated altogether. The microbending sensitivity can be assessed comparatively for different fiber types to measure the attenuation response in 200 micron fibers, as compared to ITU-T G.652.D fibers with a conventional coating diameter, by wrapping fiber samples under tension around a patterned measurement drum. The surface of the drum features a repeated raised patterned profile that imposes small bend stress perturbations in the fiber that are shorter in length than the diameter of the fiber. This type of test is used to replicate severe microbending effects over long section lengths of fiber to assess resistance to microbending. The results in Figure 6 below, show the relative attenuation change for 200 micron fiber alongside a conventional ITU-T G.652.D fiber, in this case Corning SMF-28e+ fiber, over the wavelength range 1250 nm to 1650 nm. Despite the reduction in coating diameter, the results show that the combination of coating and glass fiber design contribute to give sufficient microbending resilience which is comparable with an industry leading ITU-T G.652.D fiber that has a conventional coating diameter.

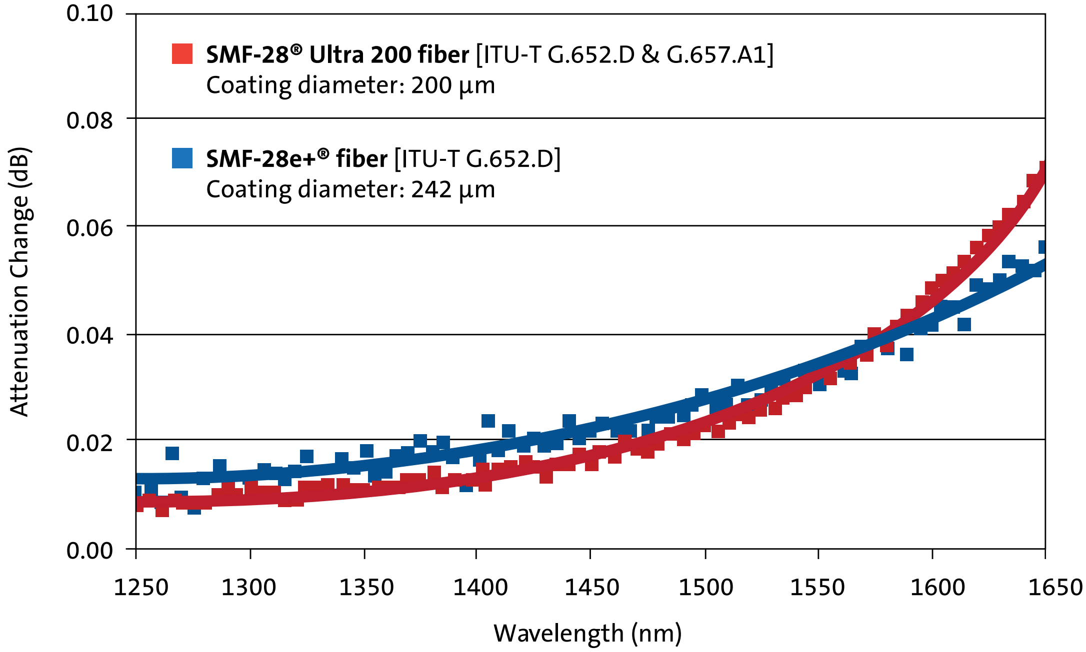

Figure 6. Comparative microbending in conventional and 200 micron fibers; assessed by wrapping fiber specimens under tension around a patterned measurement drum.

These measurement results also correspond with studies of OSP micro cables developed with SMF-28 Ultra 200 fiber. Application-based tests, such as cable bending, cable-mechanical and environmental tests show equivalent or extended cable performance which is attributed to the fiber design with improved bending resilience to ITU-T G.657.A1 standards or better.

Summary

Characterization testing and cable trials have demonstrated that SMF-28® Ultra 200 fiber satisfies the mechanical and optical specification requirements for industrialized high fiber-density micro cables used in OSP applications. The coating strip force and puncture resistance characterization test results are broadly equivalent to the lower-end distribution of historical and legacy fibers with conventional coating diameters used in similar applications. The microbending and macrobending resilience of SMF-28 Ultra 200 fiber is greater than benchmarks previously set by legacy conventional fibers due an optimal combination of glass and coating technology. The MFD specifications that are based on legacy ITU-T G.652.D and low loss fibers make SMF-28 Ultra 200 fiber attractive for OSP micro cable applications.

References

[1] Corning® SMF-28® Ultra 200 fiber product information sheet. www.corning.com/opticalfiber

[2] Corning Application Note AN-0021 “High Fiber Count Cable Miniaturization Using 200 µm Diameter SMF-28® Ultra 200 fiber, March 2015. www.corning.com/opticalfiber

[3] Quantifying the Puncture Resistance of Optical Fiber Coatings, G. Scott Glaesemann and Donald A. Clark, Corning Incorporated, IWCS Invited Paper, November 2003.

[4] Process handleability of thin-coated optical fibers, G. Scott Glaesemann, OFC Technical Digest, 1994.

[5] IEC 60793-2-50 4th Edition published in 2012, coating strip force test methodology IEC 60793-1-32.

[6] Mechanical Reliability: Applied Stress Guidelines – Corning White Paper WP5053, August 2001. www.corning.com/opticalfiber

Corning Incorporated
www.corning.com/opticalfiber

One Riverfront Plaza
Corning, New York
USA

Phone: (607)248-2000 (U.S. and Canada)
Email: cofic@corning.com