Measurement Considerations for Corning® ClearCurve® LBL and ZBL Optical Fiber

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Corning ClearCurve LBL optical fiber and Corning ClearCurve ZBL optical fiber provide low loss to bend radii as low as 7.5 or 5 mm, respectively, enabling their use in the most challenging installation environments. The design features of ClearCurve fiber that enable the superior macrobend performance also make it necessary to use standard compliant alternative measurement methods. This application engineering note identifies the measurements that are affected and provides the compliant measurement alternatives to ensure that accurate results are obtained at the factory or in the field.

Customers sometimes require spectral attenuation, macrobend loss, cable cutoff wavelength, and/or mode-field diameter (MFD) measurements on uncabled or cabled fiber. Commercial measurement systems that are readily available to conduct these common measurements employ an overfilled launch (OFL) condition which is required only for cable cutoff measurements. When spectral attenuation and MFD measurements are conducted, however, industry standards require the fiber under test to be in a single-mode condition. A single-mode condition is established by the removal of higher order modes (HOMs) that are excited in conjunction with the OFL. The HOMs are typically eliminated via macrobending through the use of mandrel mode filters. This method is effective on standard single-mode fibers and other fibers that are not designed for superior bend insensitivity.

The IEC MFD measurement standard, 60793-1-45, states the following about the use of mandrel mode filters: “use a means to remove high-order propagating modes in the wavelength range that is greater than or equal to the cut-off wavelength of the specimen. For example, a one-turn bend with a radius of 30 mm on the fiber is generally sufficient”. Furthermore, the cutoff wavelength measurement standard, IEC 60793 1 44, states that a higher order mode filter for bend insensitive fibers under test is not always suitable since the fiber is resilient to macrobend loss. In the case of bend insensitive fiber, alternate standard compliant procedures may be required to ensure that the required single-mode condition is established. For MFD measurements, ITU-T G.650.1 states in Section 5.1.1.2.3 that, “Care should be taken that higher order modes do not propagate. For this purpose, it may be necessary to introduce a loop of suitable radius or another mode filter in order to remove higher order modes.” This standard further states that “...suitable launching techniques could be: a) jointing with a fiber; (b) launching with a suitable system of optics”. Similar instructions are included in Section 5.4.1.2.3 for the measurement of spectral attenuation. The following sections explain in detail the alternative standard compliant methods that are necessary to obtain accurate measurements for MFD, cable cutoff wavelength, spectral attenuation, and macrobend loss.

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Mode-Field Diameter (MFD) Measurements

Per IEC 60793-1-45, mode field diameter measurements are typically conducted on a two meter fiber sample. Since commercially available test equipment typically employs an overfilled launch, the measurement method requires the use of a higher order mode filter to ensure a single-mode launch condition. For conventional standard single-mode fiber, this is routinely accomplished by applying one turn around a 60 mm diameter mandrel (Figure 1a). For ClearCurve LBL fiber and ClearCurve ZBL fiber, a bend of one turn around a 60 mm diameter mandrel is not a sufficient higher order mode filter. An alternate standard compliant method is needed. As noted in ITU-T G.650.1 Section 5.1.1.2.3, a fiber can be used as the higher order mode filter. This can be accomplished by splicing on two meters of SMF 28e+® optical fiber (or other ITU-T G.652-compliant standard single-mode fiber) and applying two 80 mm turns to the SMF-28e+ optical fiber (Figure 1b). Alternatively, increasing the length of fiber under test to 22 meters, which corresponds with the required length for the cable cutoff wavelength measurement, will also provide the necessary higher order mode filtering.

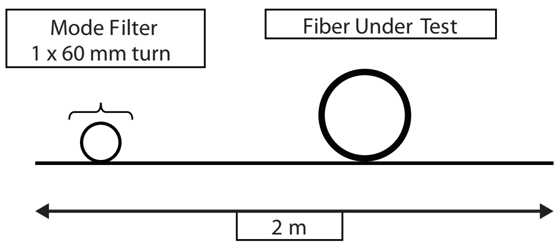

Figure 1a:
Conventional Standard Single-Mode Fiber

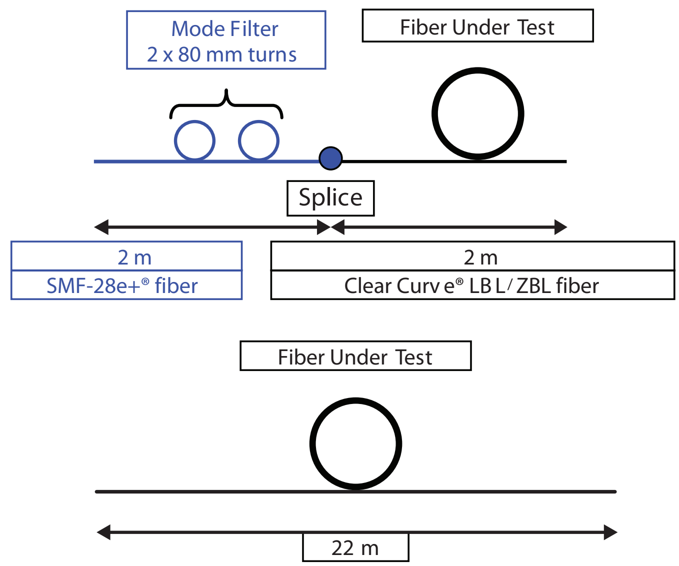

Figure 1b:
Bend Insensitive Single-Mode Fiber
with Spliced on Higher Order Mode Filter

Cable Cutoff Wavelength Measurement

Section 1 of IEC 60793-1-44 identifies two methods for measuring cable cutoff wavelength (Figure 2):

a. Bend reference technique
b. Multimode fiber reference technique

As noted in IEC 60793-1-44, the bend reference measurement method cannot be used for bend insensitive single-mode fibers since they exhibit minimal additional higher order mode attenuation when subjected to small diameter bends. If a bend reference cable cutoff wavelength measurement is attempted, the results will likely be indeterminate and unreliable (see Figure 3). This IEC standard states that cable cutoff wavelength measurements using the multimode reference technique are acceptable and provide excellent results.

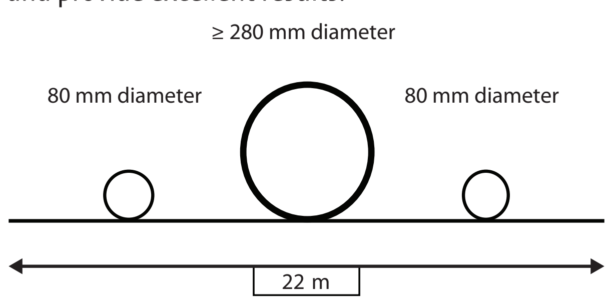

Figure 2:
Fiber under test layout for both cutoff wavelength measurement methods

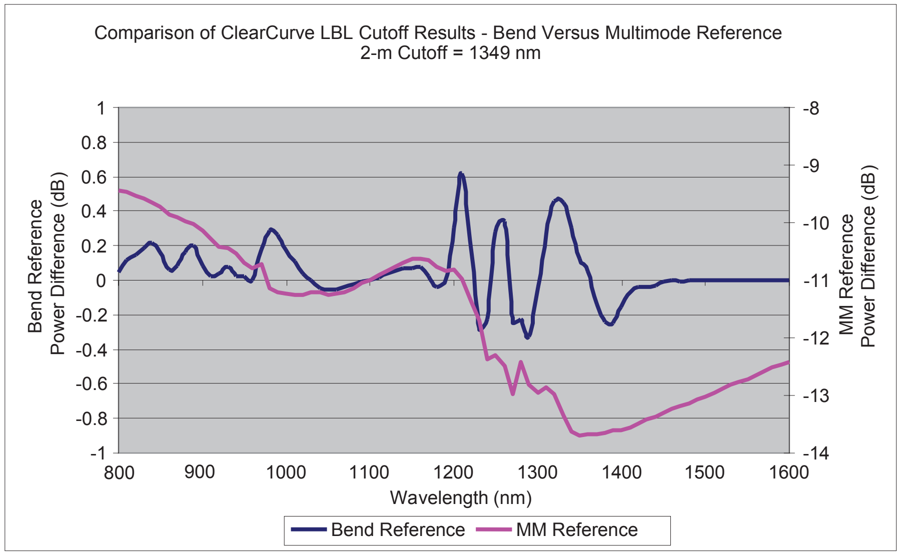

Figure 3

Cutoff Wavelength measurement results, comparison of bend versus multimode reference

Spectral Attenuation

IEC 60793-1-40 states that higher order modes must be removed when measuring fiber attenuation via the fiber cutback measurement technique. As seen in Figure 4a, a higher order mode filter would typically be implemented by placing a mandrel mode filter in the launch side of the fiber under test. This technique does not always work for a bend insensitive fiber because it is insensitive to bend and HOMs may not be completely removed. As with the MFD procedure, an alternate standard compliant higher order mode filter can be established by splicing (joining) two meters of SMF-28e+® optical fiber (or other ITU-T G.652-compliant standard single-mode fiber) to the bend insensitive fiber under test and applying two 80 mm turns to the SMF-28e+ optical fiber, see Figure 4b. With the mode filter in place, the standard attenuation measurement via the cutback technique can be completed for the fiber under test. If the SMF 28e+ fiber is not used, attenuation results up to 1400 nm may be obscured and inaccurate due to the presence of higher order modes in the reference measurement (see Figure 5).

Equation 1: $$A(\lambda) = \left| 10 \bullet \log\left(\frac{P1(\lambda)}{P2(\lambda)}\right) \right|$$

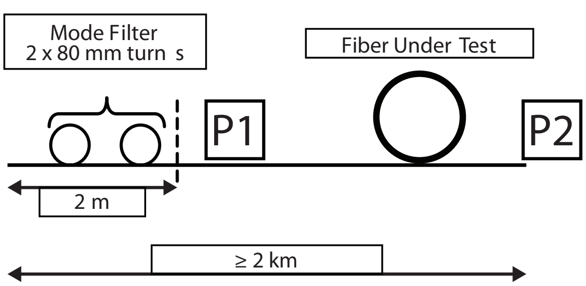

Figure 4a:

Conventional Standard Single-Mode Fiber

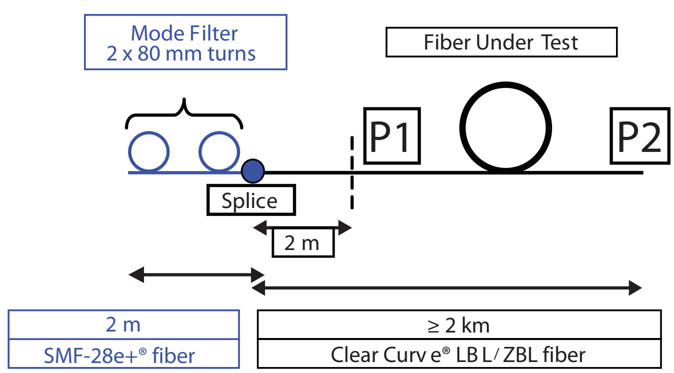

Figure 4b:

Bend Insensitive Single-Mode Fiber
with Spliced on Mode Filter

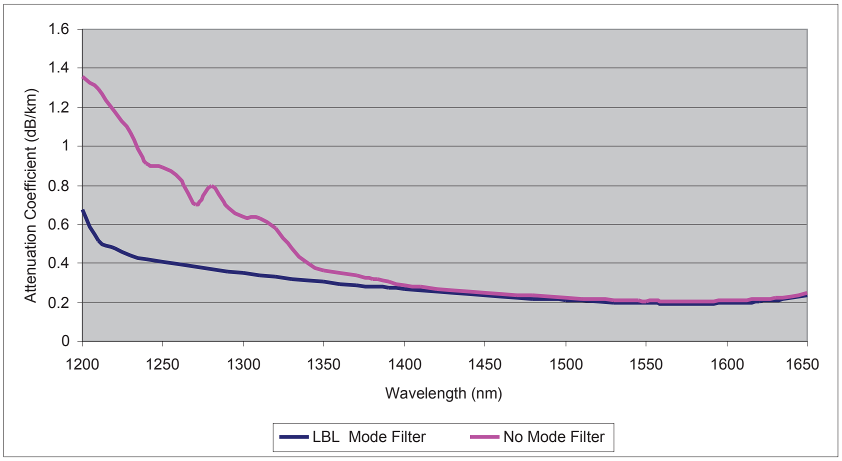

Figure 5.

ClearCurve® LBL fiber spectral attenuation measurement with and without proper mode filter

Macrobend Testing

Macrobend measurements incorporate the spectral attenuation measurement procedure as a normative reference. Therefore, Corning recommends that a two meter lead of SMF-28e+ fiber (or other ITU-T G.652-compliant standard single-mode fiber) be spliced to the sample prior to measurement. The lead meter is particularly important for multiple wrap measurements when fiber cutback is required. Corning also recommends the use of multiple wraps for macrobend testing. The additional wraps increase the measured macrobend response and abate whispering gallery modes. A minimum of five wraps should be used for five and ten millimeter radius macrobend measurements. Fifty to one hundred wraps is recommended for larger radius macrobend tests.

Field System Loss Testing

The use of 1, 2, and/or 3 jumper/cord reference measurements is common in the field to measure directly system link loss. As noted previously, shorter lengths of bend insensitive single-mode fiber may be multi-moded at 1310 nm. As a result, only conventional single-mode fibers should be used as reference jumpers for field system loss testing. If bend insensitive fiber jumpers are used, the observed testing loss may be erroneously high and not representative of actual system loss.

Other Optical Measurements

Other industry standard optical fiber measurements, such as dispersion and polarization mode dispersion, will not be impacted. Since these measurements require longer lengths of fiber (typically greater than one kilometer), the fiber will be single-moded at all wavelengths of interest. In general, any bend insensitive fiber measurements that involve sample and cutback lengths that are greater than 22 m will be no different from those on standard single-mode fibers.

Geometry and Physical Property Measurements

Industry standard glass and coating geometry measurements and other physical property measurements can be conducted in the same manner as any other single-mode fiber.

References

1. "Requirements for Bend Insensitive Fibers for Verizon's FiOS and FTTH applications" – Chen, Belben, Gallup, Mazzali, Dainese, Rhyne, NFOEC 2008.
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3. IEC 60793-1-40, "Measurement methods and test procedures – Attenuation", First Edition, 2001-07
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