Pearson Technologies Inc.

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OTDR Subtleties- BI Multimode Fibers

During the last 31 years, this author has been active in fiber-optic communications. During that time, there have been many significant changes in the technology:

- Multimode to singlemode fibers
- Attenuation rates from 6 dB/km to below 0.19 dB/km
- Wavelength from 850nm to and above 1550nm
- Data rates at 10 Mbps to 400,000,000,000 Mbps (400 Gbps)
- Optical transmission from a few kilometers to 7000km
- Fiber transmission of a single wavelength to 128 simultaneous wavelengths
- Fiber counts from 288 to 3456
- OTDR's with boxcar averagers and manual measurement to sophisticated CPU-controlled equipment providing automatic trace analysis and, in the latest generation, generation of link maps.
- Fibers from bend sensitive to bend insensitive

All of these changes have been the result of incredibly creative engineers and scientists. To them, we give our congratulations for their significant accomplishments. In this article, we address the last subject, bend insensitive fiber.

Part 1: Bend Insensitive Multimode Attenuation Rate Testing

While the industry has justifiably regarded the development of bend insensitive OM3 fibers as an advancement, there has been at least one unexpected consequence: we have observed unusual, high multimode OTDR attenuation rates, hereafter ‘rates’, in both bend insensitive fibers and cables.

These high rates can result in rejection of properly installed cables due to excessive attenuation rates, misinterpretation of rate values, and improper interpretation of such rates during troubleshooting activities. These high rates can result in misinterpretation of OTDR data from data centers, as data centers have relatively short fiber lengths, in which these increased rates occur.

The OTDR test results from some multimode fibers have indicated increased rates at the fiber ends near the OTDR. These increases are not due to high connector reflectance. Nor are these increased rates unique to a single fiber: we observed them in multiple fibers and cables. These increased rates are not due to OTDR noise, as test conditions chosen to reduce noise did not eliminate the increases. Finally, these increased rates are not unique to an OTDR, as we observed these increases with three different OTDRs.

These increased rates appear as a transient effect that decreases with increasing distance from the OTDR. A quick review of a trace may not indicate this increase, as it can be subtle.

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When we tested fiber sections, which exhibited increased forward-direction rates, in the reverse direction, these increases disappeared (Figure 1). Note that the rate exceeds the specification, 3 dB/km, at 100m in the forward direction and at 1100m, which was 100m from the launch cable, in the reverse direction.

Not all bend insensitive multimode fibers exhibit increased attenuation rates at the end near the OTDR. In Figure 2, we present an example of test results from such a BI multimode fiber, which was tested under the same conditions as those for Figure 1.

In addition, as the length of the launch cable increased, the increases in rate decreased. Thus, the rates of the fibers are dependent on the distance of the fiber segments from the OTDR (Figure 3).

This is an undesirable situation, since tests, at different times, of the same fiber with different length launch cables result in different attenuation rates. Such differences in rates create problems in two situations: during initial certification of a link and during troubleshooting. Figure 2 presents examples of this unusual increased attenuation rate.

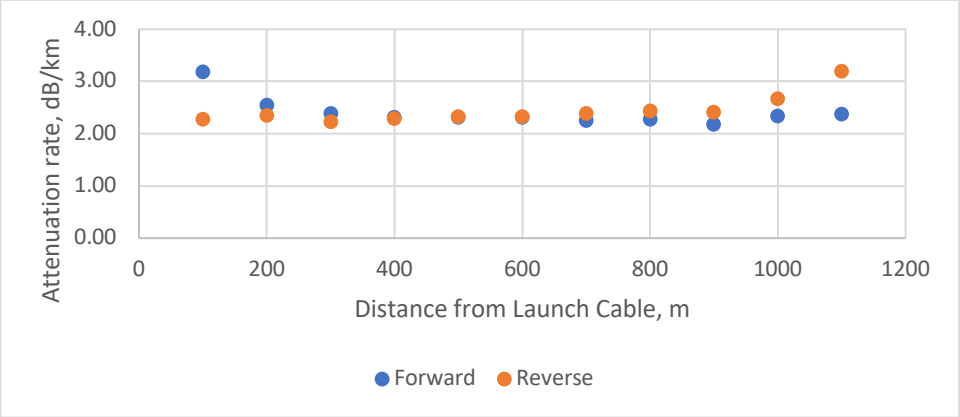

Figure 1: 100m Sub-Segment Attenuation Rates Vs. Distance from Launch Cable

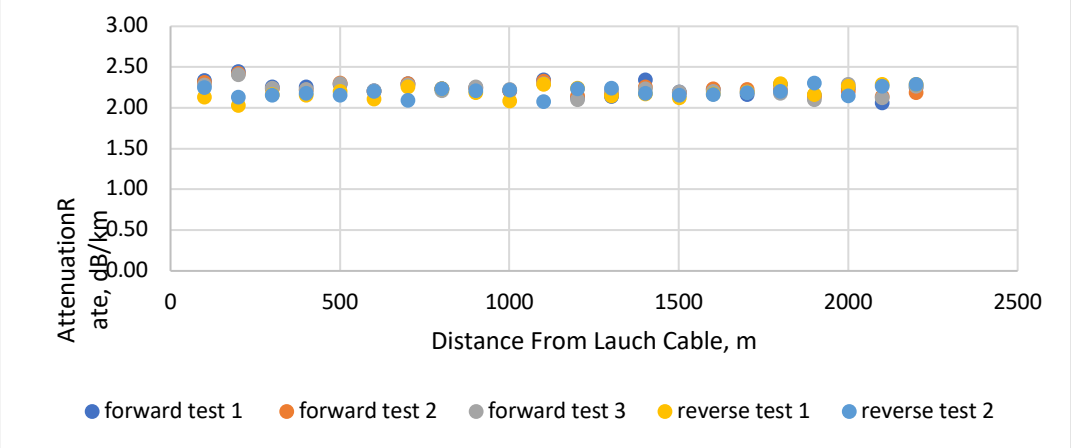

Figure 2: 100m Sub-Segment Attenuation Rate Vs. Distance from OTDR Launch Cable

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There are two consequences of using the rate values determined by the OTDR software, First, after initial installation, increased attenuation rate can result in improper rejection of the cable due to that rate exceeding the maximum specification. Second, during troubleshooting, this increased attenuation rate can be misinterpreted as indicating improper installation, damaged cable, or degraded cable.

We make the following five observations.

- Manual measurements of the OTDR rate tend to result in increased attenuation rate values.
- When the segment length is longer than the length exhibiting increased rates, approximately 100m, the automatic trace analysis software tends to reduce the increase in the rates. This reduction is a result of the use of the least-squares analysis method, (LSA) otherwise known as best fit method, for determining attenuation rate from the individual data points. The LSA method tends to distribute the rate in the section of increase over the entire fiber length.
- The increased rate occurs at multiple pulse width and time settings.
- We have not observed this behavior on 0M1 or OM 2 fibers which were not bend insensitive. Nor have we investigated this behavior on singlemode fibers.
- Because fibers with and without this increase have approximately the same reflectance, connector reflectance is not believed to be the cause increased rates.
- As increased rates are an artifact of OTDR testing, such rates do not indicate excessive power loss, as determined by standard insertion loss tests.

In summary, some bend insensitive multimode fibers exhibit increased OTDR attenuation rates due to a transient condition that occurs at the end of the fiber near the OTDR. This condition is an artifact of OTDR testing and not a characteristic of the fiber. Such increased rates can complicate link certification or troubleshooting.

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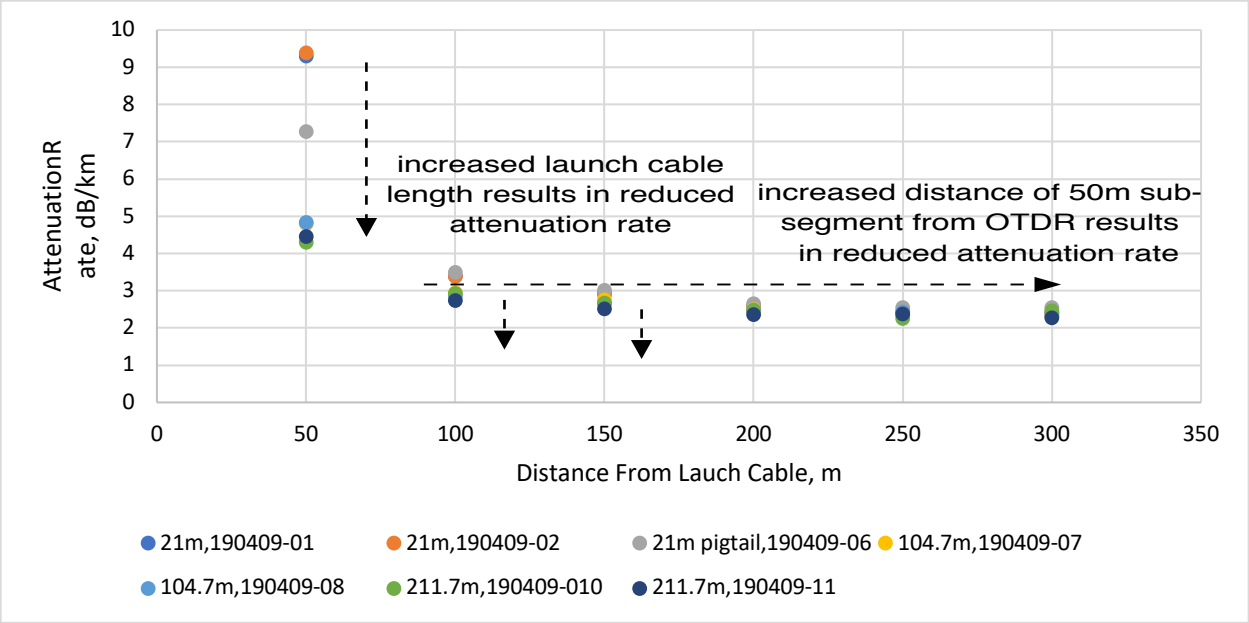

Figure 3: Attenuation Rate of ~50m Subsegments Vs. Distance from OTDR With Different Length Launch Cables

About Pearson Technologies Inc.

For the last 39 years, Pearson Technologies Inc. has provided fiber optic training in design, installation, and testing of fiber optic networks. In addition, Pearson Technologies provides technical support for lawsuits involving patent and cable damage issues. For more information, contact: Eric R Pearson, CFOS/T/C/S/I at: fiberguru@ptnowire.com, www.ptnowire.com, or 770-490-9991.