Application Note

Testing optical fiber in a Manufacturing Environment

MT9083
Access Master

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Background
Optical cable manufacturing companies test their completed cables with an OTDR (Optical Time Domain Reflectometer) to ensure key parameters of their fiber. Some cable manufactures are moving from the more expensive traditional lab bench top style of OTDR to a more cost effective field test OTDR's used by telecom operators and installers.
The priority, importance's and accuracy of the tests performed by the cable manufactures are different from telecom operators, these areas are discussed in this application note.
As field OTDR's are designed around telecom operators it's important for the cable manufacture to understanding these differences and possible effects on the results of the cable under test.

Below are the key areas of interest with regards to OTDR's for cable manufactures, including information on possible affect coursed by different specifications.

Common OTDR wavelengths
The wavelength selection for cable manufactures can differ from the telecom operator requirements. Key wavelengths for the telecom operator are normally 1310, 1490, 1550nm for testing the network at operational wavelengths and 1625nm for confirming good installation practices (macro bending for example).
For the cable manufactures often 1383nm is more important than 1625nm to gain insight into any possible issues with the water peak or confirm the water peak as been removed on relative fibers. ITU-T standard G.652 talks about the different attenuation of fiber G.652C and G.652D both have reduced water peak requirements. The attenuation of these fiber types at 1383nm is required to be less than or equal to the highest attenuation between 1310 to 1625nm. As 1310nm has the highest attenuation across this spectrum people often refer to the loss per km at 1383nm having to be less than that at 1310nm. Full specification details can be obtained from the ITU web site at http://www.itu.int which should always be referenced for the latest and most accurate information.

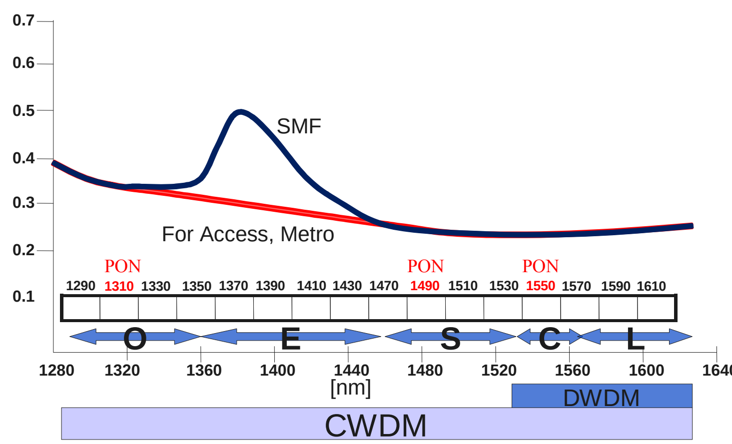


Figure 1 showing dB loss per km on both G.652 and G.652C/D fiber.

Figure 1 shows the two common fiber attenuation curves of dB loss across spectrum, with or without the water peak.

Attenuation at different wavelengths
It is also possible to see in figure 1 above that the dB/km loss is different at different wavelengths with 1550nm having the smallest loss while 1310 and 1625nm being higher. If we now look into more details around the most commonly used wavelengths we can see that either side of 1310 and 1550nm the loss isn't constant. As the fiber doesn't have constant loss at this point it can course issues for cable manufactures when looking at the dB/km loss which this is often considered the most important specification.

As the loss varies in an ideal situation a cable manufacture should test on an exact wavelength to ensure the correct reading but when looking at OTDR test equipment specifications they indicate the wavelength accuracy varying up to ±30nm.
When looking at a range from 1280nm - 1340nm and the dB loss of the fiber across this range, the typical loss slop of fiber across this spectrum varies by an average of 0.00105dB/km/nm with 1310nm having a typical loss of 0.3300dB/km.

- Note table 1 is based on a typical slop of fiber, different fiber manufactures specifications will vary. It is also assuming the loss to be linear across this spectrum to simplify the mathematics, in reality the loss of fiber across spectrum is non-linear.

Wavelength in nm	Variation from 1310nm	Loss difference from 1310nm assuming 0.00105dB/km/nm	dB/km loss at wavelength	Affect
1280	-30	-0.0315	0.3615	Higher loss than expected making the cable look bad.
1310	0	0	0.3300	Ideal dB/km loss number
1340	+30	+0.0315	0.2985	Lower loss than possible to obtain on optical fiber

Table 1. 1310nm loss per km variation across a range of ±30nm

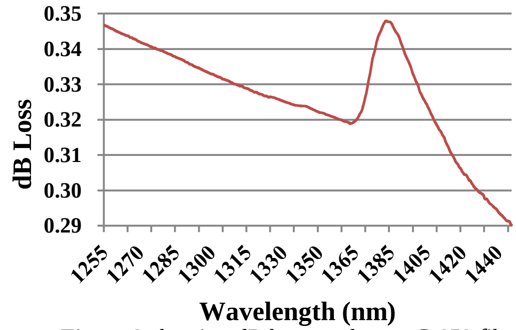
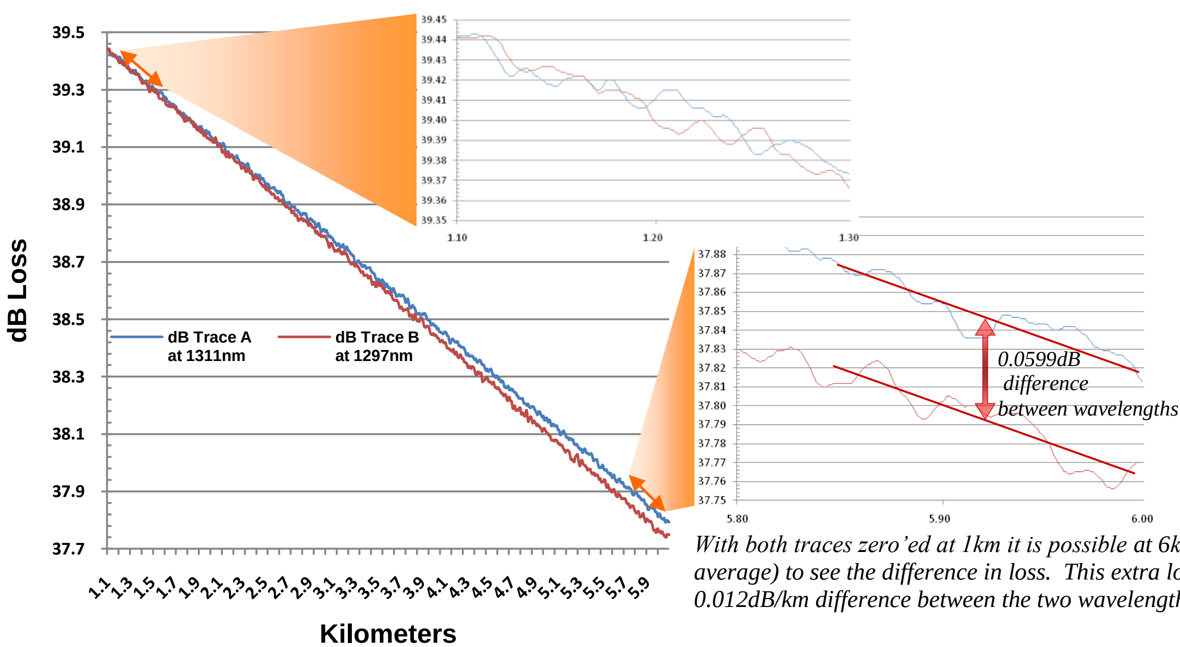


Figure 2 showing dB loss per km on G.652 fiber

When completing actual spectrum loss across cable the results will vary from the above calculated results. Figure 2 is a test of optical attenuation loss on G.625 optical fiber.

In figure 3 you can see two different OTDR traces of the same fiber with the only difference being the wavelength used for testing. In this case the difference in wavelength is only 14nm (1297 – 1311nm) which corresponds to a loss variation of 0.0137dB/km/nm at 1297 and 0.0011dB/km/nm at 1311 which is a loss of 0.344dB/km and 0.329dB/km, rather than the normal 0.33dB/km at 1310nm.



With both traces zero'ed at 1km it is possible at 6km's (5.8 window average) to see the difference in loss. This extra loss equates to 0.012dB/km difference between the two wavelengths tested.

Figure 3. The same fiber tested at 1297 and 1311nm showing the difference in loss per km

With the above information we can see the actual transmutation wavelength of the OTDR supplied to a cable manufactory is very important or at a minimum understanding it's affect on the results of any testing.
It's also important to note if the OTDR specifications are "Typical" or "Guaranteed", with guaranteed meaning it is within the stated specification (at time of shipment or re-calibration) while typical isn't so well defined and it indicates the larger % of this type of OTDR shipped are within the specification.

Linearity of the Trace

For telecom operators trace linearity is commonly discussed with reference to long distance measurements especially at the far end of the OTDR's dynamic range or across different internal amplification stages of the OTDR. Linearity across these areas is very important for testing long distances such as telecom exchange to exchange fibers. Modern OTDR's are designed to minimize any bad linearity effects as well as checked and adjusted (if required) during the calibration process.

In Figure 3 we can see two OTDR traces with the red trace showing an OTDR with bad linearity and the blue a good reference trace.

As cable manufactures are commonly testing short optical distances the above mentioned areas are often not of a major concern. Cable manufactures are more often concerned with linearity after a reflection. This is especially important at the connection point of the launch fiber and the fiber under test which is often completed using a bare fiber adaptor. Due to the nature of how a bare fiber adaptor works (aligning two cleaved fibers to touch) this is often not a perfect connection, commonly coursing a large reflection.

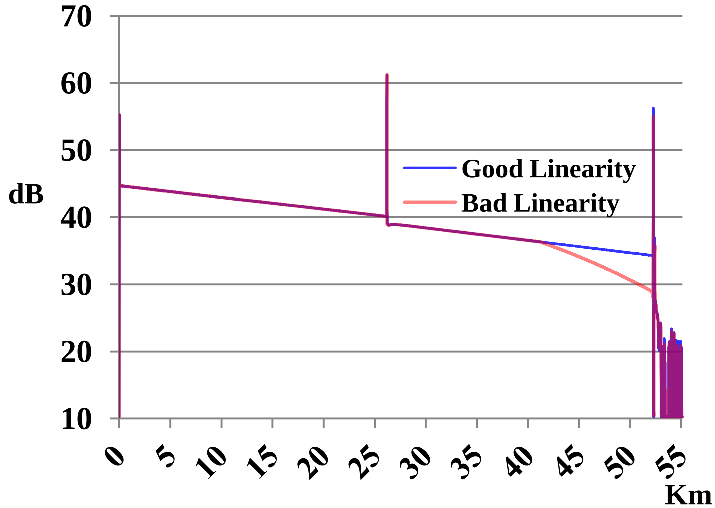


Figure 3. OTDR with bad linearity over a long distance.

Fig 4 below shows two traces overlaid, the blue trace showing a good connection at 2.31km while the red showing the effect of a less than perfect connection. The bad connection shows a very high reflectance of over -25.5dB, this is coursing the no-linear section of the trace directly after the event. Cable manufactures often measure the dB/km by placing one marker just after the launch cable and the second at the end of the fiber, the placement of the first marker within this no-linear section will course an inaccurate dB/km reading.
This high reflection is also the course of the ghost event at 4.62km (2 x 2.31) which is not a real event but an image coursed by the high reflection at 2.31km.

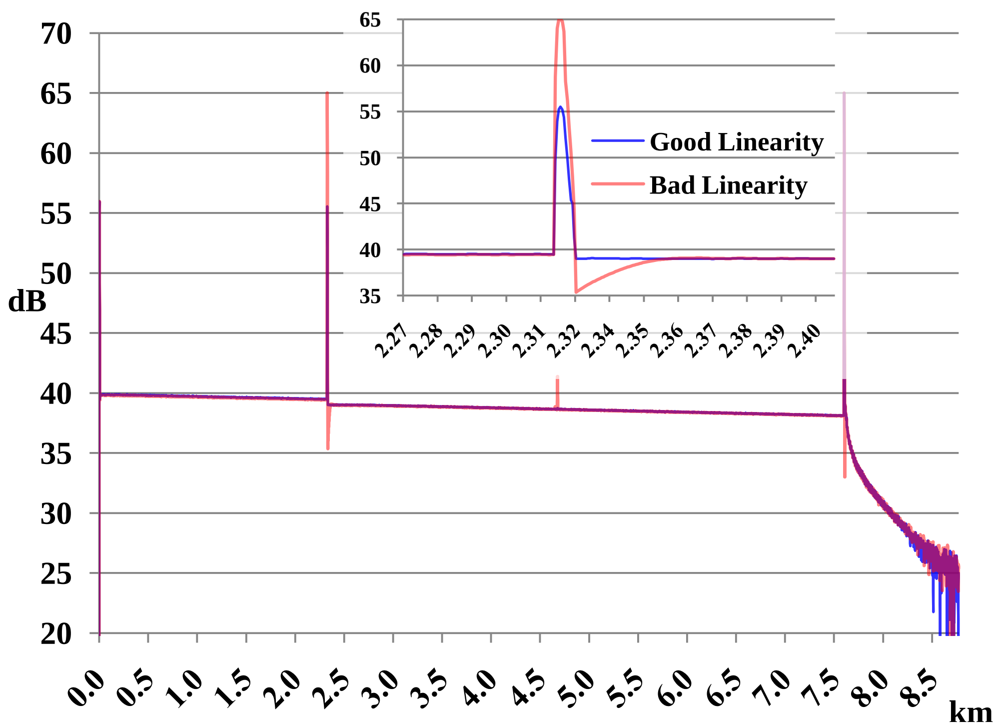


Figure 4. Affect of linearity after large reflection

With the testing of relatively short distances, less than 10km the affect of this bad connection coursing the recovery issue is much more relative due to the large possible impact on the dB/km result. To address this issue it is possible move the position of your first marker to a point of the trace where normal linearity is obtained.

Normal linearity is where the dB/km loss is constant along the length of the trace i.e. setting two markers 100m apart and as you move these markers along the trace there is minimal change in the dB/km loss figure. This distance location after a reflection will vary as it depends on many factors such as reflectance of the event, PW (Pulse Width), Range and Resolution settings of the OTDR. Due to this it's not possible to simply say "x" distance away from the reflection is the location you should set your first marker.
To addresses this issue always use clean and high quality connectors with reflectance values of lower than -50dB and the correct optical setting for the fiber under test. The most critical setting will be your PW followed by the Resolution and Range settings.

Conclusion

OTDR design has advance in many areas in recent years which has allowed cable manufactures to utilize field portable versions of OTDR's for their testing requirements. Key areas allowing this to happen are testing time for achieving an accurate clean trace, fast real time measurements, short dead zones, high resolution, automated trace naming and reporting. But selecting an OTDR for cable manufacturing testing also requires some careful consideration of other areas such as wavelength accuracy and linearity as discussed above. Understanding these key areas not only assist in the correct OTDR selection but also gaining greater insight to measurement results especially with reference to dB/km measurements preformed in a cable manufacturing environment.

Anritsu Field Optical Solutions

MT9083 ACCESS Master Series ACCESS Master MT9083 is the first all-in-one tool that does not compromise performance. It features extremely high resolution to see those closely spaces splices and connectors, while still being able to certify 100+ km spans- quickly and accurately. Whatever your work, construction or maintenance or long haul, Anritsu has an MT9083 model for your needs.	
CMA5000a Multi-Layer Network Test Platform CMA5000a optical test modules can support field installers, maintenance engineers and manufacturing requirements. With high dynamic range, extremely high datapoint spacing and scripting remote control it's the ideal tool for any requirement. Combining the OTDR modules is also possible with other optical technologies such as PMD, CD and ORL.	

Anritsu

Specifications are subject to change without notice.

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