OCC-206-9

Fiber Optic Field Testing Guidelines Excerpt from Optical Cable Corporation's INSTALLATION GUIDE

Field Testing

Field testing fiber optic cables can be done with different types of equipment. Most test procedures for this equipment have been standardized by national standards bodies such as TIA (Telecommunications Industry Association) and EIA (Electronic Industries Alliance). The most commonly used pieces of equipment are the power meter and source and the OTDR (Optical Time Domain Reflectometer).

Power Meters

The power meter is used in conjunction with a source (operating at wavelengths of 850 nm & 1300 nm for multimode fibers or at 1310 nm & 1550 nm for singlemode fibers) to measure the light loss in a fiber optic cable. The unit of measure is milliwatt (mW) or decibel (dB). In the measurement of light loss in an optical fiber or cable, a decibel is the ratio, in logarithmic form, of the power levels at the input and output ends of the cable.

The test source for a loss measurement should be similar to the actual sources that will be used in the network system that is under test. The source should be the same type, wavelength, and modal distribution as the network transmitters.

Mulitmode Fiber Modal Effects

In order to test multimode fiber optic cables accurately with a power meter and source, the modal distribution must be conditioned. The most commonly used mode filter during field testing is the mandrel wrap, which removes higher order modes effectively by stressing the fiber. TIA/EIA-455-50B "Light Launch Conditions for Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements" requires different mandrel sizes based upon the fiber core size.

Fiber Core Size	Mode Filter Mandrel Diameter
50µm	25 mm
62.5µm	20 mm
100µm	25 mm

5 turns around the mandrel is required. The mandrel should be smooth and round. For fiber that has been jacketed, the mandrel wrap diameter should be reduced by the overall cable diameter. For example, to test a 3 mm cable would require a 22 mm mandrel for a 50µm multimode fiber (25 mm - 3 mm = 22mm). For larger cable diameters, be careful not to exceed the minimum bending radius limits when using the mandrel wrap. Stripping or removing the buffered or coated fibers from a cable is the preferred approach.

Singlemode Fiber Modal Effects

Singlemode fiber supports one mode of transmission. Problems with mode distribution are not a factor. However, it does take a short distance for sinlgemode fiber to actually become singlemode. Short singlemode fibers may have multiple modes. A 4 to 6 inch diameter loop of fiber may be used to strip out these multiple modes.

Testing

There are two methods that can be used to measure loss with power meters in fiber optic cables: Single reference testing and double reference testing. Both methods are described in TIA/EIA-455-171 "Attenuation by Substitution Measurement – for Short Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies".

Single Reference Testing

Single reference testing is done by mating the fiber optic cable that needs to be tested to a reference launch cable, which is connected to a source, and measuring the power out the far end of the fiber optic cable with a power meter. In order to get an accurate measurement of the fiber optic cable, the loss of the reference cable has to be "zeroed" out (0 dB) or subtracted from the total loss. This is done by connecting the reference cable to the source and to the meter. Depending on the equipment, this loss of the reference cable can either be "zeroed" out (0 dB) on the power meter or the loss may have to be written down and then subtracted from the loss of the fiber optic cable when it is tested. See Figures 1-1 and 1-2.

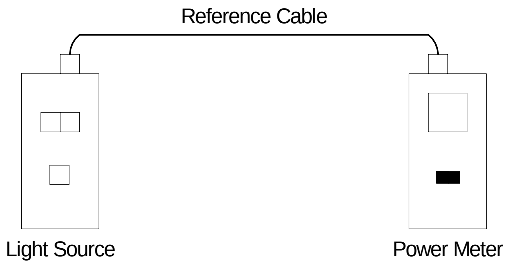

Figure 1-1: Referencing (Zeroing) the Launch Cable for Single Reference Testing

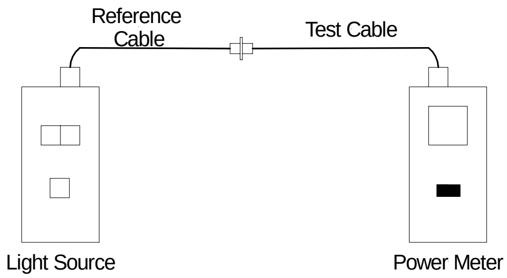

Figure 1-2: Single Reference Testing

However, since only one launch cable is used, the loss measured for the fiber optic cable also includes the loss of the connector mated to the launch cable and the fiber optic cable. Optical Cable Corporation does not recommend this method of loss testing with power meters.

Double Reference Testing

Double Reference testing is done by attaching the fiber optic cable that needs to be tested between two reference cables, one attached to the source and one to the power meter. In order to get an accurate measurement of the fiber optic cable, the loss of the two reference cable has to be "zeroed" out (0 dB) or subtracted from the total loss. This is done by connecting the two reference cables together, with one attached to the source and one attached to the meter. Depending on the equipment, this loss of the reference cables can either be "zeroed" out (0 dB) on the power meter or the loss may have to be written down and then subtracted from the loss of the fiber optic cable when it is tested. See Figures 2-1 and 2-2.

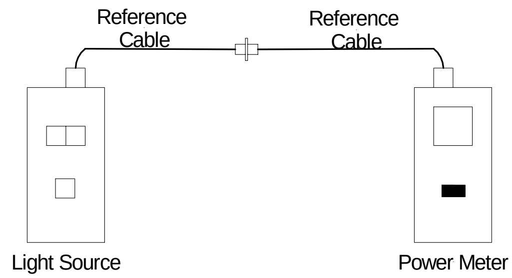

Figure 2-1: Referencing (Zeroing) the Launch Cables for Double Reference Testing

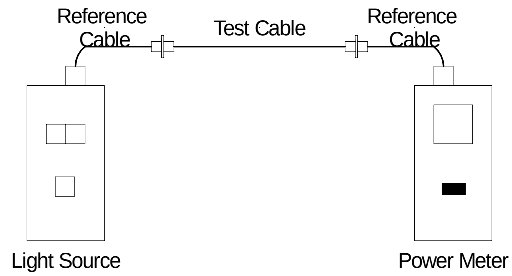

Figure 2-2: Double Reference Testing

Precautions

When testing with power meters, it is necessary to adhere to certain steps prior to and during testing.

All connectors being used should be cleaned prior to use. If several tests are being done, it may be necessary to periodically clean the connectors. The quality of the launch cable will affect the measurements.

When turning on the power meter and source for use, ample time should be given to allow the power meter and light source to warm up and stabilize.

Connectors on the ends of the reference cables that have poor end-faces (cracked, chipped, etc) should not be used. These damaged connectors could possibly damage the end face of the connectors on the test cable when mating and un-mating is done.

Optical Time Domain Reflectometer

The optical time domain reflectometer (OTDR) is used to visually represent an optical fiber's attenuation characteristics along its length. The OTDR plots these characteristics with the distance as the X-axis and the attenuation as the Y-axis. The OTDR uses backscattering to visually display these characteristics. When testing with an OTDR, short pulses of light are sent down the fiber from the OTDR. The reflected light measured by the OTDR is backscattering.

By knowing the fiber's index of refraction, the OTDR can accurately compute the length of a fiber and locate events along the fiber, such as splices, connector interfaces, bad bends, etc. The OTDR also measures the received optical power of the reflected light and plots an optical fiber's attenuation-by-distance display.

The graphical displays produced by the OTDR are an advantage over the power meters. The graphs can be stored for documentation and used for troubleshooting later. Another advantage for the OTDR is that only one end of the cable that is being tested is needed to make a measurement.

OTDR Test Set Up

If the cable to be tested is not connectorized, the cable should be stripped to expose approximately 6 inches or more of fiber. The fiber should be cleaned and cleaved. This also includes removing all primary coatings down to the cladding diameter of the fiber.

A quality "launch reel" of the same fiber type being tested should be connected to the OTDR with a length of approximately 1 km. This "launch reel" is necessary in order to measure past the "dead zone" in the OTDR. See Figures 3-1 and 3-2. Dead zones in the OTDR result from the very short period of time after the OTDR launches a light pulse into the fiber during which the OTDR cannot "see" the reflected light from the fiber. These dead zones occur at the beginning of the OTDR plots and can be up to 1 km in length. In the dead zone, the OTDR cannot determine events in the fiber. Therefore, it is necessary to have the launch reel. One end of the launch reel should be connectorized with a connector that mates to the OTDR output and the other end of the launch reel should be prepped for the type of connection needed on the fiber being tested (connector if testing to connectorized cable or bare fiber adaptor if testing to bare fiber). See Figure 3-2.

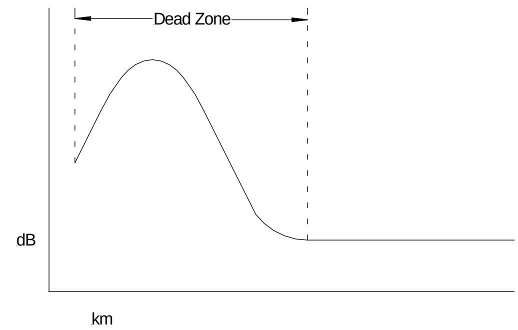

Figure 3-1: Dead Zone in OTDR Plot

The OTDR should be turned on and ample time should be given to allow the OTDR source to warm up and stabilize. Enter in the OTDR parameters for the test such as the wavelength, index of refraction, pulse length, etc. Be sure that no source is connected at the opposite end of the fiber being tested. If there is, disconnect the source at the opposite end. This could possibly damage the OTDR.

Once the previous items have been completed, connect the launch reel to the fiber being tested (either by connector adaptor or bare fiber adaptor). Start the OTDR test and allow the OTDR average the measurements long enough to provide a smooth trace.

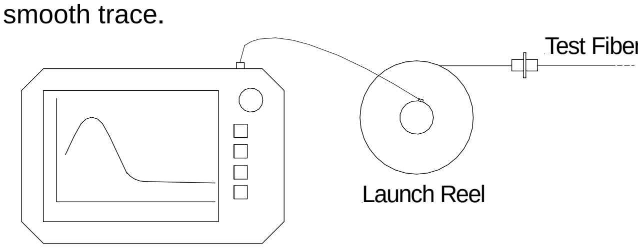

Figure 3-2: OTDR Test Set Up

OTDR Events

As mentioned earlier, the OTDR plots the length of the fiber on the X-axis and the loss (dB) on the Y-Axis. The sloped line plotted on the OTDR represents the fiber. The slope of the line represents the attenuation of the fiber over its length.

Also, the beginning of the plot is the called dead zone. See Figure 3-1. This is the non-linear region of the trace where OTDR events cannot be seen. Past the dead zone, the linear portion of the plot and accurate loss readings of the fiber under test can be seen. Following are plots with various events that may occur and explanations of those events (Figures 4-1 through 4-5).

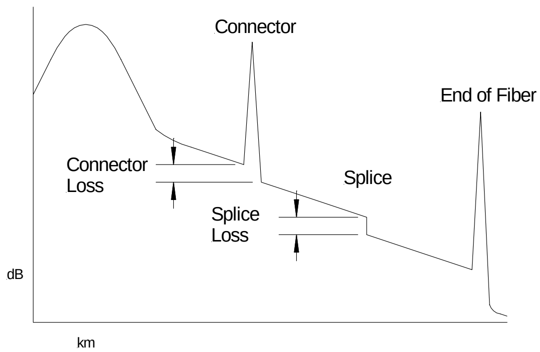

Figure 4-1: OTDR Plot with Connector and Splice Loss

The plot in Figure 4-1 represents an OTDR plot that contains a launch reel connected to fiber that contains a splice in it. The launch reel contains the dead zone and has a connector at the end of the launch reel. Where two connectors are mated together, the OTDR plot reveals a slight reflection (or spike) in the plot. The Y-axis difference from where the reflection begins and ends is the connector loss (two connectors mated together).

The plot in Figure 4-1 also reveals a splice in the fiber. A splice is displayed on the plot as a sharp drop. The Y-axis difference in where the drop begins and ends is the splice loss.

The plot in Figure 4-1 also shows the end of the fiber. This is seen as a sharp reflection (or spike) caused by the OTDR pulse reflected when hitting air. If there is no reflection at the end of the plot, then there is a possibly that the fiber is broke somewhere in the cable and the end of the plot is not the end of the cable. See Figure 4-2.

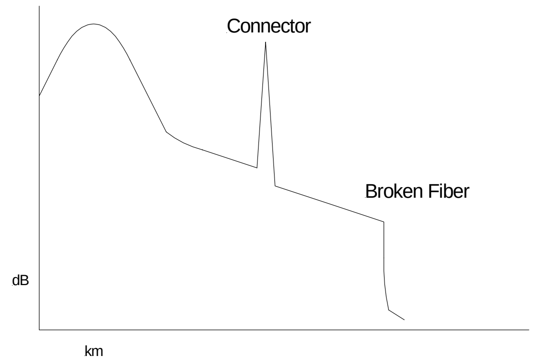

Figure 4-2: OTDR Plot with Broken Fiber

Splices can also be seen as a sharp rise (splice gainer). See Figure 4-3. This scenario is typically caused by a difference in mode field diameters between two fibers at the splice. For example, a splice gainer may occur when a splice is measured from light passing from a 62.5 µm fiber into a 50 µm fiber. In order to obtain a true splice loss, TIA/EIA-455-61A *Measurement of Fiber or Cable Attenuation with an OTDR* requires that a bi-directional average be taken to obtain the most accurate loss for a splice.

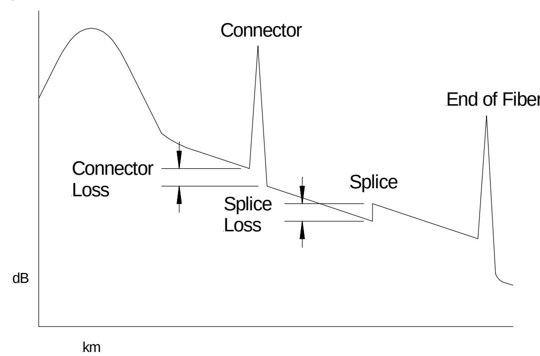

Figure 4-3: OTDR Plot with Connector and Splice Gainer

Other TIA/EIA documents that can be referenced when using an OTDR are TIA/EIA-455-59A *Measurement of Fiber Point Discontinuities Using an OTDR* and TIA/EIA-455-60A *Measurement of Fiber or Cable Length Using an OTDR*.

OTDR "ghosts" are typically seen on OTDR plots when testing short cables with highly reflective connectors. See Figure 4-4. These are caused by reflected light from a connector reflecting back and forth. Ghosts can be deceptive. The reflective event will appear to be connector loss. However, the reflective event will not show any loss (0 dB change on the Y-axis). Ghosts can be eliminated by reducing the reflections by using index matching fluid on the reflective connector or sometimes by thoroughly cleaning the connector.

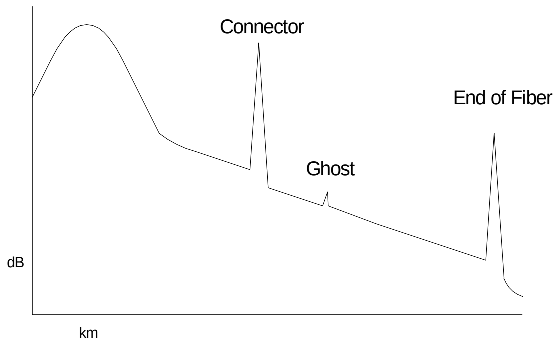

Figure 4-4: OTDR Plot with a Ghost

Point discontinuities can show up as “steps” on an OTDR plot. These steps can be caused by bends in the cable that exceed the minimum bending radius, the cable being crushed, etc. The plot in Figure 4-5 represents a cable with a step in the middle of the cable and a step near the end of cable.

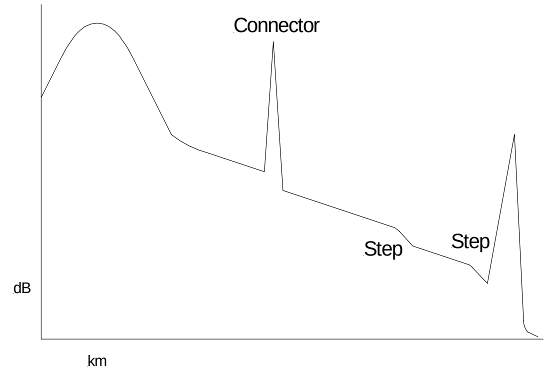

Figure 4-5: OTDR Plot with Steps