Fiber Optic Services And Products

EYE ON FIBER

The Novice 10 Minute Introduction to Fiber Optics

Fiber optic communications has been around for the last 25 years. However, many do not understand the basics of this exciting and powerful technology. More importantly, many novices do not understand the basic rules that govern the handling, installation and use of cables and connectors. In this article, we will present a brief overview of these basics of installation, use and handling. For a more detailed presentation, see Successful Fiber Optic Installation- The Essentials (V7.2, © Pearson Technologies Inc., 2007)

Fiber optic systems consist of fibers, two for data communications, one for some video links, which are encased in a cable to protect the fiber during installation and use, connectors on the ends of the cables and optoelectronics, which perform a conversion of the electrical signal to an optical signal at the transmitter and the reverse conversion at the receiver.

The fiber is usually glass with an outer diameter of 125 µm, approximately 0.005≤. Since the fiber is glass, the bending of the fiber and cable must be controlled. Control of bending is critical during two activities: installation of the cable and installation of connectors.

During installation of the cable, the installer must control both the short-term bend and the long-term bend radii. Violation of either of these bend radii can result in damage to the fiber. This damage has two forms: breakage during handling and delayed breakage after installation.

The short-term bend radius is the minimum radius to which the cable can be bent while the installer is applying the maximum recommended installation load, another important limitation of the cable. The rule of thumb is that the short-term bend radius is 20 times the cable diameter. For example, a .25≤ diameter cable may be bent to a radius of 5≤ (a diameter of 10≤) without risk of damage.

The long-term bend radius is the minimum radius to which the cable can be bent while it is under no load. The rule of thumb is that the long-term bend radius is 10 times the cable diameter. For example, a .25≤ diameter cable may be bent to a radius of 2.5≤ without damage. The installer must perform all handling of the cable without violating these two bend radii. (Wrapping the cable around your hand or stepping on the cable to pull it into place will probably violate a bend radius!)

Violation of either bend radius can result in a third problem: reduction in power at the receiver, which is often called excess optical power loss. The most common mistake during installation of cables is violation of the long-term bend radius to cause excess power loss.

The fiber has three regions: the core, the cladding and the primary coating, originally called the buffer coating (Figure 1). The core is the center region, in which most of the light energy travels. The cladding surrounds the core and confines the light to the core. The primary coating protects the cladding from damage so the fiber can retain its intrinsic high strength.

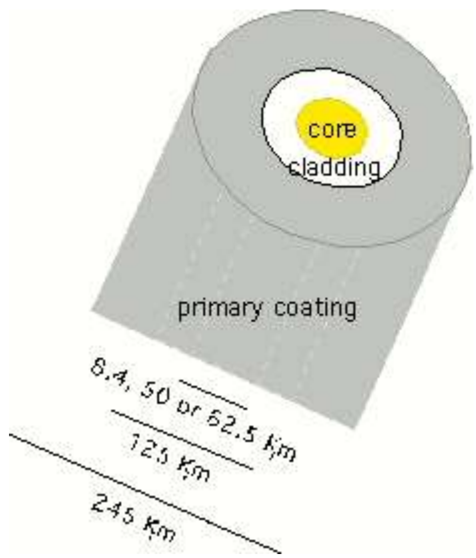

Figure 1: The Fiber Structure

During installation of the connectors, the installer removes the primary coating (stripping the coating) from the core and cladding. Note that the installer cannot strip the cladding. To do so to a glass fiber is impossible! If it were possible, stripping the cladding would allow the light to escape from the side of the fiber, not from the end!

After this coating is stripped, the cladding can be scratched, causing the fiber to lose its high strength. (Remember what happens to a pane of glass when you scribe it to break it so that it fits.)

If scratched and bent during connector installation, the fiber will break. If the fiber breaks inside the connector, the installer may lose the connector. The installer can avoid breaking the fiber by rotating the connector back and forth while inserting the fiber into the connector.

After the installer places the connector onto the fiber, the installer may need to cure the adhesive which grips the fiber. The installer cures 3M Hot Melt Æ connectors, some epoxy connectors and quick cure adhesive connectors by waiting the required time. The installer cures some epoxy connectors by heating the connector for a minimum required time.

Once the adhesive has cured, the installer must finish the end of the connector. Usually, the installer finishes the connector by polishing the end of the fiber so that the connector has the lowest possible power loss. From my experience with more than 32,000 connectors and training more than 4600 installers, I have observed that 95 % of the connectors that are lost are lost during end finishing. If the installer uses light pressure during three of the finishing steps, he is unlikely to lose the connector or cause high power loss.

These three steps are: scribing, air polishing and pad polishing. The installer removes excess fiber from the end of the connector by scratching the fiber with a sapphire, diamond or carbide tool. If the installer scratches the fiber with a light pressure and without bending the fiber, he will not break the fiber improperly. If the installer pulls the fiber away from the tip of the connector, he is unlikely to lose the connector.

The installer air polishes the connector by moving a coarse polishing film against the fiber until the fiber is flush with the bead of adhesive or epoxy. Again, use of a light pressure avoids breaking the fiber.

The installer polishes the connector by removing epoxy or adhesive with successively finer polishing films. Polishing is performed on a hard rubber pad. Glass plates were used in the past, but do not produce results acceptable for use with advanced optoelectronics (Gigabit Ethernet). By polishing with a light pressure, the installer avoids losing the connector, either by breaking the fiber or by over polishing the fiber.

After the installer polishes and cleans the connector, it will have low loss when the core is round, clear, featureless and flush with the ferrule (Figure 2). When the core meets this description, there is nothing to block the light or to divert the light from its proper path. For almost all connectors available today, the typical loss is 0.3 dB/pair. Note that this value is dB/pair, not dB/end.

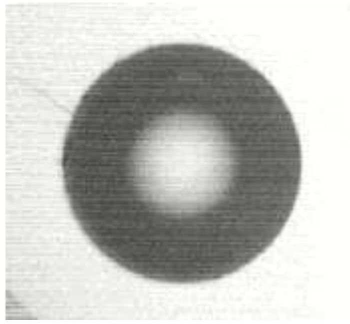

Figure 2: The Appearance Of A Properly Installed Connector

After polishing and cleaning the connector, the installer caps the connector. If a connector does not have a cap, dirt and dust from the air will collect on the core. Dirt on the core will block at least some of the light of a large core, multimode fibers with 50 or 62.5 µm core diameters. Dirt on the core can block all of the light if the fiber is singlemode with a core diameter will be 8-11 µm!

Installing fiber optic cables and connectors is not extremely difficult, but does require attention to details. After all, when my two sons were 11 and 13 years old, I taught them to build jumpers for use in training programs. The achieved low power loss and high reliability: I have never lost a jumper during training due to their installation methods!

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