FIBER OPTICS

THE BASICS OF FIBER OPTIC CABLE

BRIEF OVER VIEW OF FIBER OPTIC CABLE ADVANTAGES OVER COPPER:

• **SPEED:** Fiber optic networks operate at high speeds - up into the gigabits
• **BANDWIDTH:** large carrying capacity
• **DISTANCE:** Signals can be transmitted further without needing to be "refreshed" or strengthened.
• **RESISTANCE:** Greater resistance to electromagnetic noise such as radios, motors or other nearby cables.
• **MAINTENANCE:** Fiber optic cables costs much less to maintain.

In recent years it has become apparent that fiber-optics are steadily replacing copper wire as an appropriate means of communication signal transmission. They span the long distances between local phone systems as well as providing the backbone for many network systems. Other system users include cable television services, university campuses, office buildings, industrial plants, and electric utility companies.

A fiber-optic system is similar to the copper wire system that fiber-optics is replacing. The difference is that fiber-optics use light pulses to transmit information down fiber lines instead of using electronic pulses to transmit information down copper lines. Looking at the components in a fiber-optic chain will give a better understanding of how the system works in conjunction with wire based systems.

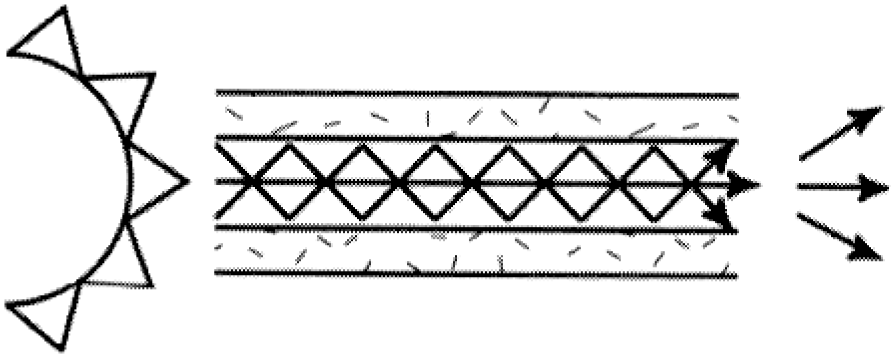
At one end of the system is a transmitter. This is the place of origin for information coming on to fiber-optic lines. The transmitter accepts coded electronic pulse information coming from copper wire. It then processes and translates that information into equivalently coded light pulses. A light-emitting diode (LED) or an injection-laser diode (ILD) can be used for generating the light pulses. Using a lens, the light pulses are funneled into the fiber-optic medium where they transmit themselves down the line.

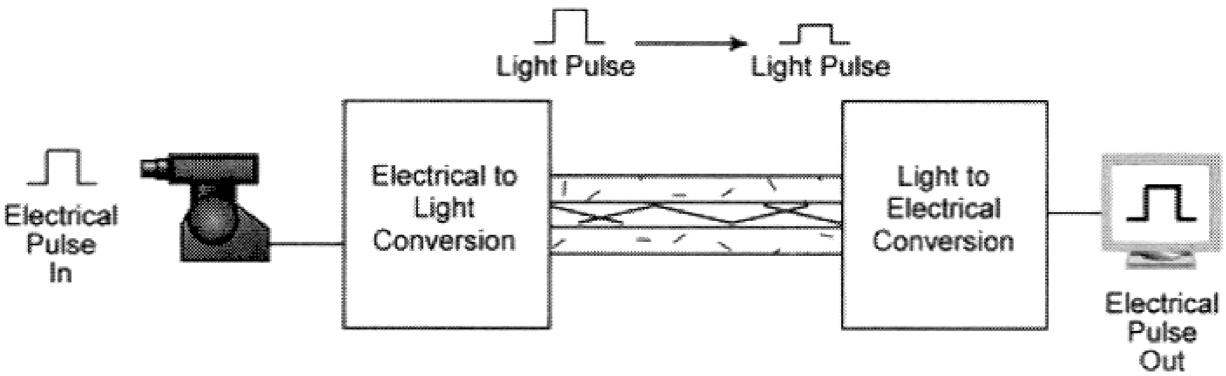
Think of a fiber cable in terms of very long cardboard roll (from the inside roll of paper towel) that is coated with a mirror.
If you shine a flashlight in one you can see light at the far end - even if bent the roll around a corner.

Light pulses move easily down the fiber-optic line because of a principle known as total internal reflection. "This principle of total internal reflection states that when the angle of incidence exceeds a critical value, light cannot get out of the glass; instead, the light bounces back in. When this principle is applied to the construction of the fiber-optic strand, it is possible to transmit information down fiber lines in the form of light pulses.

There are three types of fiber optic cable commonly used: single mode, multimode and plastic optical fiber (POF).

Transparent glass or plastic fibers which allow light to be guided from one end to the other with minimal loss.





Fiber optic cable functions as a "light guide," guiding the light introduced at one end of the cable through to the other end. The light source can either be a light-emitting diode (LED)) or a laser.

The light source is pulsed on and off, and a light-sensitive receiver on the other end of the cable converts the pulses back into the digital ones and zeros of the original signal.

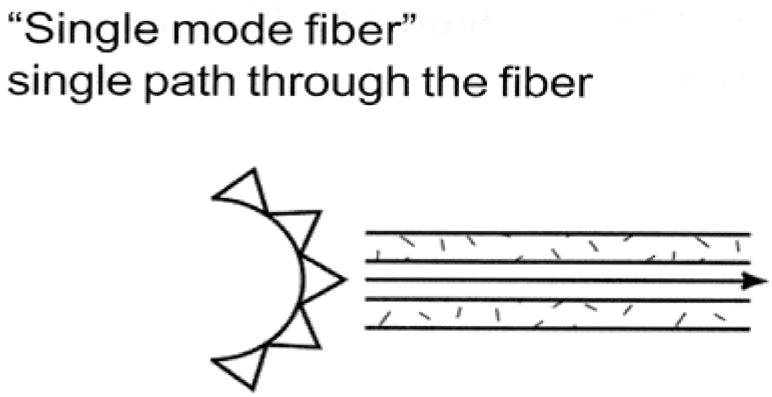
Even laser light shining through a fiber optic cable is subject to loss of strength, primarily through dispersion and scattering of the light, within the cable itself. The faster the laser fluctuates, the greater the risk of dispersion. Light strengtheners, called repeaters, may be necessary to refresh the signal in certain applications.

While fiber optic cable itself has become cheaper over time - a equivalent length of copper cable cost less per foot but not in capacity. Fiber optic cable connectors and the equipment needed to install them are still more expensive than their copper counterparts.

Single Mode cable is a single stand of glass fiber with a diameter of 8.3 to 10 microns that has one mode of transmission. Single Mode Fiber with a relatively narrow diameter, through which only one mode will propagate typically 1310 or 1550nm. Carries higher bandwidth than multimode fiber, but requires a light source with a narrow spectral width. Synonyms mono-mode optical fiber, single-mode fiber, single-mode optical waveguide, uni-mode fiber.

Single-mode fiber gives you a higher transmission rate and up to 50 times more distance than multimode, but it also costs more. Single-mode fiber has a much smaller core than multimode. The small core and single light-wave virtually eliminate any distortion that could result from overlapping light pulses, providing the least signal attenuation and the highest transmission speeds of any fiber cable type.

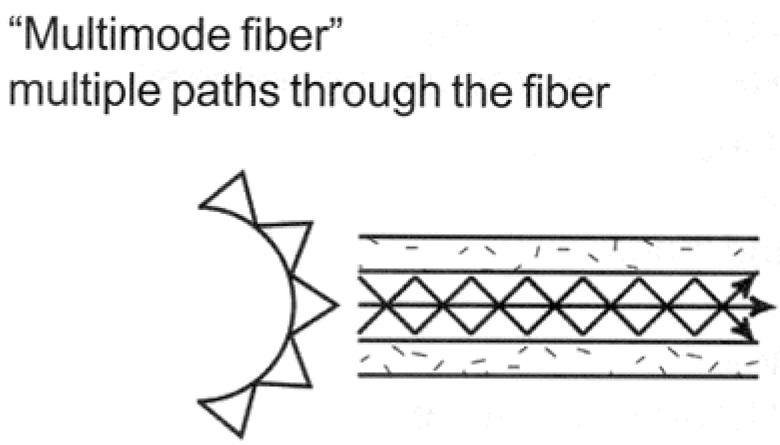
Single-mode optical fiber is an optical fiber in which only the lowest order bound mode can propagate at the wavelength of interest typically 1300 to 1320nm.

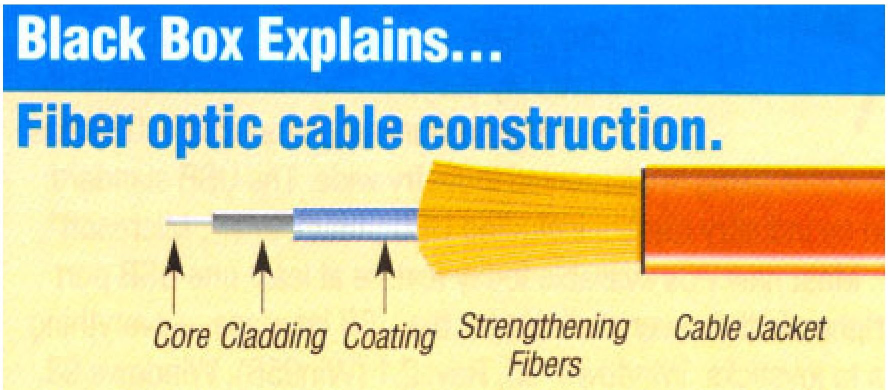


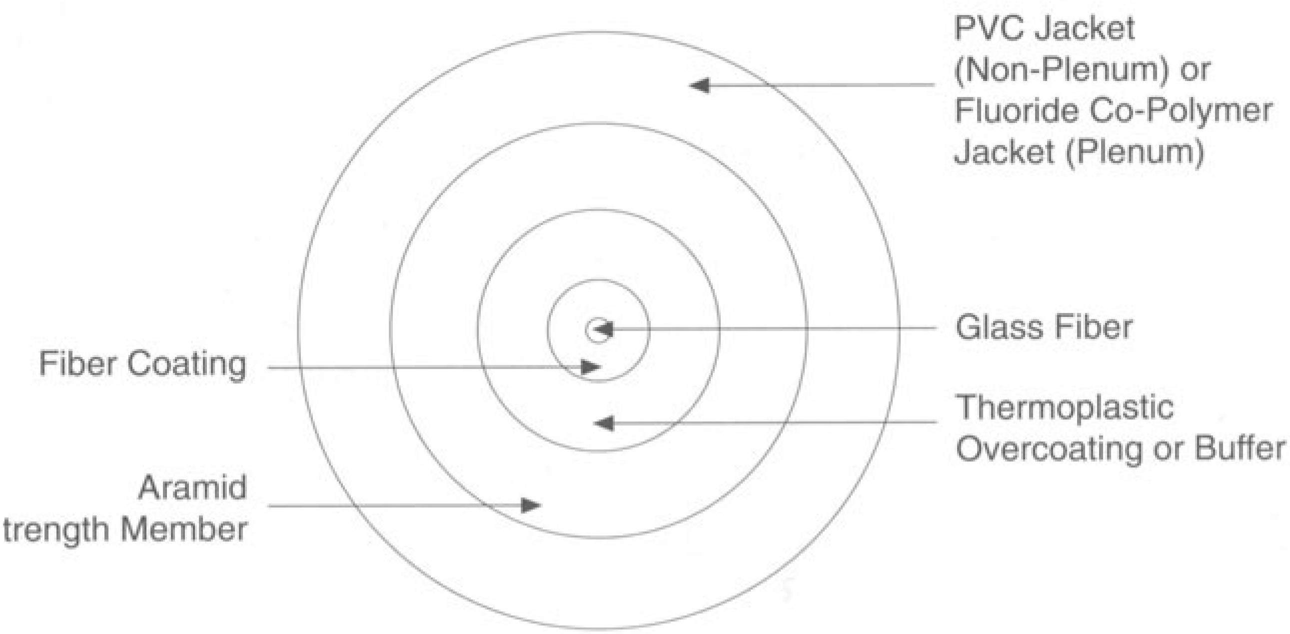
jump to single mode fiber page

Multimode cable is made of of glass fibers, with a common diameters in the 50-to-100 micron range for the light carry component (the most common size is 62.5). POF is a newer plastic-based cable which promises performance similar to glass cable on very short runs, but at a lower cost.

Multimode fiber gives you high bandwidth at high speeds over medium distances. Light waves are dispersed into numerous paths, or modes, as they travel through the cable's core typically 850 or 1300nm. Typical multimode fiber core diameters are 50, 62.5, and 100 micrometers. However, in long cable runs (greater than 3000 feet [914.4 meters), multiple paths of light can cause signal distortion at the receiving end, resulting in an unclear and incomplete data transmission.







Buffered Cable

The use of fiber-optics was generally not available until 1970 when Corning Glass Works was able to produce a fiber with a loss of 20 dB/km. It was recognized that optical fiber would be feasible for telecommunication transmission only if glass could be developed so pure that attenuation would be 20dB/km or less. That is, 1% of the light would remain after traveling 1 km. Today's optical fiber attenuation ranges from 0.5dB/km to 1000dB/km depending on the optical fiber used. Attenuation limits are based on intended application.

The applications of optical fiber communications have increased at a rapid rate, since the first commercial installation of a fiber-optic system in 1977. Telephone companies began early on, replacing their old copper wire systems with optical fiber lines. Today's telephone companies use optical fiber throughout their system as the backbone architecture and as the long-distance connection between city phone systems.

Cable television companies have also began integrating fiber-optics into their cable systems. The trunk lines that connect central offices have generally been replaced with optical fiber. Some providers have begun experimenting with fiber to the curb using a fiber/coaxial hybrid. Such a hybrid allows for the integration of fiber and coaxial at a neighborhood location. This location, called a node, would provide the optical receiver that converts the light impulses back to electronic signals. The signals could then be fed to individual homes via coaxial cable.

Local Area Networks (LAN) is a collective group of computers, or computer systems, connected to each other allowing for shared program software or data bases. Colleges, universities, office buildings, and industrial plants, just to name a few, all make use of optical fiber within their LAN systems.

Power companies are an emerging group that have begun to utilize fiber-optics in their communication systems. Most power utilities already have fiber-optic communication systems in use for monitoring their power grid systems.

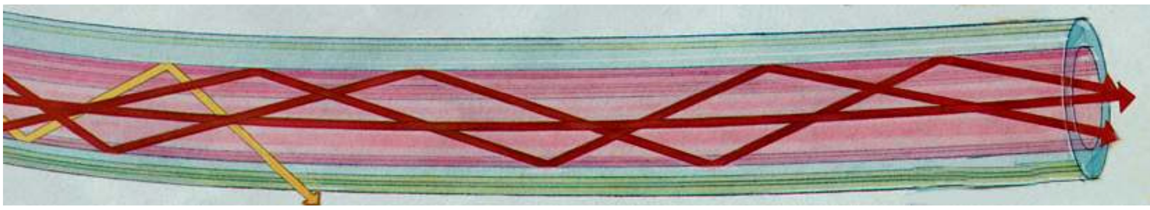
Fiber

by John MacChesney - Fellow at Bell Laboratories, Lucent Technologies

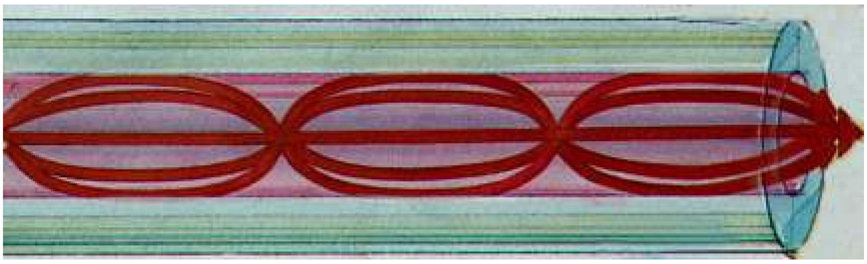
Some 10 billion digital bits can be transmitted per second along an optical fiber link in a commercial network, enough to carry tens of thousands of telephone calls. Hair-thin fibers consist of two concentric layers of high-purity silica glass the core and the cladding, which are enclosed by a protective sheath. Light rays modulated into digital pulses with a laser or a light-emitting diode move along the core without penetrating the cladding.

The light stays confined to the core because the cladding has a lower refractive index—a measure of its ability to bend light. Refinements in optical fibers, along with the development of new lasers and diodes, may one day allow commercial fiber-optic networks to carry trillions of bits of data per second.

Total internal refection confines light within optical fibers (similar to looking down a mirror made in the shape of a long paper towel tube). Because the cladding has a lower refractive index, light rays reflect back into the core if they encounter the cladding at a shallow angle (red lines). A ray that exceeds a certain "critical" angle escapes from the fiber (yellow line).

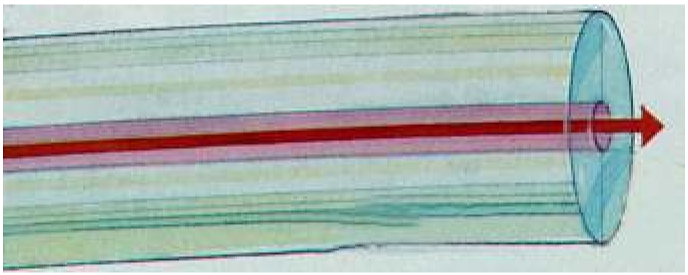


STEP-INDEX MULTIMODE FIBER has a large core, up to 100 microns in diameter. As a result, some of the light rays that make up the digital pulse may travel a direct route, whereas others zigzag as they bounce off the cladding. These alternative pathways cause the different groupings of light rays, referred to as modes, to arrive separately at a receiving point. The pulse, an aggregate of different modes, begins to spread out, losing its well-defined shape. The need to leave spacing between pulses to prevent overlapping limits bandwidth that is, the amount of information that can be sent. Consequently, this type of fiber is best suited for transmission over short distances, in an endoscope, for instance.



GRADED-INDEX MULTIMODE FIBER contains a core in which the refractive index diminishes gradually from the center axis out toward the cladding. The higher refractive index at the center makes the light rays moving down the axis advance more slowly than those near the cladding. Also, rather than zigzagging off the cladding, light in the core curves helically because of the graded index, reducing its travel distance. The shortened path and the higher speed allow light at the periphery to arrive at a receiver at about the same time as the slow but straight rays in the core axis. The result: a digital pulse suffers less dispersion.

SINGLE-MODE FIBER has a narrow core (eight microns or less), and the index of refraction between the core and the cladding changes less than it does for multimode fibers. Light thus travels parallel to the axis, creating little pulse dispersion. Telephone and cable television networks install millions of kilometers of this fiber every year.



BASIC CABLE DESIGN

1 - Two basic cable designs are:

Loose-tube cable, used in the majority of outside-plant installations in North America, and tight-buffered cable, primarily used inside buildings.

The modular design of loose-tube cables typically holds up to 12 fibers per buffer tube with a maximum per cable fiber count of more than 200 fibers. Loose-tube cables can be all-dielectric or optionally armored. The modular buffer-tube design permits easy drop-off of groups of fibers at intermediate points, without interfering with other protected buffer tubes being routed to other locations. The loose-tube design also helps in the identification and administration of fibers in the system.

Single-fiber tight-buffered cables are used as pigtails, patch cords and jumpers to terminate loose-tube cables directly into opto-electronic transmitters, receivers and other active and passive components.

Multi-fiber tight-buffered cables also are available and are used primarily for alternative routing and handling flexibility and ease within buildings.

2 - Loose-Tube Cable

In a loose-tube cable design, color-coded plastic buffer tubes house and protect optical fibers. A gel filling compound impedes water penetration. Excess fiber length (relative to buffer tube length) insulates fibers from stresses of installation and environmental loading. Buffer tubes are stranded around a dielectric or steel central member, which serves as an anti-buckling element.

The cable core, typically uses aramid yarn, as the primary tensile strength member. The outer polyethylene jacket is extruded over the core. If armoring is required, a corrugated steel tape is formed around a single jacketed cable with an additional jacket extruded over the armor.

Loose-tube cables typically are used for outside-plant installation in aerial, duct and direct-buried applications.

3 - Tight-Buffered Cable

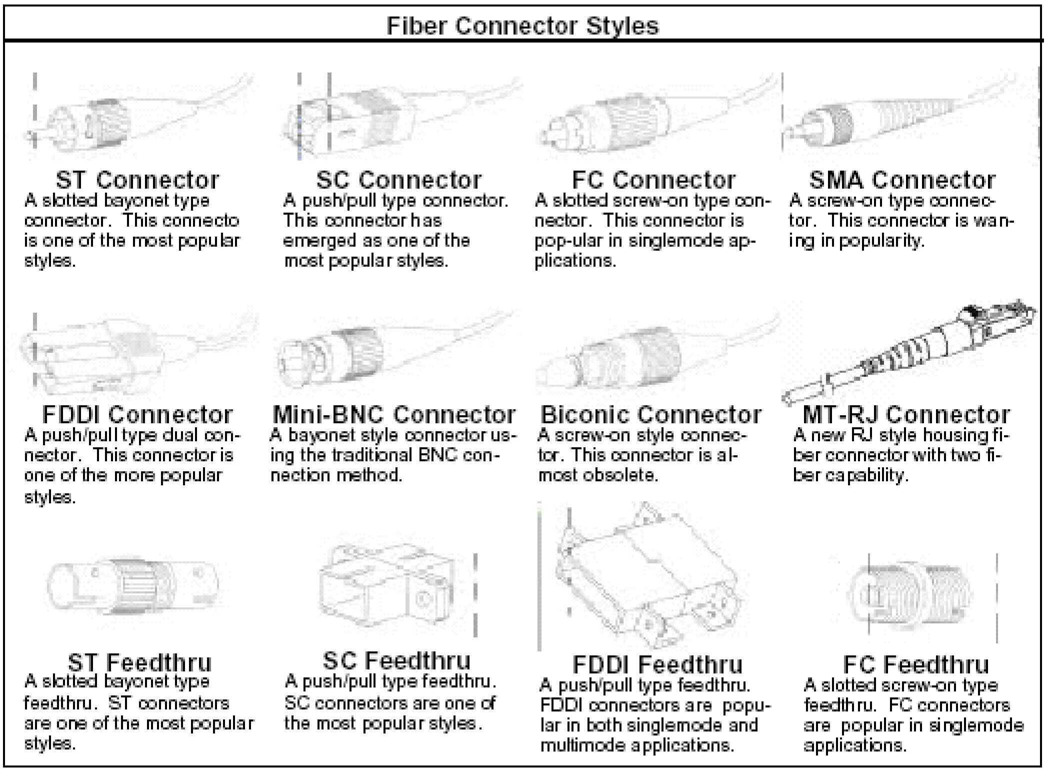
With tight-buffered cable designs, the buffering material is in direct contact with the fiber. This design is suited for "jumper cables" which connect outside plant cables to terminal equipment, and also for linking various devices in a premises network.

Multi-fiber, tight-buffered cables often are used for intra-building, risers, general building and plenum applications.

The tight-buffered design provides a rugged cable structure to protect individual fibers during handling, routing and connectorization. Yarn strength members keep the tensile load away from the fiber.

As with loose-tube cables, optical specifications for tight-buffered cables also should include the maximum performance of all fibers over the operating temperature range and life of the cable. Averages should not be acceptable.

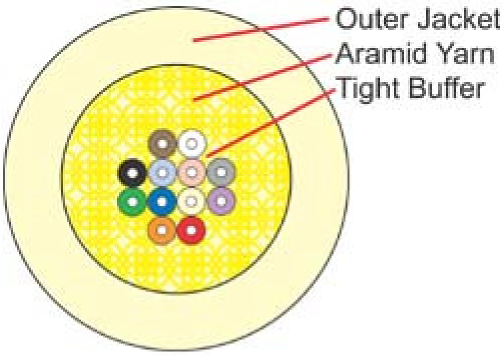
Connector Types



cable connectors

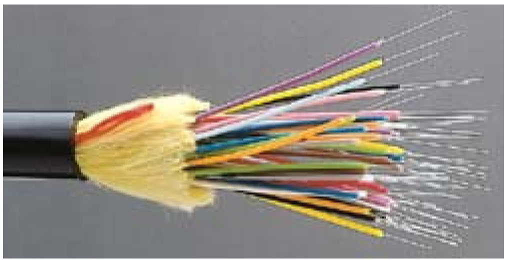
here are some common fiber cable types

Distribution Cable



Distribution Cable (compact building cable) packages individual 900µm buffered fiber reducing size and cost when compared to breakout cable. The connectors may be installed directly on the 900µm buffered fiber at the breakout box location. The space saving (OFNR) rated cable may be installed where ever breakout cable is used. FIS will connectorize directly onto 900µm fiber or will build up ends to a 3mm jacketed fiber before the connectors are installed.

Indoor/Outdoor Tight Buffer

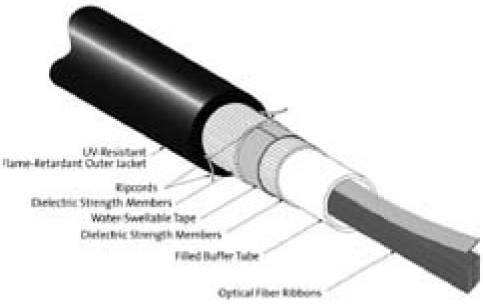


FIS now offers indoor/outdoor rated tight buffer cables in Riser and Plenum rated versions. These cables are flexible, easy to handle and simple to install. Since they do not use gel, the connectors can be terminated directly onto the fiber without difficult to use breakout kits. This provides an easy and overall less expensive installation. (Temperature rating -40ºC to +85ºC).

Indoor/Outdoor Breakout Cable

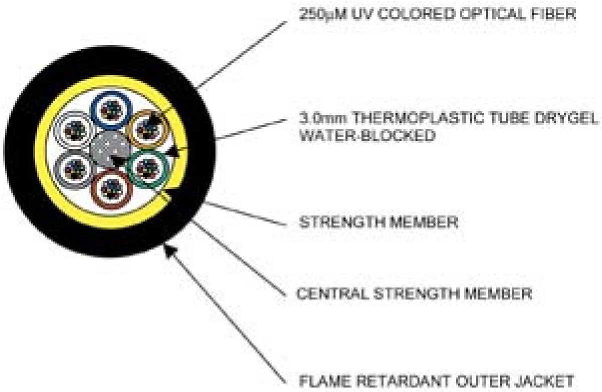
FIS indoor/outdoor rated breakout style cables are easy to install and simple to terminate without the need for fanout kits. These rugged and durable cables are OFNR rated so they can be used indoors, while also having a -40c to +85c operating temperature range and the benefits of fungus, water and UV protection making them perfect for outdoor applications. They come standard with 2.5mm sub units and they are available in plenum rated versions.

Corning Cable Systems Freedm LST Cables



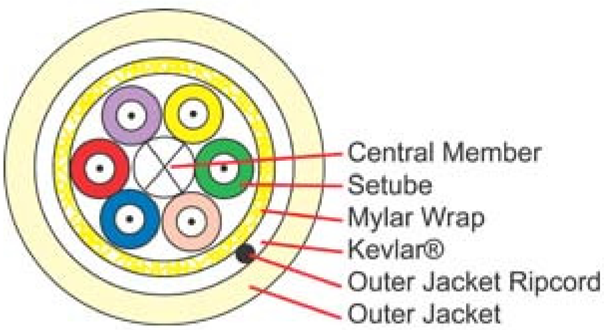
Corning Cable Systems FREEDM® LST™ cables are OFNR-rated, UV-resistant, fully waterblocked indoor/outdoor cables. This innovative DRY™ cable with water blocking technology eliminates the need for traditional flooding compound, providing more efficient and craft-friendly cable preparation. Available in 62.5µm, 50µm, Singlemode and hybrid versions.

Krone Indoor Outdoor Dry Loose Tube Cable



KRONE's innovative line of indoor/outdoor loose tube cables are designed to meet all the rigors of the outside plant environment, and the necessary fire ratings to be installed inside the building. These cables eliminate the gel filler of traditional loose tube style cables with super absorbent polymers.

Loose Tube Cable

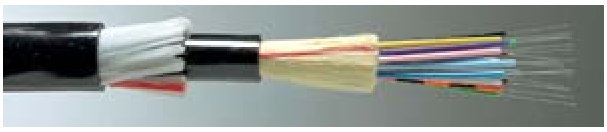


Loose tube cable is designed to endure outside temperatures and high moisture conditions. The fibers are loosely packaged in gel filled buffer tubes to repel water. Recommended for use between buildings that are unprotected from outside elements. Loose tube cable is restricted from inside building use, typically allowing entry not to exceed 50 feet (check your local codes).

Aerial Cable/Self-Supporting

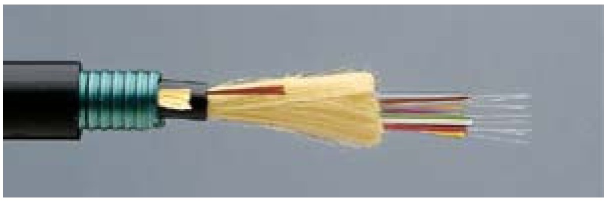
Aerial cable provides ease of installation and reduces time and cost. Figure 8 cable can easily be separated between the fiber and the messenger. Temperature range (-55ºC to +85ºC)

Hybrid & Composite Cable



Hybrid cables offer the same great benefits as our standard indoor/outdoor cables, with the convenience of installing multimode and singlemode fibers all in one pull. Our composite cables offer optical fiber along with solid 14 gauge wires suitable for a variety of uses including power, grounding and other electronic controls.

Armored Cable



Armored cable can be used for rodent protection in direct burial if required. This cable is non-gel filled and can also be used in aerial applications. The armor can be removed leaving the inner cable suitable for any indoor/outdoor use. (Temperature rating -40ºC to +85ºC)

Low Smoke Zero Halogen (LSZH)

Low Smoke Zero Halogen cables are offered as as alternative for halogen free applications. Less toxic and slower to ignite, they are a good choice for many international installations. We offer them in many styles as well as simplex, duplex and 1.6mm designs. This cable is riser rated and contains no flooding gel, which makes the need for a separate point of termination unnecessary. Since splicing is eliminated, termination hardware and labor times are reduced, saving you time and money. This cable may be run through risers directly to a convenient network hub or splicing closet for interconnection.

What's the best way to terminate fiber optic cable? That depends on the application, cost considerations and your own personal preferences. The following connector comparisons can make the decision easier.

Epoxy & Polish

Epoxy & polish style connectors were the original fiber optic connectors. They still represent the largest segment of connectors, in both quantity used and variety available. Practically every style of connector is available including ST, SC, FC, LC, D4, SMA, MU, and MTRJ. Advantages include:

• Very robust. This connector style is based on tried and true technology, and can withstand the greatest environmental and mechanical stress when compared to the other connector technologies.
• This style of connector accepts the widest assortment of cable jacket diameters. Most connectors of this group have versions to fit onto 900um buffered fiber, and up to 3.0mm jacketed fiber.
• Versions are. available that hold from 1 to 24 fibers in a single connector.

Installation Time: There is an initial setup time for the field technician who must prepare a workstation with polishing equipment and an epoxy-curing oven. The termination time for one connector is about 25 minutes due to the time needed to heat cure the epoxy. Average time per connector in a large batch can be as low as 5 or 6 minutes. Faster curing epoxies such as anaerobic epoxy can reduce the installation time, but fast cure epoxies are not suitable for all connectors.

Skill Level: These connectors, while not difficult to install, do require the most supervised skills training, especially for polishing. They are best suited for the high-volume installer or assembly house with a trained and stable work force.

Costs: Least expensive connectors to purchase, in many cases being 30 to 50 percent cheaper than other termination style connectors. However, factor in the cost of epoxy curing and ferrule polishing equipment, and their associated consumables.

Pre-Loaded Epoxy or No-Epoxy & Polish

There are two main categories of no-epoxy & polish connectors. The first are connectors that are pre-loaded with a measured amount of epoxy. These connectors reduce the skill level needed to install a connector but they don't significantly reduce the time or equipment need-ed. The second category of connectors uses no epoxy at all. Usually they use an internal crimp mechanism to stabilize the fiber. These connectors reduce both the skill level needed and installation time. ST, SC, and FC connector styles are available. Advantages include:

• Epoxy injection is not required.
• No scraped connectors due to epoxy over-fill.
• Reduced equipment requirements for some versions.

Installation Time: Both versions have short setup time, with pre-loaded epoxy connectors having a slightly longer setup. Due to curing time, the pre-loaded epoxy connectors require the same amount of installation time as standard connectors, 25 minutes for 1 connector, 5-6 minutes average for a batch. Connectors that use the internal crimp method install in 2 minutes or less.

Skill Level: Skill requirements are reduced because the crimp mechanism is easier to master than using epoxy. They provide maximum flexibility with one technology and a balance between skill and cost.

Costs: Moderately more expensive to purchase than a standard connector. Equipment cost is equal to or less than that of standard con¬nectors. Consumable cost is reduced to polish film and cleaning sup-plies. Cost benefits derive from reduced training requirements and fast installation time.

No-Epoxy & No-Polish

Easiest and fastest connectors to install; well suited for contractors who cannot cost-justify the training and supervision required for standard connectors. Good solution for fast field restorations. ST, SC, FC, LC, and MTRJ connector styles are available. Advantages include:
• No setup time required.
• Lowest installation time per connector.
• Limited training required.
• Little or no consumables costs.

Installation Time: Almost zero. Its less than 1 minute regardless of number of connectors.

Skill level: Requires minimal training, making this type of connector ideal for installation companies with a high turnover rate of installers and/or that do limited amounts of optical-fiber terminations.

Costs: Generally the most expensive style connector to purchase, since some of the labor (polishing) is done in the factory. Also, one or two fairly expensive installation tools may be required. However, it may still be less expensive on a cost-per-installed-connector basis due to lower labor cost.