Fiber Optic Cable Installation

Generally speaking, fiber optic cable can be installed using many of the same techniques as conventional copper cables.

General Guidelines

The following contains information on the placement of fiber optic cables in various indoor and outdoor environments. In general, fiber optic cable can be installed with many of the same techniques used with conventional copper cables. Basic guidelines that can be applied to any type of cable installation are as follows:

- Conduct a thorough site survey prior to cable placement.
- Develop a cable pulling plan.
- Follow proper procedures.
- Do not exceed cable minimum bend radius.
- Do not exceed cable maximum recommended load.
- Document the installation.

Conduct a Site Survey

The purpose of a site survey is to recognize circumstances or locations in need of special attention. For example, physical hazards such as high temperatures or operating machinery should be noted and the cable route planned accordingly. If the fiber optic cable has metallic components, it should be kept clear of power cables. Additionally, building code regulations must be considered. If there are questions regarding local building codes or regulations, they should be addressed to the authority having jurisdiction, such as the fire marshal or city building inspector.

Develop a Cable Pulling Plan

A cable pulling plan should communicate the considerations noted during the site survey to the installation team. This includes the logistics of cable let-off/pulling equipment, the location of intermediate access points, splice locations and the specific responsibilities of each member of the installation team.

Follow Proper Procedures

Because fibers are sensitive to moisture, the cable end should be covered with an end cap, heavy tape or equivalent at all times. The let-off reel must never be left unattended during a pull because excess or difficult pulls, center-pull or backfeeding techniques may be employed.

Do Not Exceed Cable Minimum Bend Radius

Every Belden cable has an installation minimum bend radius value. During cable placement it is important that the cable not be bent to a smaller radius. After the cable has been installed, and the pulling tension removed, the cable may be bent to a radius no smaller than the long term application bend radius specification.

The minimum bend radii values still apply if the cable is bent more than 90 degrees. It is permissible for fiber optic cable to be wrapped or coiled as long as the minimum bend radius constraints are not violated.

Do Not Exceed Cable Maximum Recommended Load

While fiber optic cables are typically stronger than copper cables, it is still important that the cable maximum pulling tension not be exceeded during any phase of cable installation. In general, most cables designed for outdoor use have a strength rating of at least 2700 N. Belden fiber optic cables also have a maximum recommended load value for long term application. After cable placement is complete the residual tension on the cable should be less than this value. For vertical installations, it is recommended that the cable be clamped at frequent intervals to prevent the cable weight from exceeding the maximum recommended long term load. The clamping intervals should be sufficient to prevent cable movement as well as to provide weight support.

Leave Extra Cable

A common practice is to leave extra cable at the beginning and at the end of the cable run. Also, extra cable should be placed at strategic points such as junction boxes, splice cases and cable vaults. Extra cable is useful should cable repair or mid-span entry be required.

Document the Installation

Good record keeping is essential. This will help to ensure that the cable plant is installed correctly and that future trouble shooting and upgrading will be simplified. All Belden fiber optic cables have a unique lot number shown on the shipping spool. It is important that this number be recorded. Cable pre- and post- installation test data should be recorded in an orderly and logical fashion.

Pulled Installations

In order to effectively pull cable without damaging the fiber, it is necessary to identify the strength material and fiber location within the cable. Then, use the method of attachment that pulls most directly on the strength material—without stressing the fiber.

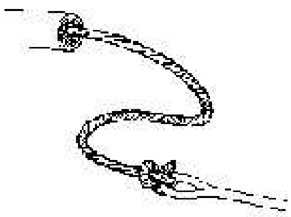
As a general rule, it is best to install cable prior to connector attachment. After connectors have been attached, it becomes more difficult to protect the fiber from inadvertent stress. If a pull is to be made entirely in one direction, connectors may be pre-installed on one end, leaving the other end for pulling.

If the cable ***must*** be installed with connectors attached, every practical means must be taken to protect the connectorized end from damage or stress. Cushioned enclosures should be used to protect connectors during pulling.

The leading end of the cable should be sealed to prevent intrusion of water or other foreign material while pulling.

Bi-directional pulls are possible by laying the cable into large "figure-8"-shaped loops on the ground, from where it can feed from both ends.

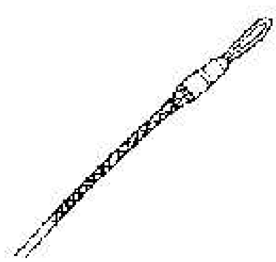
For ease of cable installation, the area of the cable divided by the area of the duct or conduit should be less than 53% per a single cable. Permissible area to be occupied for 2 cables is 31%, for 3 or more cables it is 40%.



Direct Attachment: Strength member is tied directly to the pulling fixture. The cable end must be sealed to prevent intrusion of moisture while pulling.

Direct Attachment

With direct attachment, cable strength material is tied directly to the pulling fixture. Conventional cable tools may be used. Loose fiberglass threads are not suitable for direct attachment because they may break if knotted. Fiberglass epoxy rods are too rigid to tie, but may be secured to the pulling fixture by using tight clamping plates or screws.



Indirect Attachment: Pulling forces are distributed over the outer cable structure.

Indirect Attachment

With indirect attachment, pulling forces are distributed over the outer portion of the cable structure. If cable strength materials are located directly beneath the jacket, this method will produce the least amount of stress on the fiber.

A popular type of pulling fixture for indirect attachment is the "Chinese Basket" or "Kellems Grip".* The Kellems Grip is usually reliable for cables of 1/4" diameter or more. Large pulling forces are possible with a Kellems Grip if the grip's diameter and length are properly matched to cable characteristics.

A Kellem Grip should spread pulling forces over a 1m length of cable. For small cables, pre-stretching and taping the Kellems Grip to the cable helps to assure even pulling.

Cable Lubricants

Many lubricants are available for lowering friction forces. These include greases, waxes, clay slurries and water-based gels. Fiber optic jacket materials are compatible with most of these. For new conduit, lubrication of the conduit before pulling is suggested—particularly if there are several bends.

Air Plenums, Trays, Raceways

Installation procedures for open placement of fiber optic cables are the same as for electrical cables. Care should be taken to avoid sudden, excessive force so as not to violate tensile load and radius limits. Sharp bending and scraping at entrances and covers should be avoided.

Direct Burial

Belden outdoor cables may be buried directly in the ground. Environmental hazards include freezing water, crushing forces from rocky soil, ground disruption from construction, and rodents. Burying the cable 90 to 120 cm deep may help prevent most of these hazards.

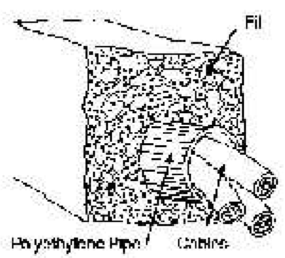
Direct plow-in installation requires a cable capable of withstanding uneven pulling forces. Loose tube cables are best suited for these types of installations.

Double jacketing, gel filling, metal sheathing and (CST)armoring are used as water barriers.

Use of double jacketed armored cables can sometimes be avoided by burying polyethylene pipe to form a simple conduit. The pipe makes a smooth passageway and may be curved to allow easy access at manholes and other pull points. Cables may be subsequently replaced without digging.

Cable Storage

It is frequently required to store cables prior to installation. Temperature ranges for cable storage are listed in the corresponding catalog- or datasheet pages. It is recommended that cable ends be sealed to prevent intrusion of moisture.



Polyethylene pipe can be used as a simple conduit. This allows use of less expensive cables in direct burial applications.

Cable Preparation

The following is a general description of cable preparation and termination procedures.

Jacket Removal
The procedure for stripping fiber optic cables is very similar to electronic cables. However, care should be taken not to cut into the layer of aramid directly beneath the jacket. This would either reduce the pull strength of the cable, or weaken the connection. For this reason, if a blade must be used, a cut which does not completely penetrate the jacket can be made. This will weaken it sufficiently and allow the jacket to be peeled. Most Belden cables utilize a ripcord capable of tearing the outer sheath.

Cutting and Trimming Aramid
Aramid can be easily cut with sharp scissors if the threads are confined in movement so that cutting pressure can be applied. Ceramic scissors may also be used.

Steel and Fiberglass Epoxy Rod Members
Temperature stabilized cables of both loose and tight buffer constructions often have steel or fiberglass epoxy rods. Use of heavy-duty cutters is recommended for these hard materials.

Buffer Tube Trimming
Buffer tubes are made of plastic materials with various characteristics of hardness and flexibility. Belden buffer tubes are both flexible and strong, but may be trimmed easily. The simplest way is to score one side of the buffer tube firmly with a razor blade, then bend the tube sharply away from the score mark. The broken-off piece is then pulled straight off, leaving the fiber intact.A stripping tool which barely cuts through the tube is also satisfactory. If it is intended to cut through both the buffer tube and the fiber, use diagonal cutters and cut through cleanly.

Breakout Element Trimming
Breakout subunit element jackets are most easily removed by a stripping tool which cuts circumferencially. The jacket may then be pulled straight off, exposing the aramid.

Fiber Preparation

Fiber Stripping
Optical fibers must be stripped of buffer coatings to allow a close fit within precision connectors. (Note: always wear safety glasses or goggles when working directly with fibers.)
Buffer coatings are usually removed mechanically with sharp blades or calibrated stripping tools. In any type of mechanical stripping, the key is to avoid nicking the fiber.

(Note: Dispose of broken pieces of fiber by placing them on a piece of tape. Glass fibers are difficult to see and may not be felt until through the skin. Eyes should not be rubbed while working with fibers.)

Splicing Optical Fibers

Preparation of fibers for splicing is very similar to the process described under connectorization. After jacket materials, strength members and buffer tubes have been cut to the appropriate lengths, the fiber buffer coatings must be removed.

Cleaving
After the buffer coatings have been removed, fibers must be cleaved in preparation for splicing. Cleaving is a method of breaking a fiber in such a way as to create a smooth, square end on the fiber.

Principles of Cleaving
Glass is typically strong until a flaw occurs and creates a region of high stress under pressure. The first step in the cleaving process is to create a slight flaw or "scribe" in the outer surface of the fiber.

Optical fibers can be scribed with a sharp blade of hard material such as a diamond, ruby, sapphire or tungsten carbide. The scribe is made by *lightly* touching the cleaned fiber, at a right angle, on the desired cleave point with a scribing tool. Only the lightest pressure is required to produce a scribe if the blade is sharp. NOTE: DO NOT USE A SAWING MOTION. A crude or slanted scribe will produce shattered or scalloped end surfaces.

After the scribe is made, a *straight* pull will produce the cleanest break. If bending accompanies pulling, a square break is less likely, especially with large fibers. Dispose of broken fiber pieces by placing them on a piece of tape. ALWAYS WEAR SAFETY GLASSES WHEN WORKING WITH OPTICAL FIBERS.

The level of quality required for a given cleave depends on the application. For fusion splicing, mechanical splicing and some connectors systems, cleaves must be nearly perfect. Some connector and splicing systems use cleaving to produce the *final* end surface on the fiber (no subsequent grinding or polishing). However, for quick continuity checks with a flashlight, less than perfect cleaves may be acceptable.

A 30x to 50x hand microscope is useful for quick checks of cleave quality.

Cleaving tools are available in inexpensive hand models or more sophisticated mechanized tools.

Splicing Methods
There are two basic types of splices: Fusion and Mechanical.

Fusion Splicing
Fusion splices are made by positioning cleaned, cleaved fiber ends between two electrodes and applying an electric arc to fuse the ends together. A perfusion arc is applied to the fiber while the ends are still separated to vaporize volatile materials which could cause bubbles.

Final precise alignment is done by moving fiber ends together until there is slight pressure between end surfaces.

An ideal fusion cycle is short and uses a ramped or gradually increasing arc current. A short, ramped cycle is considered least likely to produce excessive thermal stress in fibers. Cold temperatures require increased time and arc current.

Experienced operators consistently produce fusion splices with losses less than 0.2 dB per splice and averaging 0.3 dB on multimode fibers. Sophisticated fusion splicing systems for single-mode fibers produce typical splice losses of 0.05 to 0.1 dB.

Mechanical Splicing
Mechanical splicing systems position fiber ends closely in retaining and aligning assemblies. Focusing and collimating lenses may be used to control and concentrate light that would otherwise escape. Index matching gels, fluids and adhesives are used to form a continuous optical path between fibers and reduce reflection losses.

Testing

The Flashlight Test
A simple continuity test for short-to-medium length fiber optic links is to shine a flashlight into a cleaved or connectorized link and observe if light comes out of the other end. On short lengths, it may be necessary to cleave only the end where the flashlight injects light into the fiber.

This simple check can be made on cable lengths of up to a 1,5km and more. If cable ends are outdoors, sunlight may be used. NOTE: on longer lengths, the light observed at the opposite end may appear red in color. This is normal and is caused by the filtering of light within the fiber.

CAUTION: NEVER LOOK DIRECTLY INTO A FIBER CONNECTED TO LIGHT LAUNCHING EQUIPMENT. THIS CAN CAUSE PERMANENT EYE DAMAGE.

The Optical Time Domain Reflectometer (OTDR)

OTDRs are typically used to measure distance and attenuation over the entire fiber link. They are also used to identify specific points along the link where losses occur, such as splices.

An OTDR is an optical radar which measures time of travel and the return strength of a short pulse of light launched into an optical fiber. Small reflections occur throughout the fiber, becoming weaker as power levels drop with distance. At major breaks, large reflections occur and appear as strong peaks on an oscilloscope. Testing of short and medium distance fiber optic systems seldom requires an OTDR. In smaller systems, optical power meter tests are faster and more useful.

Magnifying Glasses and Microscopes
Because the naked eye cannot detect scratches or defects in optical fibers, use of magnification equipment is required. For most routine inspections, and ordinary battery-powered illuminated microscope of 30x to 100x can produce satisfactory results. Some microscopes are available with special adapters specifically designed for use with fiber optic connectors.