liquid in your eye which is mostly water, which absorbs light in the infrared heavily. Light from most fiber optic sources will be absorbed by this liquid, so any potential harm is likely to come to the lens or cornea, not the retina. While the expanding beam of the light exiting the fiber makes it less of an issue for direct viewing, using a fiber inspection microscope can be a problem. A microscope will focus virtually all the light back into the eye. Many microscopes used in fiber optics, therefore, have filters to absorb any infrared (IR) light that could be harmful. Be wary of inexpensive microscopes which may not have IR blocking filters.
To be certain fibers are safe to inspect or work with, always check fibers in an operating network with a fiber optic power meter to ensure no light is present before inspecting any connector with a microscope.

Bare Fiber Safety
Fiber optics installation, however, is not without risks. The more common problem is getting scraps of fiber in your eye when working with fiber. While few fiber optic systems have harmful levels of power, every termination and splice produces shards (scraps) of optical fiber which is potentially very harmful to your eyes and skin or may stick in your clothing and be carried to other locations where it may be harmful to others.
These shards of fiber are tiny, thin and often very sharp where they broke off the fiber. They can easily puncture your skin, burying themselves deep enough to be difficult to pull out, if only you could see them. Being transparent they practically disappear once embedded in your skin. In most parts of your body, they merely become a nuisance, perhaps infecting or causing an irritating bump, until they eventually work themselves out.
Around your eye, however, they can be much more difficult to find and remove. The tears that wet your eyes make the transparent glass shards practically impossible to find and remove. The sharp ends of the fiber may cause it to embed itself in the eye or surrounding tissue, making it even more difficult to remove. Unlike metallic particles, they cannot be removed with magnets,
It is imperative to follow procedures that minimize the dangers to the eye. Always wear protective eyewear with side shields, even if you normally wear glasses, to prevent any flying shards from getting near your eyes. Be extremely careful whenever handling fibers, especially when stripping fiber or scribing and breaking fiber extending out of an adhesive connector. Instead of breaking it, scribe it gently, then slide your fingers up the connector ferrule, grasping the fiber and pulling it off. Then dispose of it carefully.
Most cleavers used for splicing or terminating prepolished/splice connectors hold the fiber after cleaving, so the only problem is disposing of it. We recommend using disposable containers like those used for soups at carry-out restaurants. Use it for all your fiber scraps and then seal it and dispose of it properly.
You can also set up your workplace to make it easier to avoid problems. Use a black plastic mat for a work surface. The dark background will make it easier to see the fibers you are working with and handle them more carefully. Any broken fibers that fall on the mat are easily found for disposal.
Some techs like to place a length of double stick tape or a loop of black electrical tape on the mat and stick fibers to the adhesive surface, then dispose of the tape when finished. I prefer to simply use a disposable container and place every fiber scrap into that container rather than leave them exposed on the work surface.

Other Considerations for Safety
Chemicals: Fiber optic splicing and termination use various chemical cleaners and adhesives as part of the processes. Normal handling procedures for these substances should be observed. Even simple isopropyl alcohol, used as a cleaner, is flammable and should be handled carefully. Manufacturers will supply "material safety data sheets" (MSDS) on request or they may be found on the Internet.
Splicing hazards: Fusion splicers use an electric arc to make splices, so care must be taken to insure no flammable gasses are present in the space where fusion splicing is done.
No Smoking: Smoking should also not be allowed around fiber optic work. The ashes from smoking contribute to the dirt problems with fibers, in addition to the possible presence of combustible substances (and, of course, the health risks.)
Electrical Hazards: Installation of fiber optic cabling does not normally involve electrical hazards unless the cable includes conductors. However, these cables are often installed in proximity to electrical and conductive cables. Whenever you are near these cables, there is always a potential shock hazard. Be careful! If you are not familiar with electrical safety, we recommend you take a course on the NEC (National Electrical Code) and safety practices for installers!

Fiber Optic Installation Safety Rules
This is all very important, important enough to have a few workplace rules for all fiber optic techs that can prevent workplace accidents:

Work on a black work surface as it helps to find fiber scraps.
Wear disposable aprons to minimize fiber particles on your clothing. Fiber particles on your clothing can later get into food, drinks, and/or be ingested by other means.
Always wear safety glasses with side shields and protective gloves. Treat fiber optic splinters the same as you would

treat glass splinters.
Never look directly into the end of fiber cables until you are positive that there is no light source at the other end. Use a fiber optic power meter to make certain the fiber is dark. When using an optical tracer or continuity checker, look at the fiber from an angle at least 6 inches away from your eye to determine if the visible light is present..
Only work in well ventilated areas.
Contact lens wearers must not handle their lenses until they have thoroughly washed their hands.
Do not touch your eyes while working with fiber optic systems until your hands have been thoroughly washed.
Keep all combustible materials safely away from electrical devices including splicers, testers and curing ovens.
Put all cut fiber pieces in a properly marked container for disposal.
Thoroughly clean your work area when you are done.
Do not smoke while working with fiber optic systems.
Keep all food and beverages out of the work area. If fiber particles are ingested they can cause internal hemorrhaging.

Installing Fiber Optic Cable

Receiving Fiber Optic Cabling and Equipment on Site
Fiber Optic equipment and components are subject to damage by improper handling or storage and must be handled accordingly.

Receipt
Fiber optic cable, equipment and supplies should be scheduled for delivery to the work site as closely to the time of use as possible to minimize possible damage from other construction, weather or theft. Coordinating deliveries can be difficult so delivery to a staging area offsite or providing a locked storage container onsite should be arranged. When initially received, all fiber optic components should be carefully inspected for damage and tested for continuity or loss if damage is suspected. Ensure that all components and parts have been shipped, received, match quantities ordered (e.g. fiber optic cable contains the number and type of fiber ordered and is the length ordered), and that any discrepancies or damaged goods are noted, the supplier notified and replaced as required.

Handling
Handle reels of fiber optic cable with care. All reels, regardless of size or length, should have both ends of the cable available for continuity testing. A fiber tracer or visual fault locator and bare fiber adapters can be used for continuity testing.
The cable reels should be moved carefully to avoid damage to the cable. Move small, lightweight spools of fiber optic cable by hand. Move larger reels with appropriate lifting equipment or using two or more installers skilled in the moving operation. Lifting equipment should only move reels with a matched set of slings or chokers, attached to an appropriately sized piece of pipe inserted into the hole in the center of the reel. Slings and chokers should never be attached around the spooled cable area of the reel.

Storage
All equipment and cabling should be stored in a clean and dry location, protected from harsh environments such as extremes of cold and heat. Due to the value of the cable and potential for theft, all components should be in secure storage with guards provided when or where necessary.

General Guidelines For Installing Fiber Optic Cable

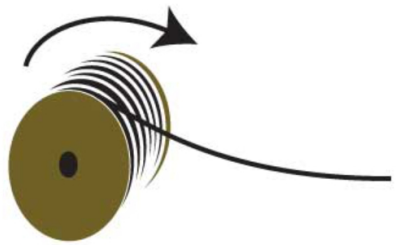
Fiber optic cables are installed in so many different applications that generalizing on how to install fiber is very difficult, so this book will try to cover universal concerns and mention specifics where appropriate.
Fiber optic cable may be installed indoors or outdoors using several different installation processes. Outdoor cable may be direct buried, pulled or blown into conduit or innerduct, or installed aerially between poles. Indoor cables can be installed in raceways, cable trays above ceilings or under floors, placed in hangers, pulled into conduit or innerduct or blown though special ducts with compressed gas. The installation process will depend on the nature of the installation and the type of cable being used.
Installation methods for wire and optical fiber communications cables are similar. Fiber cable is designed to be pulled with much greater force than copper wire if pulled correctly, but excess stress on the cable may harm the fibers, potentially causing eventual failure. Particular care should be taken during installation to prevent exceeding the bend radius or kinking the cable which can harm the fibers.

Installation Guidelines
Follow the cable manufacturer's recommendations as no one knows how to handle cable as well as the company

Follow the cable manufacturer's recommendations as no one knows how to handle cable as well as the company which made it. Fiber optic cable is often custom-designed for the installation and the manufacturer may have specific instructions on its installation.
Check the cable length to make sure the cable being pulled is long enough for the planned cable run. Try to complete the installation in one pull if possible. Prior to any installation, assess the route carefully to determine the methods of installation and obstacles likely to be encountered.

Pulling Tension
Cable manufacturers install special strength members, usually aramid yarn (Dupont Kevlar), to absorb the stress of pulling the cable. Fiber optic cable should only be pulled by these strength members unless the cable design allows pulling by a grip on the jacket. Any other method may put stress on the fibers and harm them.
Swivel pulling eyes should be used to attach the pulling rope or tape to the cable to prevent cable twisting during the pull.
Cables should not be pulled by the jacket unless it is specifically approved by the cable manufacturers and an approved cable grip, often called a "Kellems Grip," is used. These grips are usually tied to the strength members also.
Tight buffer cable can be pulled by the jacket in premises applications if a large (~40 cm, 8 in.) spool is used as a pulling mandrel. Wrap the cable around the spool 5 times and hold gently when pulling.
Do not exceed the maximum pulling tension rating. Consult the cable manufacturer and suppliers of conduit, innerduct, and cable lubricants for guidelines on tension ratings and lubricant use.
When pulling long lengths of cable in conduit or innerduct (up to approximately 3 miles or 5 kilometers in the outside plant, hundreds of meters in premises cabling), use proper cable lubricants but make certain it is compatible with the cable jacket. If possible, use an automated puller with tension control and/or a breakaway pulling eye. On very long OSP runs (farther than approximately 2.5 miles or 4 kilometers), pull from the middle out to both ends or use an automated fiber puller at intermediate point(s) for a continuous pull.
When laying loops of fiber on a surface during a pull, use "figure-8" loops to prevent twisting the cable.

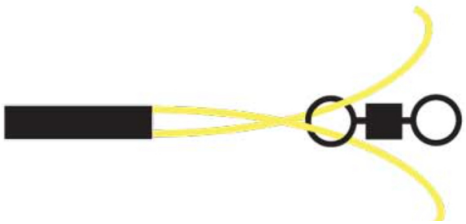
Twisting Cable
Do not twist the cable. Twisting the cable can stress the fibers. Tension on the cable and pulling ropes can cause twisting. Use a swivel pulling eye to connect the pull rope to the cable to prevent pulling tension causing twisting forces on the cable.

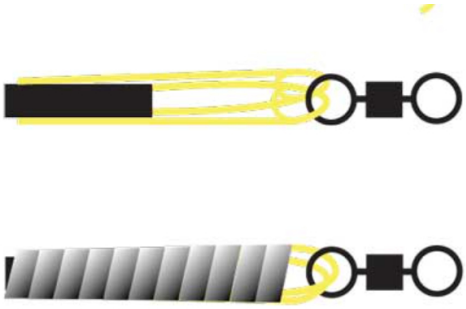


Roll the cable off the spool instead of spinning it off the spool end to prevent putting a twist in the cable for every turn on the spool. When laying cable out for a long pull, use a "figure-8" on the ground to prevent twisting. The figure 8 puts a half twist in on one side of the 8 and takes it out on the other, preventing twists.

Installing Swivel Pulling Eyes on Fiber Optic Cable
Cable manufacturers install special strength members, usually aramid yarn (Dupont Kevlar), for pulling. Fiber optic cable should only be pulled by these strength members unless the cable design allows pulling by the jacket. Any other method may put stress on the fibers and harm them.
Swivel pulling eyes should be used to attach the pulling rope or tape to the cable to prevent cable twisting during the pull.

Procedure For Installing Swivel Pulling Eyes:

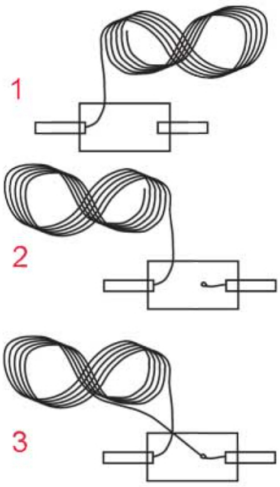




Strip the cable jacket and cut back all fibers to the end of the jacket, leaving the aramid strength members only.
Separate the aramid yarn into two bundles and loop it through the swivel eve in opposite directions.
Tie knots in each bunch at the eye and loop the strength members back to the cable jacket.
Tape the strength members along the jacket and up to the pulling eye.

How To "Figure 8" Cable for Intermediate Pulls in OSP Installations

On very long OSP runs, typically longer than approximately 2.5 miles or 4 kilometers, it may be necessary to use an automated fiber puller at intermediate point(s) for a continuous pull or pull from the middle out to both ends (midspan pull.) When laying loops of fiber on a surface during a pull, use “figure-8” loops to prevent twisting the cable. The figure 8 puts a half twist in on one side of the 8 and takes it out on the other, preventing twists.



Use this procedure for pulling from one end:
Pull the cable out of the conduit or innerduct and lay on the ground in a large "figure 8" pattern. The size of the "8" will be determined by the size and stiffness of the cable, but 6-12 feet (2-4 m) is a common size. The end of the cable will be against the ground - you might want a tarp or plastic sheet to keep the cable clean. Pull slowly and carefully lay the cable in the figure 8 pattern to keep it from becoming kinked.
Using several installers, pick up the cable and flip it over so the end to be pulled to the next location is on top.
Attach the end to the pull rope with appropriate swivel pulling eyes and continue the pull.

For a midspan pull, use these directions:
This procedure eliminates having to flip the cable in the Figure 8 on the ground over.
Place the cable reel a mid point on the long span (ensuring the maximum pulling length in either direction would not be exceeded).
Pull the one end of cable through the conduit to one end of the span.
Roll the cable off the reel and Figure 8 the remaining cable on the ground. The end on the cable will be on the top of the figure 8.
Pull the second end of the cable through the conduit to the other end of the span.

Bend Radius
Do not exceed the cable bend radius. Fiber optic cable can be broken when kinked or bent too tightly, especially

during pulling. If no specific recommendations are available from the cable manufacturer, the cable should not be pulled over a bend radius smaller than twenty (20) times the cable diameter.
After completion of the pull, the cable should not have any bend radius smaller than ten (10) times the cable diameter.

Vertical Cable Runs
Drop vertical cables down rather than pulling them up whenever possible. Support cables at frequent intervals to prevent excess stress on the jacket. Support can be provided by cable ties (tightened snugly, not tightly enough to deform the cable jacket) or Kellems grips. Use service loops can to assist in gripping the cable for support and provide cable for future repairs or rerouting.

Installing Premises Cable in Cable Trays
Fiber optic cable is often installed in cable trays in premises applications. Cable trays should not be shared with copper communications cables as their weight may harm the fiber cables. Likewise, large quantities of fiber cables in a tray may put too much pressure on the cables on the bottom. In applications where cable trays are used for copper communications cables, it may be possible to suspend lightweight fiber cables below the cable trays.

Use of Innerduct
It may be prudent to install critical indoor fiber optic cables inside bright orange “innerduct” to ease cable installation and protect it from future damage. Bright orange innerduct will identify fiber optic cable to any workers at a later date and possible prevent damage. The additional initial cost of the innerduct may be offset by the simplification of the installation saving worker time.

Use Of Cable Ties
Fiber optic cables, like all communications cables, are sensitive to compressive or crushing loads. Cable ties used with many cables, especially when tightened with an installation tool, are harmful to fiber optic cables, causing attenuation and potential fiber breakage. When used, cable ties should be hand tightened to be snug but loose enough to be moved along the cable by hand. Then the excess length of the tie should be cut off to prevent future tightening. Hook-and-loop fastener ties are preferred for fiber optic cables, as they cannot apply crush loads sufficient to harm the cable.

Fire Stopping
Indoor cables will have to meet fire codes and pass inspection, so every cable that penetrates a fire-rated wall will have to be firestopped. All telecommunications firestopping must comply with applicable codes and standards. All penetrations must be protected by approved firestops. Fire stopping compounds
and devices shall be used whenever a fire separation has been breached by an installation. In most locals the breaching of a fire separation will require physical monitoring until it has been repaired. Check with the “Authority Having Jurisdiction” for specific requirements on the project before commencing work.

Grounding and Bonding
Conductive cables require proper grounding and bonding for applicable conductors. Although most fiber optic cables are not conductive, any metallic hardware used in fiber optic cabling systems (such as wall-mounted termination boxes, racks, and patch panels) must be grounded. Ground systems shall be designed as specified by the NEC and other applicable codes and standards. Most telecom rooms have a grounding bus bar which has a high quality building ground and connections to devices that require grounding.

Splicing and Termination

The processes of termination and splicing are covered in detail in Chapter 7. Terminations and splices in the field have no unusual requirements other than a need to find adequate dust-free space with moderate temperatures for working.

Splicing
Outside plant splicing is usually done in a special splicing trailer or truck. Inside the truck is a climate-controlled splicing lab with adequate bench space for working with the cables and splice closures. Sometimes, it’s necessary to splice in the open, in a small tent or even in an aerial bucket. The installer has to be able to cope with the conditions found in the installation. In extremely cold conditions, a heated facility will probably be necessary as cables become stiff and equipment hard to operate. Hot climates may be easier on the processes but are equally uncomfortable for the installer.

Ideally splices should be tested with an OTDR as soon as they are made and before placing it in a splice tray. Fusion splicers give an estimate of splice loss, but it's just an estimate. The OTDR can confirm the quality of the splice, giving the installer an assurance that the splice is good and the splice closure will not have to be reopened to redo a bad splice.
Extreme care should be taken when placing splices in splice trays and arranging buffer tubes or fibers in the closure. One problem that occurs much too often is the fibers are broken as the trays and closure are assembled. Finding breaks in fibers inside the closure is difficult since they are too close to the splice to be resolved by an OTDR. If the splice is near enough to allow tracing with a visual fault locator, it may be found with visual inspection.
Cables must be secured to the splice closure and sealed properly. Generally loose tube cables will have the tubes extending from the entrance of the closure to the tray, where they are secured, then approximately 1 meter of bare fibers are organized in the tray after splicing. Care must be taken to properly bond electrical conductors such as the armor on some cables or center metallic strength members to the closure and at each end.
All closures must be sealed to prevent moisture entry. Closures must be properly secured, with the location being determined by the installation type, and excess cable properly coiled and stored. This may be in a pedestal or vault, on a pole or tower or buried underground.

More on splicing.

Termination
Termination, at least, is generally done inside a building near the communications equipment, whether terminating outside cable plants or premises cables. The installer may still have problems with finding adequate space, for example in a telecom room with rows of patch panel and equipment racks. Hopefully, the cable installer has provided service loops for each cable to allow the cables to be brought to an open area for termination. Many installers use portable fold-up tables or rolling carts to create a workspace where they can reach the ends of the cables.
If the building is still under construction, dust can be a problem. Even in completed buildings, air conditioning systems can blow dust around. Be alert for dust and if working in a dusty environment is necessary, clean all the tools, polishing film and connectors as often as necessary.
If terminating singlemode cables by fusion splicing pigtails on each fiber, follow the same cautions on placing splices or fibers in cable trays and closures to prevent damage. For direct termination of 900 micron buffered multimode fibers in a distribution cable, allow adequate length to store excess fiber lengths and take care to avoid tight bends that can cause problems with loss of fiber failure in the future.
Like splices, each connector should be checked when the fiber termination is completed. Inspect every polished connector with a microscope to ensure polishing was done properly. If possible, test every prepolished/splice connector with a visual fault locator. After both ends of a fiber are terminated, end to end loss should be tested and documented. High loss connectors must be reterminated and it saves time to do it while the installer is already set up on the site.

More on termination.



Labeling and Documentation
It is usually the installer who terminates the cable that has the job of labeling each termination point. Ideally, the label has been created as part of the design of the cable plant and the installer only has to match the color codes of the fibers to the label, and, if not already placed, stick the label on the patch panel at the appropriate place. This is an important process, as the designation on each fiber will be used to record test data, connection to equipment and be followed during later moves, adds and changes. Doors to patch panels should be marked as to usage and include