

optic cable, always try to have a few extra fibers available, just in case fibers are damaged during installation. The astute contractor tries to always use the same types of components on every job so they are familiar with not only the installation procedures but the typical costs, yield (i.e. number of connectors or splices that will pass testing first time) and any problems likely to be encountered.

If any components are not familiar to the installers, they need to learn how to install them correctly, either by experimenting in the office on off-time or getting manufacturers to train them. The need for training may also arise if new equipment types are required, such as outside plant cable placing tools or new types of test equipment. The cardinal rule of installation is never take an unfamiliar component or tool on the job; it's a recipe for disaster.

Buyers need to order the components when the job is acquired, scheduling delivery to the job site either to have everything available before the installation begins, or on a large job with an extended schedule, according to how long the installation of that component will take. Here you also need to plan on where the components will be delivered to, either a staging area in your warehouse, for example, or to the job site.

Components delivered to the job site may require security. Theft can be a problem with cable particularly, since many thieves think all cables contain copper and the price of copper makes cable worth stealing. But vandalism is another concern, requiring components be either locked up or if too large to put indoors like large spools of cable or fiber optic innerduct, may require on site overnight guards.

Next, one needs to schedule labor. Again, the estimates should tell you how many installers of what experience will be needed and how long they are expected to need to complete the installation. If any training is needed, additional time may need to be added to the schedule.

Having covered labor and materials in the schedule, the planning is almost done. Review the schedule with everyone involved to get them on board and start the processes, beginning with acquiring materials. Then add to the plan a review of safety rules for supervisors, installers and anyone expected to be on site. Also add notes to keep all scrap cable, connectors, etc. to package and present to the user in case they are needed for future restoration.

If the start date is not tomorrow (because the customer wanted it yesterday!) and you have other projects in the interim, pull out this schedule regularly to check if everything is on schedule to prevent any last minute surprises.

Installation Checklist

Planning for the installation is a critical phase of any project as it involves coordinating activities of many people and companies. The best way to keep everything straight is to develop a checklist based on the design. The checklist below is comprehensive but each project will have some of its own unique requirements that need to be added to the list.

Pre-install checklist:

Main point of contact/project manager chosen

Link communications requirements set

Equipment and component requirements set and vendors chosen

Link route chosen, permits obtained

Cable plant components and vendors chosen

Coordination with facilities and electrical personnel complete

Documentation completed and ready for installation, preliminary restoration plans ready

Test plan complete

Schedule and start date set for installation, all parties notified

Components ordered and delivery date set, plans made for receiving materials (time, place,) arrange security if left outside or on construction site

Contractor/installer chosen and start date set

Link route tour with contractor(s)

Construction plans reviewed with contractor(s)

Components chosen reviewed with contractor(s)

Schedule reviewed with contractor(s)

Safety rules reviewed with contractor(s)

Excess materials being kept for restoration reviewed with contractor(s)

Test plan reviewed with contractor(s)

Before starting the install:

All permits available for inspection

Sites prepared, power available

All components on site, inspected, 24-hour security arranged if necessary

Contractor available

Relevant personnel notified

Relevant personnel notified

Safety rules posted on the job site(s) and reviewed with all supervisors and installation personnel

During The Installation:

Inspect workmanship at every step

Daily review of process, progress, test data

Immediate notification and solution of problems, shortages, etc.

After completion of cable plant installation:

Inspect workmanship

Review test data on cable plant

Set up and test communications system

Update and complete documentation

Update and complete restoration plan

Store restoration plan, documentation, components, etc.

Preparing For Outside Plant Installations

Outside plant (OSP) installations of fiber optic cables can be much more diverse than premises installations. OSP installs may include installing aerial cable, direct-buried cable, underground cable in conduit or installing conduit or innerduct and then pulling cable, or placing cable underwater. A single link may include several types of installation, for example aerial in one section, pulling in conduit on a bridge crossing and burying the rest of the cable.

Cables may end when pulled into buildings or terminated at the top of poles where surveillance cameras or wireless access points are located. Splices where cables are concatenated can be placed in pedestals, buried underground or hung in aerial splice closures.

The diversity of OSP installation makes it extremely important for the contractor to know the route of the cable to be installed intimately. Like the estimator who should walk the route before beginning the estimating process, the contractor needs to see for themselves the actual situations they are going to encounter. That inspection allows them to determine what problems may be encountered, what special equipment may be needed and even double check that all the permits needed are in order. Long cable pulls in conduit may require lubricants or intermediate pulls where your installers need to know how to "figure 8" cable to prevent kinking, a procedure described later in this chapter.

Call Before You Dig



The old story about the most likely fiber optic communications system failure being caused by "backhoe fade" is not a joke – it happens every day. But it reminds us that digging safely is vitally important. The risk is not just interrupting communications, but the life-threatening risk of digging up high voltage cables or gas lines. There are several services that maintain databases of the location of underground services that must be contacted before any digging occurs, but mapping these should be done during the design phase and double-checked before digging to

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ensure having the latest data.

At the same time as the cable is installed, markers like these indicating its location and ownership can also be installed.

Pulling and Placing OSP Cable

OSP installations fall into four broad categories, underground, direct buried, aerial and submarine (or underwater.) Each used different procedures, tools and even cables.

Underground Cables



Digging trenches to bury fiber optic duct and pulling cables into duct

Underground cables are pulled in conduit that is buried underground, usually 3-4 feet (1-1.2 meters) deep to reduce the likelihood of accidentally being dug up. The process usually begins with digging a trench to bury the conduit which is generally 4 inch plastic pipe, sometimes with pre-installed innerduct (also called duct liner) with a pulling tape to facilitate the actual cable pulling process. Directional boring can also be used to avoid digging up the surface, for example in crossing streets or sidewalks. If the conduit and cables are all dielectric, a conductive marker tape may be buried about a foot above the conduit to assist in future cable location and as a warning to anyone digging in the vicinity of the cable.

Due to the disruptive nature of burying conduit, especially under roadways, many governments which grant permits for burying cable require the contractor to install extra conduits along the route to prevent having to dig again for any future cable installations. Since many cities have extensive conduits already buried for other services or may have required extra conduit to be buried during prior installations, conduit may be available for pulling new fiber optic cables.

Innerduct inside the conduit separates the cables and provides easier pulling of cables. Conduit can be purchased with innerducts installed, generally with pulling tapes also. If the innerduct does not have a pulling tape installed, a line may be blown through the duct to pull a stronger pulling tape or line through the duct.

Unless innerducts are installed in a conduit, only one cable can be installed in the conduit unless all the cables are pulled together. Pulling a cable into a conduit which already has several cables may cause tangling, increasing pulling tension and potentially damaging cables. Multiple cables may be pulled at once if the total cable fill and pulling tension does not exceed recommendations.

Innerduct or duct liners come in several types, including flexible tubes with corrugated or smooth interiors.

Corrugated tubes with smooth liners have a greater tendency to flatten, limiting cable size, while corrugated interiors may be more fragile. A new type of duct liner is more like a fabric sleeve that lies flat until the cable is pulled through it, and takes up less space in the cable than rigid innerduct allowing space for more cables.

The length of cable that can be pulled will depend on many factors, including the type of cable, conduit or innerduct, temperature, and straightness of the run that affect the coefficient of friction. Except for short pulls, cables should be lubricated to reduce friction that increases pulling tension. Lubricants should be of a type approved by the cable manufacturer, not lubricants for copper communication or electrical cables, and applied per the lubricant and/or cable manufacturer. Some lubricant manufacturers offer online calculators that will help in choosing and using lubricants. Most cables can only be safely pulled by attachment of a swivel pulling eye to the strength members of the cable. Swivels are important to reduce twisting loads on the cable. For high tension loads, a breakaway swivel is used to prevent damage if pulling tension exceeds the cable specification. Some cables are rated for pulling by the jacket if a flexible wire mesh grip, commonly called a Kellems Grip, is used. These are also usually attached to the strength members of the cable. Later in this chapter are instructions for attaching pulling eyes.

Tension for pulling cables is often high enough that a powered capstan will be needed, probably for all but the shortest pulls. The capstan should be equipped with a monitor that can shut down pulling if a preset tension is

exceeded. If tension becomes too high, the cause of excess friction needs to be found and fixed.

As with any cable installation, it is important to not bend the cable too tightly which may cause damage to the cable or its fibers. Standard cable guidelines are a minimal bend radius of 20 times the cable diameter under tension and 10 times the cable diameter after the pulling tension is removed. After pulling the cable may still have some tension at points, but if properly lubricated and carefully pulled, it should be minimal.

Cables can be pulled completely from one end if the length is short enough and there are no intermediate locations like manholes or vaults where the cable is to be pulled through, not spliced at that location. Devices exist to assist at midspan allowing pulling out of one conduit and into another at some locations, or the cable may be pulled to the location, laid on the ground in a figure 8 pattern to prevent twisting and then pulled through the next section.

Alternately, cable can be pulled in one direction from an intermediate point, the remaining cable unspooled in a figure 8 pattern, the flipped and pulled in the other direction. See the section on figure 8 cable pulls later in this chapter.

Cables can sometimes be installed by blowing special cable types into ducts called duct lines, micro-ducts or sub-ducts which have been installed in larger conduit or even pipes for carrying water, sewage or gas. High pressure compressed air provides an aerodynamic effect, floating the cable on the air stream and carrying it down the duct, allowing installation lengths as long as 2 km (6,500 feet.)

At any cable ends where splicing or termination is required, an extra 30-60 feet (10-20 meters) of cable should be left for splicing. Most splicing will be done in a trailer or tent on the ground and extra cable is needed to reach the splice location and have extra length to strip for splicing. Before beginning installation, check splice closure instructions for cable lengths required for splicing or midspan entry. Always allow extra length to cut off the pulling eye from the pulling end.

As with any cabling installation, work should be done in a neat and workmanlike manner. Cables should be neatly lashed in the proper locations in manholes or vaults, using cable ties but never tighten cable ties tightly as that can cause problems with the cable or fibers. Service loops should also be neatly lashed in place. At intermediate locations, it is extremely important to place identification tags on fiber optic cables to allow easy identification and prevent damage in the future if the cable is mistaken for a cable that is to be cut and removed.

Cables terminated inside premises need to be neatly installed. Conduit or cable trays should be used to protect the cables. Most building, fire or electrical codes limit the length of OSP cable that can be run indoors unless the cable is in conduit, so proper cable installation includes meeting appropriate building codes.

Buried Cables



Plowing in direct buried cables (L) and directional boring (R)

If the geography allows, fiber optic cables of the appropriate types can be buried directly in the ground by plowing directly into the ground, directional boring or trenching and placing the cable in the trench. Where the ground is soft and relatively free of rocks and the land is flat and has no obstacles for the movement of heavy equipment, direct burial is a fast method of installation, allowing several miles/km of cables to be installed in a day. In more built-up areas, trenching may be easier because plowing requires big machinery and lots of room.

Heavy-duty cables can be buried directly or cables in ducts for extra protection can be installed using direct burial techniques. Cables can be supplied already in ducts for burial. An alternative technique is to bury duct and blow cables into the ducts as is done in underground installations.

Typically trunk cables in most areas are installed 3-4 feet deep (1-1.2 m), but in residential or urban areas, cables may be buried only 2 feet (0.6 m) deep. Some cables can be directly installed in sawn grooves in roads, but these are only buried a few inches deep, still within the roadway material and are filled with sealer. If the cable is all dielectric, a conductive marker tape may be buried about a foot above the conduit to assist in future cable location and as a warning to anyone digging in the vicinity of the cable.

Plowing cables can be done with large static plows or smaller vibratory plows, but they should be plows rated for pulling fiber optic cables. Plows for copper cables may not meet fiber requirements for cable support, bend radius, tension or vibration. Sometimes the cable plowing is preceded by a ripping operation where a preliminary plowing

is done to prepare the ground and find underground obstacles.

Plowing in cable requires careful feeding of the cable into the cable chute of the plow to reduce stress. A capstan feed is used on many plows to synchronize cable feed. The cable reel and feed chute should be isolated from vibration also.

Plowing in fiber optic cables is a process that demands care and experience. Needless to say the plow operator and crew need to know what they are doing and exercise great caution. Inexperienced personnel should work with an experienced crew to learn the proper procedures.

Trenching involves digging a trench with a backhoe or trencher, laying the cable and then filling the trench. All sizes of trenchers are available, and don't need to be fiber specific equipment unlike plows. The contractor needs to be careful about sharp objects or rocks in the trench or filler since they may damage the cable. If the ground is rocky, burying the cable in sand before filling the trench will provide protection.

Cables may also be buried by directional boring, a method often preferred when crossing roads or shallow waterways as it does not require digging up the surface. The size and length of the bore are related, as bigger bores can not be made over as long a length, and both may be determined by the type of ground encountered. Directional boring also requires exact knowledge of other buried utilities to prevent damage to them during the boring process.

Buried cables may be spliced in closures which are buried along the cable route or placed above ground in a pedestal. At any cable ends where splicing or termination is required, an adequate length of cable must be left, typically an extra 30-60 feet (10-20 meters) of cable for splicing in a trailer or tent on the ground. Before beginning installation, check splice closure instructions for cable lengths required for splicing or midspan entry. Always allow extra length to cut off the pulling eye from the pulling end.

As with any cabling installation, work should be done in a neat and workmanlike manner. Cables should be neatly lashed in the proper locations in manholes or vaults, using cable ties but never tighten cable ties tightly as that can cause problems with the cable or fibers. Service loops should also be neatly lashed in place. At intermediate locations, it is extremely important to place identification tags on fiber optic cables to allow easy identification and prevent damage in the future if the cable is mistaken for a cable that is to be cut and removed.

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Aerial Cables



Installing aerial cable to CCTV camera (L), OPGW spliced to underground fiber optic cable

In many areas, cables are still installed on utility poles. Aerial cables are subject to continual tension as well as extra tension caused by temperature changes, wind and in some areas, the weight of ice. Most fiber optic cables do not have sufficient strength to allow direct aerial installation, but there are methods to install them aerially as well as special cables that are designed for aerial installation.

The simplest solution is to lash a regular OSP cable to a messenger, usually a metallic stranded cable used to support the cable but sometimes another cable if it has adequate strength. CATV overbuilds sometimes lash fiber cables to existing coax cables and even power cables can have fiber optic cables lashed to them. The messenger must be selected to have adequate strength to support the fiber optic cable over the span between support structures. Care must be taken when installing fiber optic cables with a messenger to accommodate length variations in the messenger, for example due to stretching in the wind or with temperature changes. Since optical fiber cables are designed not to stretch as that would stress the optical fibers, slack must be provided, usually at the supports, to reduce tension on the fiber optic cable when the messenger length changes. The National Electrical Safety Code and RUS provide guidelines for support structure design, but manufacturers should always be consulted about the proper support methods for the cables being chosen for aerial installation.

The first stage of a lashed aerial installation is installation of the support messenger cable. Typically the strand will be laid on the ground along the span, pulled onto the poles using pulleys, then have the tension adjusted and the