The Fiber Optic Association Inc.
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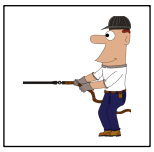
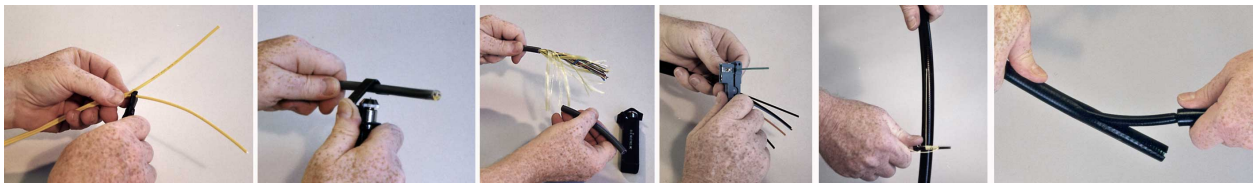


Fiber U Basic Skills Lab Workbook

Fiber Optic Cable And Fiber Preparation



This exercise will cover fiber optic cable preparation for pulling, splicing and terminatilon for several common types of cables. Before starting this exercise, you should read the workbook on Tools.

Equipment: cable tools
Fiber optic cables: simplex or Zipcord, distribution, breakout, loose tube and armored.

Visual Aids
The following visual aids show the processes described in these exercises.
FOA Instructional YouTube Videos: (https://foa.org/tech/ref/contents.html#YT)

- Fiber Optic Cable, Part 1 Introduction
- Fiber Optic Cable, Part 2, Zipcord
- Fiber Optic Cable, Part 3 Distribution Cable
- Fiber Optic Cable, Part 4 Breakout Cable
- Fiber Optic Cable, Part 5 Loose Tube Cable
- Fiber Optic Cable, Part 6, Armored Cable

FOA Online Guide To Fiber Optics: VHO Cable Preparation:
https://foa.org/tech/ref/cable/VHO-cable/VHO-cables.htm

Introduction

In order to successfully install, splice and terminate fiber optic cable, it is important to understand the construction of cables and how to handle it during installation and how to prepare the cable by exposing the fibers without damaging them.

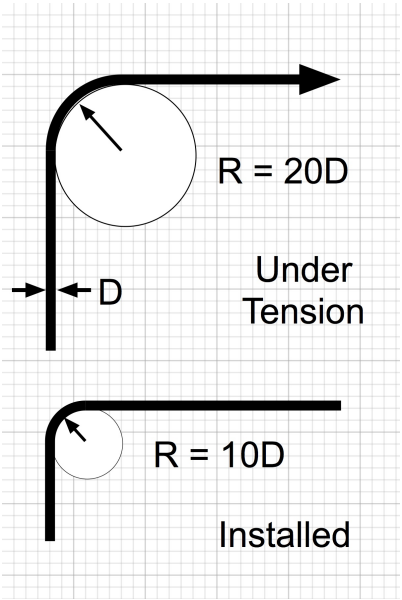
Cable Design Criteria

Designing a cable requires consideration of all the installation stress and environmental factors involved during installation and during the cable's lifetime. Here are some of the most important factors considered and the specifications for those performance limits.

Pulling Strength: Some cable is simply laid into cable trays or ditches, so pull strength is not too important. But other cable may be pulled thorough 2-5 km or more of conduit.

Even with lots of cable lubricant, pulling tension can be high. Most cables get their strength from an aramid fiber (Kevlar is the duPont trade name), a unique polymer thread that is very strong but does not stretch - so pulling on it will not stress the other components in the cable. The simplest simplex cable has a pull strength of 100-200 pounds, while outside plant cable may have a specification of over 800 pounds.

Bending Limits (Bend Radius): The normal recommendation for fiber optic cable bend radius is the minimum bend radius under tension during pulling is 20 times the diameter of the cable. When not under tension, the minimum recommended long term bend radius is 10 times the cable diameter.



Fiber optic cable bend radius under tension (top) and after pulling (bottom)

Bend radius example: A cable 13mm (0.5") diameter would have a minimum bend radius under tension of 20 X 13mm = 260mm (20 x 0.5" = 10") That means if you are pulling this cable over a pulley, that pulley should have a minimum radius of 260mm/10" or a diameter of 520mm/20" - don't get radius and diameter mixed up!

Crush Loads: Cables may be laid in trays with other cables in some premises installations, so crush loads may be important. Otherwise, when installing cables, it is important to not crush cables by walking on them or rolling equipment (including vehicles) over them.

Long cable pulls through conduit require special techniques, including using breakaway swivels, pulling capstans and other hardware to limit the cable bend radius to prevent damage. Aerial cable can also be problematic as cable is lashed to a messenger or ADSS cable attached to its unique hardware. Whatever the installation method, proper attention must be paid to not exceeding these specifications for the cable. See the FOA Guide section on Cable Plant Construction for more details.

Before Starting The Cable Preparation Exercises: Secure ripcords when using short lengths of cable.

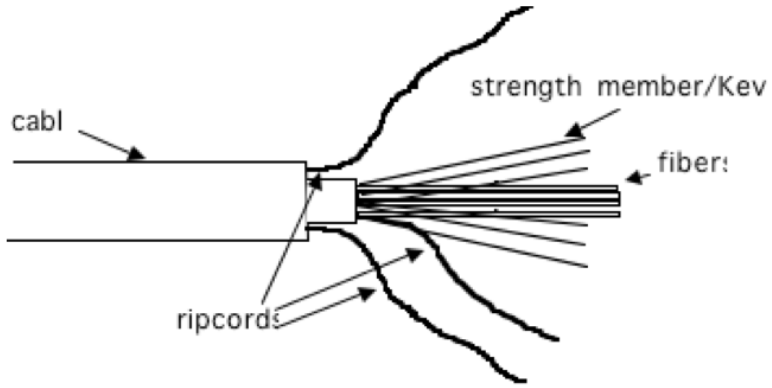
In order to successfully complete the cable exercises that include using the cable's rip-cord on short OSP loose tube or armored cables that one typically uses in the lab, an additional preparation step may be required. There may not be enough friction in the short length of cable to hold the ripcord in the cable. When the rip-cord is used to cut the cable jacket or armor, it may instead be pulled right out of the cable. To avoid this and to insure that the rip cord does its job the following steps must be done prior to the exercises.

Follow the procedures in sections below for specific instruction on removing the jackets. (see also, the Toolbox Manual for round cable slitter and armored cable cutter instructions)

Wear Safety Glasses for this exercise!!

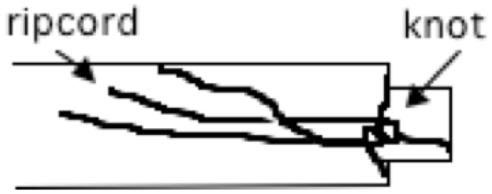
1. Remove approximately 3 inches of the outer jacket on one end of the cable. Expose ripcords. Do Not damage the exposed rip cords.

2. Locate inner ripcord (if any). If there is no inner ripcord, strand together a few Kevlar fibers and hold them aside with the rip cords.



3. Cut off all fiber and strength member close to the cable end. Do Not damage the exposed ripcords.

4. Tie all the ripcords together.



5. Tightly tape the ends of the ripcords back along the cable with black electrical tape.

6. Now one can practice using the ripcords on the other end of the cable to split the jacket without them pulling out.

Pulling And Placing Cable

In a typical classroom course, it's not easy to practice “pulling” cables in conduit or installing aerial cable on poles. Some schools do have the facilities to do so, but if not, showing students how to prepare cable for pulling is possible in the lab.

The main thing to learn is that cable must be pulled ONLY by the strength members provided in the cables, never by the fibers. Only special cables can be pulled by the jacket using a Kellums grip.

If you are ever in doubt about the proper way to pull a specific type of cable, contact an application engineer at the cable company and get specific instructions. Otherwise you may damage the fibers. Damage to a fiber optic cable is never reversible. If it is damaged, it must be removed and replaced, potentially very expensive!

Fiber Optic Cable Preparation for Termination and Splicing

These exercises will show you how to prepare fiber optic cables during installation, splicing and termination. In this course, we describe the use of several common types of cable for practice. These cables are tight buffer, distribution, breakout and loose tube cable typical of cables installed in a network. You use these samples to strip jackets and expose fibers for splicing or termination.

After working with the samples provided, fill in the worksheet at the end of the section.

Examining Cable Ratings and Markings On Premises Cabling

All indoor cables must carry identification and ratings per the NEC (National Electrical Code). Cables without markings should never be installed as they will not pass code inspections! The jacket markings will also include the fiber type, a distance marker and manufacturers identification.

Examine some indoor cables to see the markings.

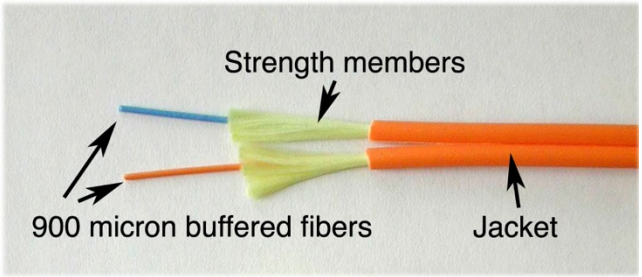
These ratings are:

- OFN optical fiber non-conductive
- OFC optical fiber conductive
- OFNR or OFCR riser rated cable for vertical runs
- OFNP or OFCP plenum rated cables for installation in air-handling plenums
- OFNG or OFCG general purpose
- OFN-LS low smoke density

Stop now and fill in the exercise worksheet.

Preparing And Pulling Simplex And Zipcord Cables

Simplex cables have a tight buffered fiber surrounded by strength members and a jacket. Since it's an indoor cable, the cable will be rated for flame retardance and marked as such on the jacket. The jacket markings will also include the fiber type, a distance marker and manufacturers identification.

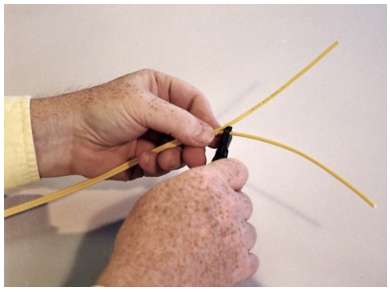
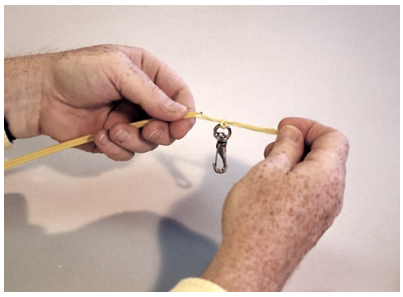
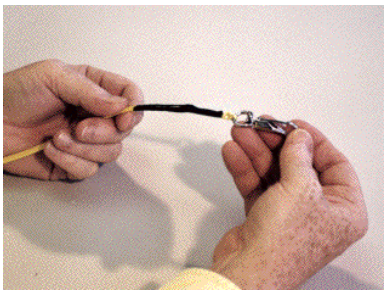


All fiber optic cable must be pulled by the strength members, since that’s how they are designed to withstand pulling tension.

There is a simple exercise to see why you do not pull fiber optic cable by the jacket. Use a 2 m (6') length of zipcord. Have two students grab each end by the jackets (don't wrap around the hand) and pull as hard as they can. The jacket will stretch and, if pulled hard enough, break. Release the tension and watch the jacket shrink back on the cable. The fibers and strength members will bunch up inside the cable causing a lumpy texture to the cables. The constriction of the fibers will cause extremely high loss and stress that may cause eventual failure. Cables should always be pulled with pulling eyes attached to the strength members.

If you are going to be pulling lots of zipcord or small fiber count cable indoors, you may want to make a pulling mandrel. It requires a round mandrel about 8-12" in diameter like a cable spool and two handles available from any hardware store.

Pulling cables properly is done with a swivel pulling eye. Following the instructions, attach the supplied swivel pulling eye to the zipcord cable.

- Split the Zipcord cable into two single fiber cables.
- Using the Miller jacket stripper, strip off the jacket exposing the Kevlar (a duPont trade name for aramid fiber) strength members and the buffered fibers.
- Cut off the fibers close to the jacket end.
- Tie the strength member to one end of the swivel pulling eye
- Tape the strength member to the cable jacket to secure the eye.

Stop now and fill in the exercise worksheet.

Breakout and Distribution Cables

Two common premises cables are breakout cables and distribution cables. Breakout cables consist of a number of single fiber sub-cables combined into a larger cable with an outside jacket. Each sub-cable has a buffered fiber surrounded by Kevlar strength members and a plastic jacket that can be terminated by a standard connector. The sub-cables are wound around a central strength member, which also acts as a bend radius limiter.

The big advantage of the breakout cable is that it can be brought to a termination point, have the jacket stripped off and individual sub-cables terminated directly. Then the sub-cables can be connected to patch panels or terminal equipment with no further hardware. The easier termination at the ends makes breakout cable very cost effective

in many building applications. The disadvantage of the breakout cable is its cost and size. For longer runs, it may not be the best choice.

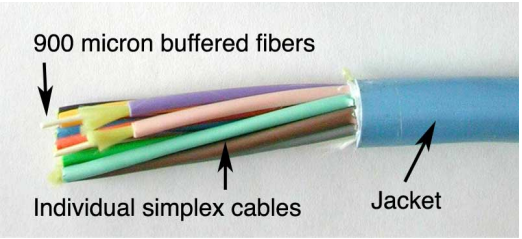
Pulling breakout cable requires more care also, due to it's more complex construction and larger size. It is usually pulled by stripping the Kevlar strength members from each sub-cable and cutting off all the fibers, then tying the Kevlar strength members to a pulling eye that is firmly attached to the central strength member. In some cases, a jacket gripper ("Kellum's Grip") is used in conjunction with the pulling eye. Consult the cable manufacturer for special instructions for longer pulls on breakout cable.

Distribution or tight-pack cables are designed for use in dry conduit or short riser applications. It consists of a bundle of 900 micron buffered fibers with a central stiffener/strength member, a wrapping of Kevlar strength members, and a outer jacket. Distribution cables are much smaller and lighter than breakout cables, but the individual buffered fibers require termination inside a patch panel or junction box or sleeving each of the individual fibers in a breakout kit before termination.

Combinations of the two designs can be made for some applications. For example, a number of smaller distribution cables can be combined into a breakout cable. At some point, the breakout cable jacket can be stripped and the individual distribution cables pulled to separate locations.

Stop now and fill in the exercise worksheet.

Preparing Breakout Cable for Termination



To prepare the breakout cable for termination, we will first use the jacket stripping tool and remove the jacket of the cable.

- Viewing the end of the cable, confirm the outside jacket is round and uniform.
- Hold the jacket slitter up to the cable jacket and use the knurled nut to set the blade depth to approximately 80-90% of the thickness of the cable jacket. You don't want to cut through the jacket as you might damage the cables inside.
- Make a trial cut of the jacket about 3-4 inches back from the end to see if the cutting depth is correct.
- Place the slitter on the cable and make several turns around the cable. Don't force anything, the tool's spring tension will cut the jacket gently.
- Remove the tool.
- With your thumb under the cable to limit the bending, bend the cable until the jacket snaps.
- Turn the cable over and repeat the bend on the opposite side so the jacket is completely snapped.
- Pull the jacket off the end of the cable.

If the jacket slitter worked correctly, you now have about 4 inches of sub-cables, a strength member and a "pull string" or "ripcord" sticking out of the end of the jacket. Use the ripcord to slit the jacket to about 2 feet back from the end.

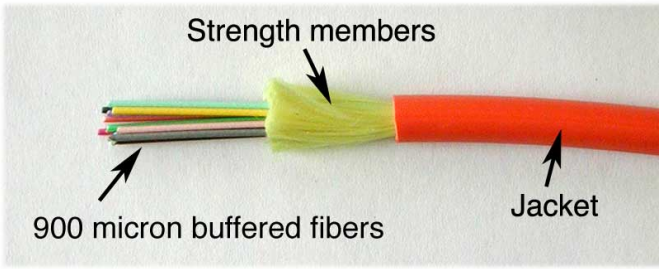
Use the needle-nosed pliers to grip the ripcord.
Coil the ripcord around the jaws of the pliers.
Pull gently back along the cable to slit the jacket. Do not pull at 90 deg to the fiber.

Use the jacket slitter to cut the jacket just beyond where the jacket was slit by the ripcord and remove the section of jacket. If there is a central strength member, cut it off, leaving only enough to tie off or clamp. Now you have two feet of sub-cables ready to prepare for termination.

The individual sub-cables should have their jacket stripped, Kevlar strength member cut to the proper length and the fiber stripped as specified by the manufacturer or the connector being installed.

Stop now and fill in the exercise worksheet.

Preparing Distribution Cable for Termination or Pulling



Distribution cable consists of a central strength member, bundles of buffered fibers, Kevlar fiber strength members wound around the fibers and an outer jacket. It is very important when cutting the jacket with the cable slitter that you do not cut through the jacket, as the fibers are simply bundled inside and may be nicked by the slitter blade.

Using a sample of distribution cable, prepare the cable as follows.

- Verify the blade depth of the cable slitter by checking it against the jacket at the end of the cable.
- Make a trial cut a few inches back from the end to make sure the blade depth is correct.
- Since the jacket on distribution cable is not tightly bound, you do not have to use the ripcord to slit the jacket, although you may.
- Cut the jacket about 18 inches back from the end.
- Break the jacket over your thumb and pull the jacket off the cable.
- Unwind the Kevlar strength members. It is probably counter-wound, so you may want to push back the Kevlar, cut to the length needed (about 10-12 inches to attach a pulling eye, less for tying off at a junction box.)
- Remove the binder tape that holds the bundles of fibers together.
- Identify the central member, unfold the fibers wrapped around it.
- For termination, cut the central member off at a length necessary for clamping or tying off.
- For pulling the cable, cut off the central strength member and all the fiber, then attach a pulling eye to the Kevlar strength members.

Stop now and fill in the exercise worksheet.

Preparing Distribution Cable for Pulling

Using the distribution cable you have already prepared for pulling, attach a pulling eye.

- Twist the Kevlar fiber to make it look like yarn and tie a knot in the end to facilitate handling.
- Use the swivel provided in the toolbox.
- Tie the swivel to the strength member about two inches from the end of the cable with two half-hitches.
- Pull the Kevlar back over the cable and cut so it overlaps the jacket by about one inch.
- Tape the Kevlar over with electrician's tape.
- Make sure there are no rough edges that can snag on the conduit during the pull.

The swivel is now ready to tie to the pulling rope.

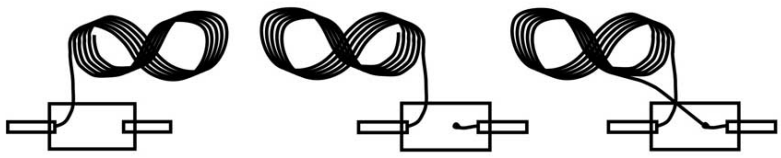
Stop now and fill in the exercise worksheet.

Pulling Cable And Figure-8s

Cables being pulled in conduits should be attached to the pulling rope with a breakaway swivel pulling eye that is attached to the strength members of the cable. Premises (indoor) cables may be pulled in conduit or laid in cable trays. Cables in cable trays should be separated from copper cables to prevent crushing. All cables need to be handled carefully to prevent overstressing from pulling tension or damage from kinking or bending under the cable minimum bend radius.

On long cable runs, it may be preferable to pull the cable from a central point towards both ends or pull to an intermediate point and then pulled in another section. Since it is very important to not put twists in the cable, the cable should be laid out on the ground in a "figure 8" pattern. The figure 8 puts a half-twist in the fiber one way, then takes it out on the other half of the "8", preventing twists. When the cable is fully pulled and laid in the figure 8, the entire cable is flipped on the ground and then the end can be pulled into the next section of conduit.

"Figure 8" Cable On Long Pulls



Pull Cable, Lay On Ground in "8" | Flip Cable On Ground | Pull End To Next Point

Indoor runs should be pulled without lubricants if possible, due to the mess they can make in a building but long runs or difficult pulls should use lubricants. (An excellent

video on lubricants for, pulling is available from American Polywater, Box 53, Stillwater, MN 55082. 612-430-2270 or fax 612-430-3634, polywater.com)

If a pull needs some leverage but not enough to require power pulling equipment, you can use a cable reel, two folding chairs and a piece of conduit to form a large version of the mandrel puller shown earlier. The cable itself will withstand up to 600 pounds of pulling force. By winding the pulling rope on the cable reel first, the reel will be pulling on the strength member of the cable, not the jacket, and several hundreds of pounds of force can be exerted safely (for both the cable and the installers!)

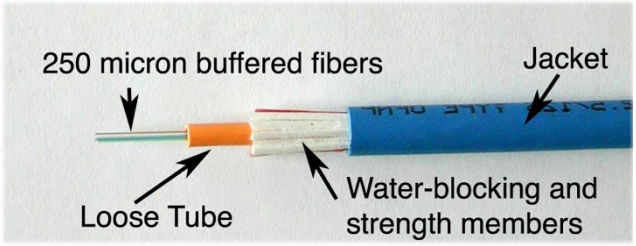
Refer to the FOA Guide for additional information on OSP construction and premises cable installation.

Stop now and fill in the exercise worksheet att he end of this document.

Preparing OSP Loose Tube Cables

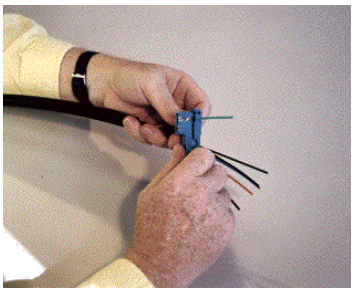
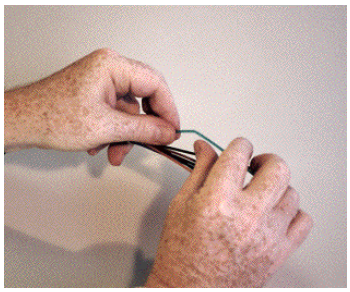
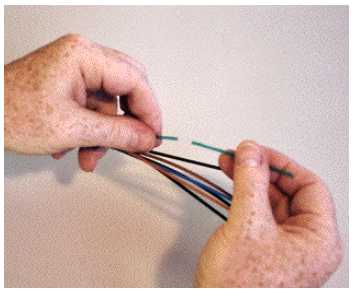
Preparing Single Jacket Loose Tube Cable

Loose tube cable is usually gel filled to protect the fibers from moisture or water. A single jacket cable cannot be pulled on the jacket, so it is important to separate the strength members if it is being prepared for pulling. In this case, we will see a cable prepared for termination or splicing.



This is the simplest type of loose tube cable with only a single tube for fibers. We'll see more complex loose tube cables when we examine armored cable.

Note: some cables may have gel in the cables to protect the fibers from moisture. Newer cables are likely to have a dry water-blocking compound that is much easier to clean. If you have a gel-filled cable, it is recommended you work over a clean work surface with disposable paper, as the gel is messy!


- Inspect the jackets for concentricity.
- Set the cable slitter blade depth to cut jacket.
- Take a test cut about 4 inches from the end of the cable.
- Slide off jacket.
- Find the ripcord and use it to slit the jacket several feet back (as long as you need for fiber splicing or termination.)
- Use the cable slitter to cut the jacket at the end of the slit and peel off the jacket.
- You now have a “gooey mess” which can be cleaned with commercially available gel cleaners in wipe form.
- Peel off the Kevlar strength members, which can be cut to the proper length for attaching to a pulling eye or tying the cable off.
- Remove the binding tape.
- Separate the loose tubes that contain the fibers and the central strength member.
- Cut the central strength member off at the proper length.
- Clean the tubes where you plan to cut them. The length will be determined by the hardware you are using for splicing or termination.
-   
- You can cut the buffer tubes by scoring them with the buffer tubing cutter. Let the cutter work on its own - do not force it.
- Feel where the tube is scored, place your thumb under it and gently snap the tube.
- Pull the tube off, exposing the fibers.
- Wipe the gel off the fibers.

Now you are ready to splice or terminate the fibers. Make sure you know which hardware you will be using so you can cut the tubes to the proper lengths.

Stop now and fill in the exercise worksheet.

Preparing Dual Jacket Outside Plant Cable

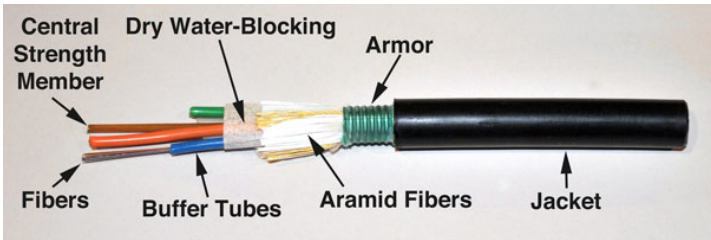
Outside plant cable is sometimes loose tube cable with strong dual jackets with aramid fiber strength members or metallic armor between the two jackets. This cable has a jacket that is strong enough that it can be pulled directly by the jacket using a Kellum's grip. Duct cable will be installed in conduit, aerial cable may have an internal strength member or require being wrapped to a messenger wire. Direct burial cable is often armored with a thin layer of metal to prevent rodent damage.

Dual jacket duct cable has two jackets with a Kevlar strength member between the two jackets. The strength member is bonded to the jackets so it can be pulled by a Kellums grip directly on the jacket. Since the strength members are contra-helically wound (two helical windings in opposite directions, overlapping), a rip cord will not work on this cable, so it is necessary to cut both jackets and the strength member at once with the cable slitter.

- Inspect the jackets for concentricity, (equal thickness all the way around).
- Set the cable slitter blade depth to cut both jackets.
- Take a test cut about 4 inches from the end of the cable.
- After cutting with the slitter for several rotations, push down hard on the slitter's cable retention bar to make sure it is cutting through the Kevlar strength member and the inner jacket.
- Break the jacket with your thumb under it.
- Pull the cut jackets off. It will be difficult due to all the materials in the cable. After pulling it a small amount, push the jacket back and the Kevlar can be cut with the scissors, making it easier to pull off.
- To cut off a longer piece of the jacket to expose fibers for splicing, use the cable slitter to slit the jackets on both sides. Use the lever on the slitter to rotate the blade for slitting.

Stop now and fill in the exercise worksheet.

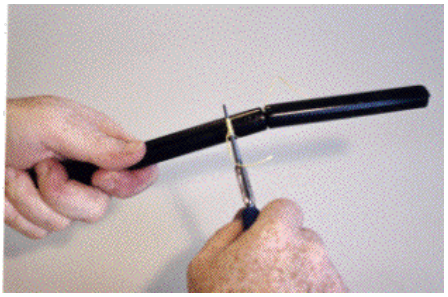
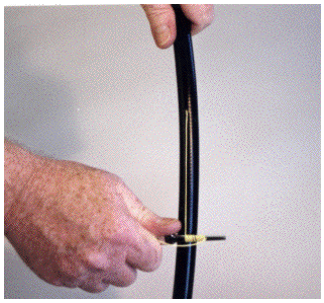
Preparing Armored Cable



Armored cable has a thin metal layer between two jackets for protection against rodent penetration in direct burial installation. The outer jacket and armor are generally

thin enough that once a small part is removed, a rip cord can be used to split the armor and outside jacket for easy removal. The armor is too hard to cut with a normal cable slitter, so a regular plumbing tubing cutter is used. The tubing cutter blade cuts about 1/8th inch deep, ideal for cutting the outer jacket and armoring without harming the inner jacket and fiber.

Use a sample armored cable to practice removing the outer jacket and armor:

- Using the armored cable cutter, make a cut about 4 inches in from the end.
- Keep tightening the cutter just until the shoulder of the cutter reaches the jacket and the cutting blade has penetrated to the full depth. It is not advisable to tighten the cutter any further as it cannot penetrate further and will merely flatten the cable.
- Remove the cutter.
- Flex the cable to finish breaking the outer jacket and armor.
- Slide the short section of outer jacket and armor off the end.
- Use the ripcord to slit the jacket. With the needle-nosed pliers, roll the ripcord around the jaws of the pliers to begin cutting through the jacket and armor.
- Pull the ripcord back along the jacket of the cable to rip the armor and jacket.
- Repeat with the other ripcord to finish slitting the armor and jacket.
- Use the armored cable cutter to cut through the jacket and armor just beyond the end of the slit.
- Pull off the slit armor and jacket segments.

The inner cable can now be handled just like any other cable for termination and splicing.

Handling and Stripping Fiber

Once the fibers are exposed after stripping the cable, they can be stripped for termination or splicing. Stripping fibers should be done carefully to not nick or break the fibers. Breaking a fiber can be a big problem in a cable since it may require stripping back the cable jacket again to ensure adequate lengths of fibers. Like other processes covered in this manual, practice is important.

It is also important to choose the correct type of stripper for you. The popular “Miller” stripper which looks like a wire stripper is very popular because it is consistent,

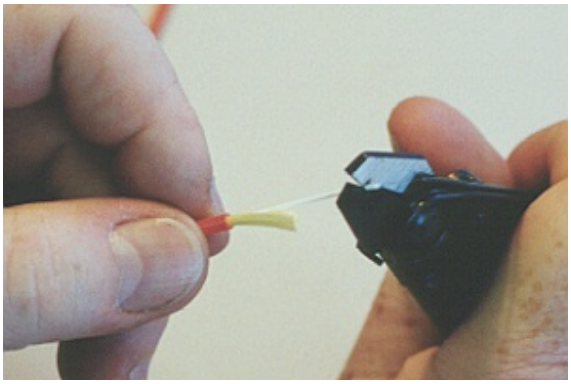
reliable and long lasting. However, it requires holding at an angle when stripping fibers making it essentially a right-handed tool. Left-handed installers need to learn to use it in their right hand or they should choose another type of stripper like the No-Nik or Micro-Strip. Ribbon fibers require special strippers, often heated to more easily remove the coatings from all the fibers at once.

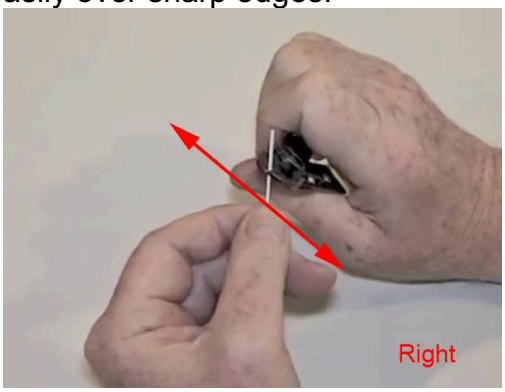
Fiber strippers: (L>R), Miller stripper, No-Nik Stripper and Micro-Strip

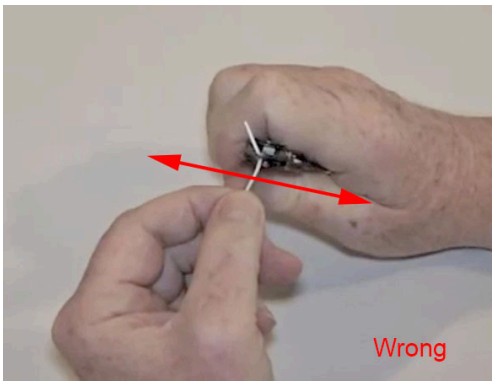
It is important when preparing the cable to determine how easily the fiber can be stripped. If possible, get a sample of the buffered fibers used by the manufacturer to test. The time it takes to strip the fiber will affect the time and cost of the installation job.

Take a piece of the tight buffered fiber from the distribution cable and try stripping it using the following guidelines.

Wear Safety Glasses for this exercise!!

- Do not use your finger to feel for the fiber ends. You can stick the fiber into your finger and it will usually break off in your finger, producing a painful experience!
- Always wear safety glasses when working with fibers, to prevent getting fiber pieces in your eye. It is very hard to remove and very painful!
- 

- To hold the fiber for stripping, hold it between your fingers, wrap it between your fingers in a zig-zag fashion or wrap it around your palm.
- Do not bend the fiber in a small radius. Fiber is very strong in tension but breaks easily over sharp edges.
- 



- Use the Miller stripper to carefully remove the buffer coating and expose the fiber. Note how the stripper should be held at an angle shown by the red arrow. You can tell the proper angle because when the stripper is held at that angle the fiber will not be bent. If the fiber bends, change the angle you hold the stripper until the fiber stays straight.
- Take small “bites” of the buffer at first – say 3mm (1/8”) to see how easy the buffer strips. If it strips easily, take larger bites.
- When stripping 900 micron tight buffer fiber, check to ensure that both the 900 micron buffer and the 250 micron buffer underneath are removed. Some strippers have separate slots in the jaws for each buffer size.

This exercise should be repeated with 250 micron buffered fiber from the OSP loose tube cable in the session above. Note with 250 micron buffer fiber it is sometimes hard to see if the buffer has been stripped. Check the jaws of the stripper to see if there are scraps of plastic after stripping.

Stop now and fill in the exercise worksheet.

The Fiber Optic Association Inc.
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Fiber Optic Cables Worksheet

Name: _____

Zipcord & Pulling

All cables should be pulled ONLY by the _____.
What is the most obvious sign of cable damage due to incorrect pulling?
_____
Can you just cut the cable, make a loop on the end and pull by that loop? Explain.
_____
What can you check to make sure the installer pulled the cable correctly?
_____

Cable Marking

What does the marking OFNR mean? Where can it be installed?
_____
What defines the requirements for fire retardency of cables?
_____

Breakout and Distribution Cable

What is the biggest advantage of breakout cable?
_____
On a breakout cable, where does the NEC or UL marking appear?
_____
If space is limited, would breakout or distribution cable be preferred?
_____

Breakout Cable

How deep should the jacket slitter blade cut into the jacket?
_____
Why do you make a “trial cut” of the jacket near the end of the cable?
_____
What tool do you use to pull the ripcord?
_____
Once the sub-cables are exposed, what else must be done to them to install connectors? _____

Distribution Cable

What do you want to pull on when pulling distribution cable?

_____

Where can you get swivel eyes?

_____

How close should the swivel be to the end of the cable?

_____

Cable Pulling

Why do you “figure 8” cable?

_____

How much pulling strength does the cable have ?

_____

What is the cable reel pulling on?

_____

Single Jacket Loose Tube Cable

Why do loose tube cables have gel filling ?

_____

How do you cut the tubes without breaking the fibers?

_____

How long should the buffer tubes be after cutting?

_____

Armored Cable

Where is armored cable usually placed?

_____

Why does the cable have armor?

_____

Why do you need ripcords with armored cable?

_____

Dual Jacket Outside Plant Cable

What can you do with dual jacket outside plant cable that you should not do with most cables? _____

Why can't you use a ripcord with dual jacket outside plant cable?
_____

Fiber Handling and Stripping

What should you do to handle fiber safely?
_____
What causes fibers to break?
_____

Effects of Stress on Cables And Fibers
Using a patchcord connected between a meter and source, wrap the cable around a small rod or pencil about 6mm (0.25") diameter.

Describe the result:

If you have a VFL (visual fault locator), attach the patchcord and bend the cable or wrap the cable around a small rod or pencil about 6mm (0.25") diameter.

Describe the result:

Explain what is happening:
