



## **Chapter 4** **Pulling Cable**

Includes new sections on common project procedures and pulling station cable and new information on extender tools and the use of plenum-rated innerduct.



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## Pulling Cable

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### Introduction

Pulling cable is an important part of a successful installation. In addition to pulling techniques, the telecommunications cabling installer must be familiar with industry standards and codes and the system's overall design. This chapter highlights tasks and procedures common to all telecommunications cabling installation projects and describes specific types of cable pulls.

### Common Project Procedures

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Cabling installation encompasses a variety of pathways, cable types and sizes, pulling methods, and tools. Every project combines these items in a unique way to meet the customer's requirements. However, some elements are common to all cabling installation projects:

- Knowledge of industry standards and codes
- Understanding of the project design
- Project planning
- Safety procedures
- Firestopping methods
- Job wrap-up tasks

### Standards and Codes

All installations must adhere to fire and building codes and should follow industry standards. A knowledge of national and local codes and an understanding of cabling installation standards, BICSI® manuals, manufacturer's specifications, and basic telephony principles are critical to the success of the project.

## Understanding the Customer's Design

As part of the planning process described in Chapter 2: Planning, the cabling installer should review the cabling installation drawings, specifications, and scope of work prior to starting the project. Knowledge of the overall design requirements, including the types, sizes, and routes of both media and pathways, will help the cabling installer determine the tools and procedures needed to pull cable.

### Media

The majority of new construction and renovation projects involve the installation of copper and optical fiber cable. These cables support many different kinds of technology applications, including:

- Voice communications.
- Data communications.
- Video systems.
- Cable television (CATV) systems.
- Other building information systems (monitoring, fire alarm, security, paging, and audio).

There are two categories of cabling installation: horizontal and backbone. Horizontal cable is installed between the telecommunications room (TR) and the work area (WA) telecommunications outlet/connector. Backbone cabling is used to interconnect TRs, equipment rooms (ERs), and entrance facilities (EFs).

NOTE: Definitions are based on ANSI/TIA/EIA-568-B.1, *Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements*.

### Pathways

Like media, pathways are also classified as horizontal, intrabuilding, and interbuilding backbone pathways. Horizontal pathways are typically provided for the installation of cabling between TRs and WAs. Intrabuilding backbone pathways normally provide access for backbone cabling between TRs, whereas interbuilding backbone pathways connect buildings.

## Understanding the Customer's Design, continued

Building designs use several types of horizontal pathways, including:

- Conduit and sleeves—Conduit may be installed from the WA telecommunications outlet/connector to the TRs in what is usually called a home run. Use caution to ensure that the maximum fill ratio of the conduit is not exceeded.
- Cable trays—Cable trays are often used in ceilings to provide a means of support for large quantities of horizontal cable or high pair-count backbone cables.
- J-hooks, bridle rings, and clamps—These devices are often used when conduit and cable trays are not available or appropriate (e.g., for individual horizontal cable runs serving a WA).
- Innerduct—Innerduct is sometimes provided as a pathway and additional protection for optical fiber cable installations.
- Building red iron (structural steel), roof support, or other building structures—These should only be used with an appropriate supporting hook, ring, or clamp designed to support the weight of the cables installed and to protect the cable after placement.

Backbone pathways may consist of sleeves that connect the spaces or rooms used for backbone cables. If these spaces are stacked (located one above the other), interfloor sleeves are typically provided. In the event a room is not stacked, a home-run conduit method may be used.

See Chapter 3: Installing Supporting Structures for details on pathways.

## Project Planning

After reviewing the cabling installation documents to determine what is required on the project, the cabling installer can prepare for the job. The following pre-cable-pulling tasks are essential:

- Determine the methods to be used in placing each type of cable.
- Make sure correct lengths and types of cable are on hand.
- Identify and obtain appropriate cable pulling tools, equipment, and supplies.
- Identify locations for accessing and pulling the cable.
- Determine the staffing required and assign tasks to team members.
- Obtain equipment that allows cabling installers to communicate with each other.

## Project Planning, continued

### Pull Strings

Pulling cable through a conduit requires some type of pulling device attached to the cable that precedes it through the conduit. That pulling device is a pull string or rope. Methods for installing the pull string or rope through the conduit include:

- Fishtape method—A fishtape is a steel or fiberglass wire rigid enough to be pushed all the way through the conduit or, in longer runs, to a pull box. It is used to retrieve the pull string or rope from the far end.
- Air-propelled methods, including:
  - A vacuum on one end and a foam ball (rat) attached to a pull string on the other end.
  - A compressed air bottle or mechanical blower used to propel a pull string attached to the propellant object.

Other devices can be purchased or made up on the job.

The installation of pull strings for cable pulls in an open ceiling and walls may be different from those used with conduit. Various ways are used to pass the pull string through the pathway, including:

- A roll of electrical tape, a small beanbag, a ball, or similar item is attached to a pull string that is thrown through the open ceiling space. It is important that the object not have the properties of a ball that would bounce off the tiles and get tangled around the ceiling support wires and lighting conductors.
- A tool used to extend the reach across building structures. These tools include:
  - Gopher poles.
  - Fiberglass poles.
  - Telescoping poles.
  - Expanding rods.
- Drop chain or fish chain for use inside walls.
- Remote-controlled appliances attached to the pull string.

## Project Planning, continued

For all of these methods, it is essential that the cables have a straight and smooth path.

In many projects, the cabling installer will have to pull backbone copper cable with high pair-counts. A 2400-pair, 24 American wire gauge (AWG) [0.51 mm (0.020 in)] backbone cable could weigh as much as 46.3 kg/m (21 lb/ft). As a result of this weight, a pull rope and attachment device of sufficient strength must be used to pull the cables.

### Verification of Cable Lengths and Types

When shipped from a distributor, cable is usually taken from a larger reel and spooled onto a smaller reel. The cabling installer must determine the size and type of reel onto which the cable is to be loaded. Cable reels may be steel, which must be returned to the factory, or wood, which is disposable. The size of the reel depends on the size and quantity of the cable. High pair-count cable can be loaded onto reels that are up to 2.1 m (7 ft) high and 1.5 m (5 ft) wide.

When cable is received at the job site, cable length should be verified. Although cable is shipped from the manufacturer with a cable run label that indicates the length of the cable, do not take this for granted. Sometimes a distributor has not verified the cable length after spooling it from a large to a smaller cable reel, and it may be too short or too long. Inspect both ends of the cable to verify the footage markings on the outer jacket and compute the actual length of the jacket. This is an accurate method for verifying cable length. Use of a time domain reflectometer (TDR) or optical time domain reflectometer (OTDR) will also provide an accurate reading of cable length.

Cables should be ordered with a factory-equipped pulling eye. If this is not possible, a substitute can be installed prior to placing the cable.

## Project Planning, continued

### Tools and Equipment

The physical weight of backbone cable often requires special tools and installation apparatus to assist the cabling installers. For vertical pathways, cabling is more easily pulled from the top down than from the bottom up because gravity helps with the pull. This is the preferred method if the reels of cable can be moved to the top floor. Sometimes this cannot happen because the reels are too large to fit through doors or on a freight elevator. When necessity demands it, backbone cable is pulled from the bottom up. In both cases, special cable-handling devices are required, including:

- Winches.
- Cable reel brake.
- Temporary take-up devices.
- Bullwheels.
- Pulleys.
- Mesh grips.
- Bull lines (pull ropes).

The type of equipment needed depends on the direction of the pull. If pulling from the bottom up, a winch may be needed. If pulling from top down, a reel brake may be needed. A reel brake is a mechanical device used to stop or slow a freewheeling reel, thus keeping it from unreeling too fast.

### Locations for Accessing and Pulling Cable

Determine if a loading dock, forklift, or other mechanical device is available to off-load large cable reels at the delivery site. While many delivery trucks are equipped with lift gates, some larger reels cannot be handled in that manner. The cabling installer must also make plans for locations to store cable that is waiting placement and must have a method for moving cable reels from the storage point to the pulling location. This includes a pathway suitable for the material and its conveyance, such as wide doorways and elevators equipped to handle the weight and room to set up reel supports, pulleys, and associated equipment.

## Project Planning, continued

### Telecommunications Equipment

Communications with coworkers is an essential part of every cable placement. Each person involved in the pull should have a designated responsibility. Everyone should be prepared to alert the person in charge of pulling the cable about possible safety concerns and problems with the actual placement. Cable can easily twist, kink, or bind during placement, and the pull must be stopped to allow corrective action to be taken.

Communications in this instance consists of two major components: the means to communicate (radios, intercoms, or other electronic devices) and a commonly understood set of commands. Terms such as “back,” “forward,” and “the other way” can mean completely different things to people standing apart on a job site. Make sure the placement crew agrees upon a standard set of commands, the methods to be employed, and the responsibility of each person for communications.

## Safety Procedures

The safety of everyone involved is important, including the building occupants, cabling team members, and other contractors working on the job site. Cabling installers must participate in their company safety programs, follow company policies and practices, and be capable of providing basic first aid and cardiopulmonary resuscitation (CPR).

To help ensure a safe installation, the cable puller must follow safety procedures in several areas. See Chapter 1: Background Information, Section 9, “Common Safety Practices,” for more detailed information.

### Clear Designation of Work Areas (WAs)

Before work begins, it is important to clearly mark the WAs to restrict access to authorized personnel only. Safety cones, yellow tape, and folding A-frame signs may be used for this purpose. If the WA is near a door or hallway corner, the markers should give oncoming pedestrians adequate advance warning of a WA ahead. In addition, WAs should never be left unattended if they present a hazard (e.g., open floor systems or open ceiling systems with open access panels or equipment).

Caution markers should be removed as soon as the work is complete. If the markers are left and people realize the work is finished, the warnings may be ignored. This could cause an accident in the future when a real danger exists.

## Safety Procedures, continued

### Proper Use of Tools and Equipment

Cabling installation involves a variety of tools and equipment that present safety risks. To help prevent accidents, manufacturers require users to be certified to use certain tools, such as powder-actuated tools. However, even a simple tool can present a safety risk. For example, hand tools must be checked to ensure that wooden or plastic handles are free of splinters, sharp-edged cuts, or other surface damage that could injure a cabling installer's hand. All tools must be examined regularly to ensure they are in safe working condition.

The careless use of tools may cause an accident. For example, do not leave extension cords or tools in places where people may trip over them. Be sure to choose a secure place to set up a ladder, and climb and work on it safely.

Carefully follow all manufacturer's instructions when mounting, securing, and using potentially dangerous mechanical equipment for cable pulling, such as winches, cable wheels, and cable brakes. Do not set up or operate this equipment without first receiving adequate training. It is also important to lift heavy equipment correctly, bending at the knees and keeping the back straight. Whenever possible, wear a lifting belt when lifting or moving heavy objects or equipment.

### Protective Clothing and Equipment

Personal protective equipment decreases the cabling installer's risk of injury. This equipment includes:

- Headgear, such as a hard hat, to protect against falling or flying objects, electric shock, and striking the head.
- Eye protection, such as a full-face shield, goggles, or safety glasses, when working with batteries, powder-actuated tools, and optical fibers. Eye protection is also necessary when working in a crawl space, above a dropped ceiling, or above eye level and looking up at the work.
- Breathing protection, such as a respirator or filter mask, when harmful dust, gas, smoke, chemical vapor, or other pollutant is present at the work site.
- Protective footwear on work sites where the feet could be injured by falling objects, rolling carts, or stepping on sharp objects. Rubber-soled shoes should be worn when working near electrical power cabling and equipment.

## Safety Procedures, continued

- Protective gloves when performing any work that has the potential for hand or forearm injuries.
- Hearing protection while working in the vicinity of loud noises.
- Well-fitting clothing to protect from minor cuts and materials that could irritate the skin, like fiberglass. Do not wear loose clothing that could get caught on tools, surroundings, or operating machinery.

## Identification of Potential Hazards

Installing cable inside a building can be hazardous and requires extra safety precautions. The cabling installation team should identify potentially hazardous areas before beginning work. The presence of electrical power cabling and electrical equipment is probably the most common environmental hazard faced by the cabling installer. Treat all electrical circuits as if they were live (energized), even after the circuits have been turned off. Cable pullers must be especially careful in situations where electrical circuits or equipment may be contacted blindly, as when fishing conduits and walls. Metal fishtape should not be used in a conduit if the exit point is unknown.

Other sources of potential hazards include dust and debris when working in floor and ceiling systems, exposure of optical fibers to the skin and eyes, asbestos, and chemical hazards.

## Firestopping

Building codes and standards provide strict requirements for sealing, or firestopping, penetrations through fire-rated walls, floors, and ceilings. Approved methods and materials must be used to reduce the chance of spreading fire, smoke, and toxic gases throughout a building. Firestop materials are available as:

- Putty.
- Pillows.
- Caulking compounds.
- Cementitious compounds.
- Blankets.
- Wrap strips.
- Collar devices and chokes.
- Composite sheets.
- Sprays.
- Mechanical systems.

## Firestopping, continued

All firestopping solutions are a combination of firestop materials, holding devices, packing materials, and other devices that make up a listed (approved) system. Do not use unapproved methods to firestop a penetration. Always use an approved and engineered system to properly firestop a penetration. Contact an appropriate firestop manufacturer for any situations that are not specifically addressed by the manufacturer's listed methods. See Chapter 5: Firestopping for additional details.

## Job Wrap-Up

Every cabling installation has several tasks that should be done after the cable is pulled. The cabling installer must label the new cables, update the building floor plans, and clean up the job site.

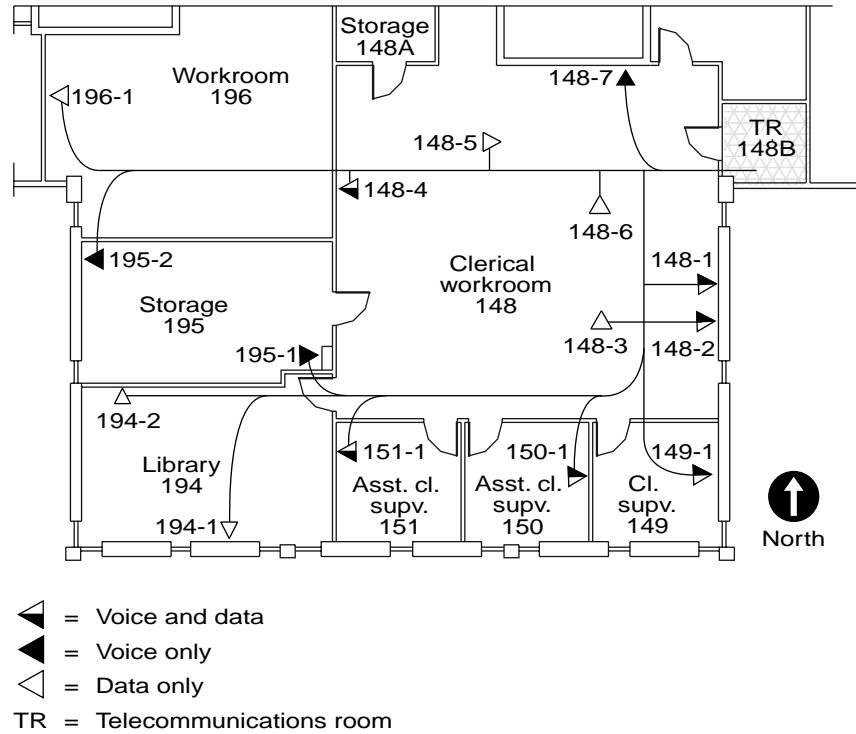
After pulling the cable, a label should be placed on each end that conforms to the labeling scheme to be used on the project. The label should identify the cables so that cabling installers will be able to identify the cables for termination.

The building plans or blueprints are the record of what is in the building. After an installation is complete, the cabling contractor must usually submit as-built plans, sometimes called record drawings, to the general contractor and building owner. These plans are a lasting record of cable information that documents the placing of cables. On the building floor plans, the cabling installer must provide the following cable information:

- Show clearly what type of cables were installed.
- Document the origination and termination point of each cable.
- Show clearly on the floor plans which pathway (e.g., conduit, cable tray) was used.
- Note the application planned for the installed cables.

**Job Wrap-Up, continued**

Figure 4.1  
 Example of marked job floor plans with common symbols



Several cleanup tasks should be done in each area of a job site after the cable is pulled. Keeping a job site clean:

- Prevents development of safety hazards.
- Reflects on the professionalism of the cabling installer and the cabling installation company.

## Job Wrap-Up, continued

General housekeeping items include but are not limited to:

- Picking up used pull strings and pull ropes immediately after use.
- Disposing of removed sheath and wire scrap.
- Storing cable reels and boxes when pulling function is complete.
- Vacuuming residue from cutouts in drywall.
- Disposing of all personal items (e.g., luncheon materials, coffee cups) and used cleaning supplies.
- Storing tools, equipment, and unused materials properly at the end of the workday.

## Cable Pulling Setup (Horizontal)

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### Overview

Through project planning tasks, the cabling installer has already identified the type of cable, supporting structures, locations, and pulling tools and methods required for the job. Once on site, additional preparation tasks help to organize the work and provide an efficient and safe installation.

Before the job of pulling cable begins, everything and everyone should be in the proper place. All materials and equipment must be in place so that the cables can be handled properly. This includes any specialized equipment capable of holding large reels, if required. Smaller equipment, such as cable trees, may be brought in to handle numerous rolls containing low pair-count cable. If all preparations are made correctly, time will be saved once pulling begins.

Cable pulling setup tasks include:

- Secure the WA.
- Post floor plan drawings in the WA.
- Select and identify the cable labeling system to be used.
- Identify pull points, transition points (TPs), and pull angles.
- Identify and establish group pulls.
- Set up and place the pull strings.
- Set up the cable reels or boxes.

## Steps—Pulling Setup

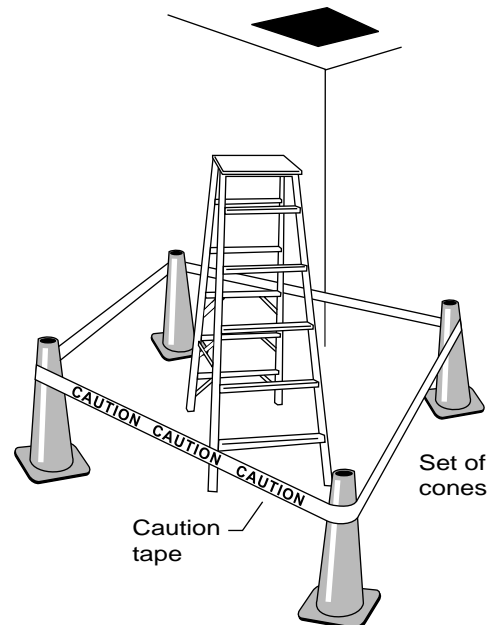
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### Step Cable Pulling Setup

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- 1 Secure the WA.
  - Set up cones, signs, barricades, and caution tape in WAs to alert everyone of danger in the area.
  - Place caution tape across the entrance to the area to restrict access to anyone other than cabling installers or other authorized personnel.
  - Notify appropriate personnel that work is beginning.

Figure 4.2  
Secured area with safety cones and caution tape

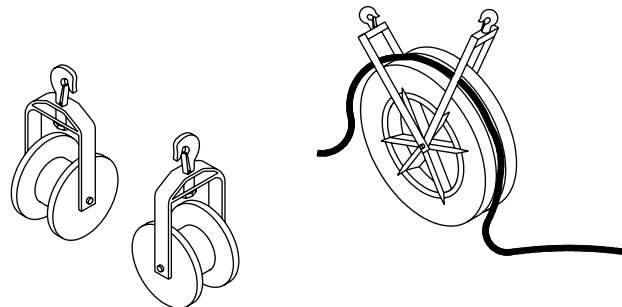


- 2 Post floor plans in a conspicuous location prior to the start of cable pulling. The plans provide a record of the pathways and media being installed. As work is completed, the cabling installer should note the type of cable installed, which conduit was used, and the application planned for the cable. After the cabling installation is complete, the building owner has the as-built plans to refer to for future work. It is a lasting record of cable information that documents the placing of cables.

Steps—Pulling Setup, continued

Step	Cable Pulling Setup
3	Set up pull string or pull rope. If no pull string or pull rope exists and is required in the conduit system, one must be installed.
4	<p>Identify pull points for each horizontal cable run.</p> <ul style="list-style-type: none"> <li>Determine the distance of the complete cable run. Ensure the distance does not exceed 90 m (295 ft). Take care to identify the changes in direction, vertically or horizontally. These changes in direction may cause the run to exceed the 90 m (295 ft) limit.</li> <li>Cables should always be installed parallel or perpendicular to major building structures.</li> <li>Take note of the number and locations of bends and identify where to feed the cable around sharp bends or turns. Pulley hangers may be used at some TPs to save staffing.</li> </ul>

Figure 4.3  
Bullwheel and pulley hangers



- Allow no more than two 90-degree bends per 30 m (100 ft) pull, if in conduit.
- Divide the total cable run distance into segments where each segment is less than the maximum of 30 m (100 ft), including end measurements, if in conduit.
- Identify a pull point, where necessary, for accessing and handling the cable.
- Where possible, minimize the number of pull points, because each pull point requires an additional person, a pulley, or a separate pull.

**NOTE:** When personnel are not available to be at all the pull points, the cable will have to be pulled to the farthest manned pull point and then placed in a figure-eight on the floor. To continue the pull, workers are relocated to the next vacant pull points until the cable pull is complete.

## Steps—Pulling Setup, continued

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**Step Cable Pulling Setup**

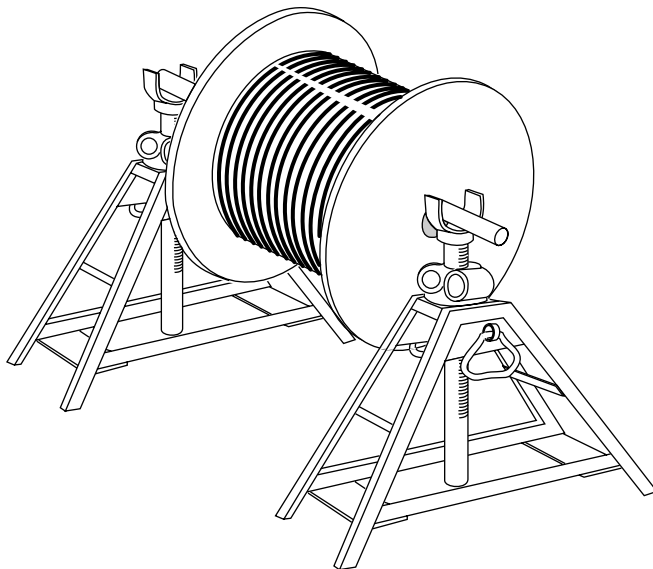

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5 For large cable reels, set up a pair of jack stands, reel dolly, or set of cable rollers. A reel dolly is basically a jack stand with wheels that allows easy relocation of the assembly. A set of cable rollers is two shallow metal troughs, each containing two small rollers. The reel can be rolled on top of the small rollers.

- Find out if the cable reel being installed is so large and heavy that a jack stand or reel dolly is required.

**NOTE:** Many contractors use jack stands for holding the reels of cable off the floor. Sometimes this equipment is made from homemade supports, and a pipe is used to appropriately suspend the reels.

*Figure 4.4  
Large reel and adjustable jack stands*



- Select a location that is large enough for the number of spools needed.
- Set up the jack stand inside the TR if there is space for it or set it up in the area just outside the TR.
- Place a pipe or crossbar (known as a mandrel) through the center hole in the reel. Get help from coworkers to lift the spool onto the jack stand. Jack stands used for placing larger cables usually have a mechanical ratcheting or hydraulic lift mechanism to assist in lifting the reels into place for pulling.
- Make sure the mandrel can support the weight of the cable reels.

**NOTE:** In some pulling operations, reel brakes may be needed to control the pay out of the cable.

### Steps—Pulling Setup, continued

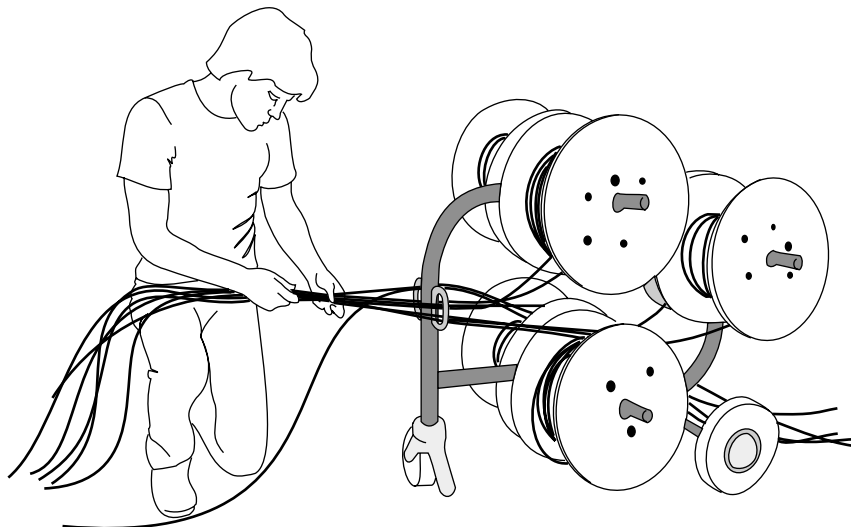
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Step	Cable Pulling Setup
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- |   |  |
|---|--|
| 6 | <p>For smaller reels, set up a cable tree.</p> <ul style="list-style-type: none"><li>• Cable trees are used when there are multiple small spools of cable being pulled at the same time.</li><li>• Select the spools of cable that will be needed for the job. Cable can be ordered with various put-up lengths. Usually put ups are 305 m (1000 ft), 457 m (1500 ft), and 1520 m (5000 ft).</li><li>• Select a location near the cable feed point that is large enough for the cable tree.</li><li>• Bring in the cable tree and set it up inside the TR if there is space or in an area outside the TR, such as in the hallway.</li><li>• Mount the spools on the cable tree.</li><li>• Find the end of each cable reel and bring them together through the guide hole on the payout end of the cable tree.</li><li>• Select one of the cables in the group as a guide cable.</li><li>• Take the next two cables and tape them to the guide cable approximately 75 mm (3 in) behind the guide cable. Continue attaching cable to the bundle in groups of two until all cables are attached to the bundle.</li><li>• Prepare the guide cable for attachment to the pull string.</li></ul> |
|---|--|

Figure 4.5  
Cable tree



**Steps—Pulling Setup, continued**

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<b>Step</b>	<b>Cable Pulling Setup</b>
7	<p>For even smaller amounts of cable, set up a cable payout box.</p> <ul style="list-style-type: none"><li>• Knock a hole in the top of the box or remove the plastic insert to expose the cable inside.</li><li>• Cable is shipped in several different containers:<ul style="list-style-type: none"><li>– Payout box</li><li>– Reel-in-a-box</li><li>– Reel</li></ul></li><li>• The payout boxes and the reel-in-a-box are convenient and require no rack to hold them. For pulling multiple reels of cable, the boxes can be stacked and numbered sequentially for proper labeling later.</li><li>• Find the end of the cable and thread it out through the hole in the box.</li><li>• Keep the cable free from any obstruction that would crimp or bend it, causing damage.</li></ul>
8	<p>Label the cables.</p> <ul style="list-style-type: none"><li>• Use the labeling system identified for the project.</li><li>• Always label cables and their reels prior to pulling cable into place. It is easier to identify and label the cables before they are pulled through the pathway.</li><li>• The label should identify the cables so that the cabling installers will be able to identify the cables for termination.</li></ul>

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## Pulling Horizontal Cable in Conduit

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### Overview

Conduit pathways for horizontal cable are usually designed to be parallel or perpendicular to the external walls of the building. Pulling cable through these pathways requires the installation and use of a pull string or rope. When pulling multiple cables, the use of a lubricant may also be needed. Lubricating the cable as it enters the conduit helps to assure a smooth pull.

No single conduit segment shall be more than 30 m (100 ft) in length, and no more than two 90-degree bends are allowed in one segment. Exceeding these limits increases the coefficient of friction and can possibly stretch the cable and damage it.

### Pull String Installation

A pull string is a thin cord used to pull cable through the conduit. The pull string must extend through the entire length of the conduit before cable can be pulled.

Pull string has a specific tensile strength rating that appears on the box. Tensile strength ratings range typically from 330 N to 880 N (74 to 198 lbf). Some pull string is designed to break if excessive tension is placed on the cable.

Placing the pull string in conduit can be done manually by using fishtape or via pressurized air methods using a foam rat or a foam ball attached to a pull string.

Fishtape is used to pull the string through the conduit, not for pulling the actual cable. It passes through the conduit to reach the pull string attached to the cable at the far end. Some fishtapes have swivel-type clips on the end for attaching to objects that need to be pulled back through the conduit.

When the fishtape method is not practical (e.g., placing pull string in excessive conduit lengths), pressurized air methods may be used. These include a vacuum cleaner or a compressed air bottle and a lightweight propellant object such as a foam ball. These methods produce the intended result of retrieving the pull string at the far end.

The following steps explain the process of installing pull string with fishtape and via pressurized air methods.

## Steps—Pull String Installation with Fishtape

Step	Placing Pull String in Conduit with Fishtape
1	Determine the length of fishtape required. After estimating the length of the run, add a few meters (feet) to each end to be sure enough fishtape is available.
2	Feed fishtape through conduit. <ul style="list-style-type: none"> <li>• Put on all necessary personal safety equipment.</li> <li>• Feed the fishtape into the end of the conduit.</li> <li>• Do not force the fishtape if the conduit contains existing cables.</li> <li>• If there is a metallic tab on the end of the fishtape, cover it with electrical tape to prevent snagging other cable already in the conduit.</li> <li>• Never feed a fishtape into a conduit without knowing where it may go. It could accidentally be fed into a live electrical junction box.</li> <li>• Push the fishtape through the conduit until it comes out the far end of the conduit.</li> </ul>
3	Attach pull string to fishtape. <ul style="list-style-type: none"> <li>• Go to the far end of the conduit where the end of the fishtape is now located.</li> </ul> <p style="margin-left: 40px;">NOTE: The end of the fishtape will have a hook, a ring, or some type of attachment device.</p> <ul style="list-style-type: none"> <li>• Securely attach the end of the fishtape to the pull string to be pulled through the conduit to prevent it from coming off during the pulling operation.</li> <li>• If the clip at the end of the tape has been removed, secure the attachment by wrapping a piece of electrical tape around the pull string and the fishtape.</li> </ul>
4	Pull the fishtape out of the conduit. <ul style="list-style-type: none"> <li>• Go back to the other end of the conduit.</li> <li>• Slowly rewind the fishtape reel to retrieve the pull string from the far end of the conduit, storing the fishtape in the holder as it is taken up.</li> <li>• Detach the fishtape from the pull string.</li> <li>• If there will be a delay prior to cable-pulling efforts, tie off the pull string at both ends. This will prevent accidentally pulling the string back into the conduit and the need to re-fish the conduit.</li> <li>• Put the fishtape away.</li> </ul>

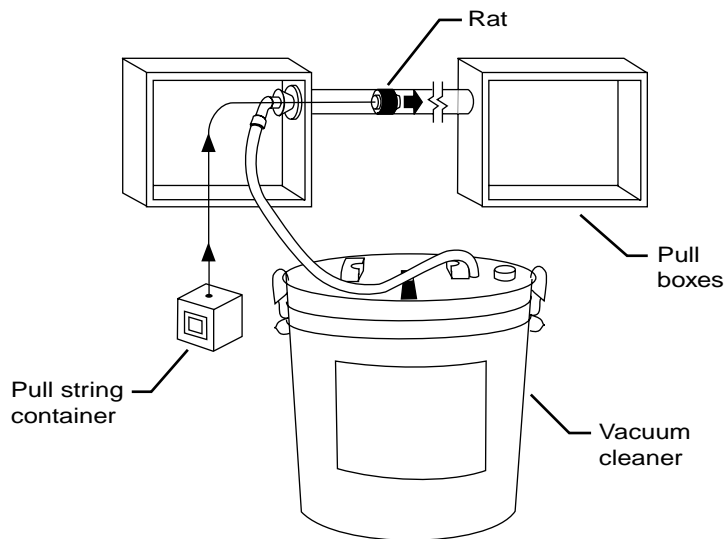
### Steps—Pull String Installation with Air-Propelled Methods

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Step	Blow Pull String Through Conduit
1	Select a propellant object that is lightweight, such as a plastic bag crumpled up or a piece of foam rubber designed for the purpose.
2	Tie a pull string to the object.
3	Place the propellant object in the conduit.
4	Place the grommet on the conduit and attach the air hose.
5	Using pressurized air, blow the object attached to the string through the conduit until it reaches the other end.
	<b>WARNING:</b> Never look into the end of a conduit when a pull line is being blown through it.
	<b>CAUTION:</b> Conduits often contain water. Always consider what could be damaged at the far end of the conduit if water were forced out of the conduit, (e.g., electronic private branch exchange [PBX] or freshly painted walls).
6	Go to the opposite end of the conduit and tie off the pull string, separating it from the propellant object.

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Figure 4.6  
Vacuum blowing a ball or a bag

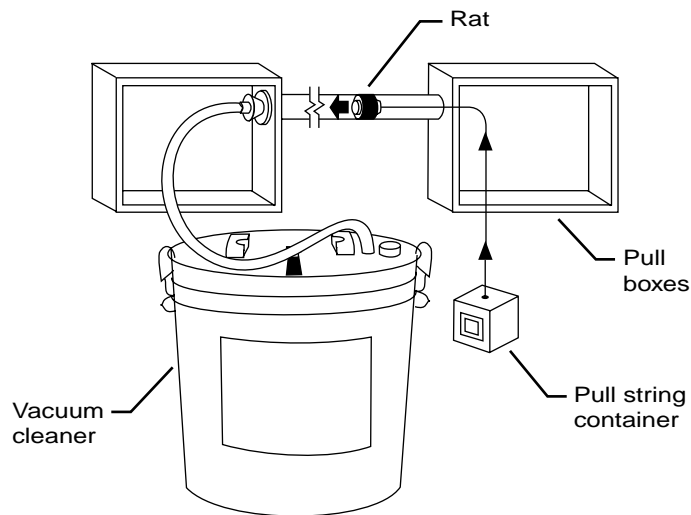


**Steps—Pull String Installation with Air-Propelled Methods, continued****Step Vacuum Pull String Through Conduit**

- 1 Attach a vacuum hose to the conduit to pull a propellant object forward from one pull point to the next.
- 2 Retrieve the object with the pull string attached.
- 3 Secure the string at the receiving end of the conduit.
- 4 If it is necessary to pull heavy cable, attach the pull string to a heavier string or rope strong enough to pull the weight of the cable in the conduit.

**CAUTION:** Always use a wet vac in case there is water in the conduit.

Figure 4.7  
Vacuuming a ball



## Conduit Pull

After the pull string is placed in the conduit, the cabling installer is ready to pull the cable. Maintaining the proper pulling tension is critical to the success of the pull. The manufacturer's tensile strength rating for the cable should be verified and must not be exceeded. For example, the maximum pull force for one 4-pair, 24 AWG [0.51 mm (0.020 in)] cable is 110 N (25 lbf). The cabling installer may consider using an 11 kg (22 lb) breakaway swivel or an 11 kg (22 lb) breakaway line attached between the pull rope and the twisted-pair cable to ensure that no more than 11 kg (22 lb) of tension is exerted on the pulled cable.

### Steps—Conduit Pull

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Step	Pulling Horizontal Cable in Conduit
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1 Choose a method of establishing cable run distances. Methods include:

- Pace or walk off the distance.

NOTE: The average walking span is approximately 1 m (3 ft).  
Determine your own span.

- Use a measuring wheel.
- Use a tape measure.
- Count ceiling tiles.
- Count conduit sections, if visible.

NOTE: A common general practice is to count ceiling tiles of known lengths, such as 0.6 m (2 ft) by 0.6 m (2 ft) lay-in or 0.6 m (2 ft) by 0.6 m (2 ft) decorator tile.

2 Estimate the length of the cable run.

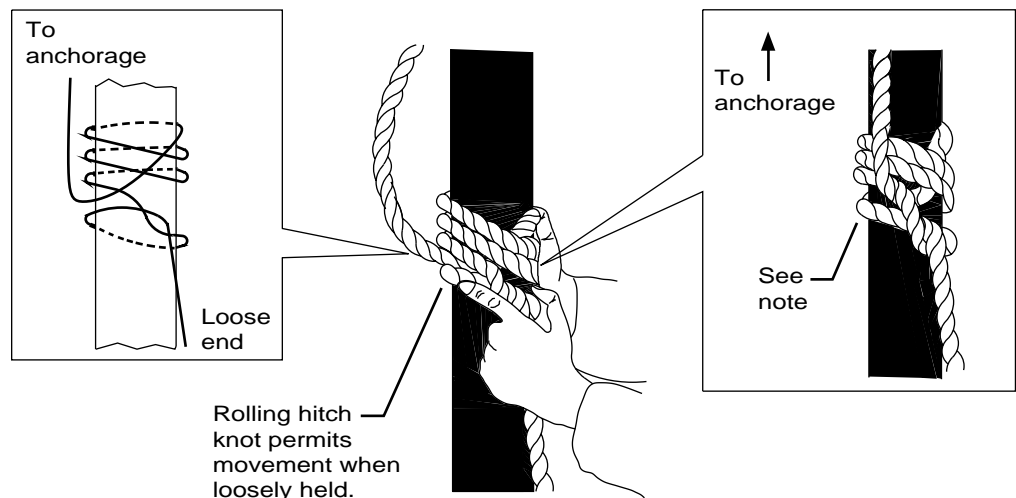
- Find the area on the floor that is just below the location in the ceiling where the conduit run is located.
- Walk the distance of the cable run, noting the locations of conduit bends and pull boxes.
- Estimate the distance walked and allow for all changes in elevation (e.g., include the vertical distance from conduits to floors or ceilings).
- Ensure each cable dispenser has enough cable to reach the full length of the run.
- Place an identification label on each cable end.
- Label each cable dispenser and cable a few meters (feet) back from the cable's end. Do not put the label too close to the end or the tape used for attaching the pull line to the cable will cover the label.

## Steps—Conduit Pull, continued

**Step Pulling Horizontal Cable in Conduit**

- 2 cont.
- Feed out a few meters (feet) of cable to prepare for entering the conduit.
  - Arrange the cables to form a smooth transition from a single cable to a larger bundle. Tape cables as necessary to hold them in place while the pull string is attached to the cable bundle.
  - Attach the pull string using a rolling hitch (three half hitches and a clove hitch). Each half hitch will bite into the cables and prevent them from slipping. The clove hitch is of little importance as long as a tight knot is placed around the last half hitch. Place electrical tape over the knots to prevent them from slipping or becoming caught during the pull.

Figure 4.8  
Rolling hitch knot



**NOTE:** Release of rolling hitch knot provides immediate snubbing action on cable to stop movement.

- Attach a trailer string to the cables to provide a string for future pulls.
- As the cable is being pulled through the conduit, keep slack available at the entrance so the cable can flow freely into the conduit.
- Guard against developing excessive bends or kinks as cable is led to the conduit.
- Some conduits may require the use of pulling lubricant to prevent excessive pulling tension on the cables.

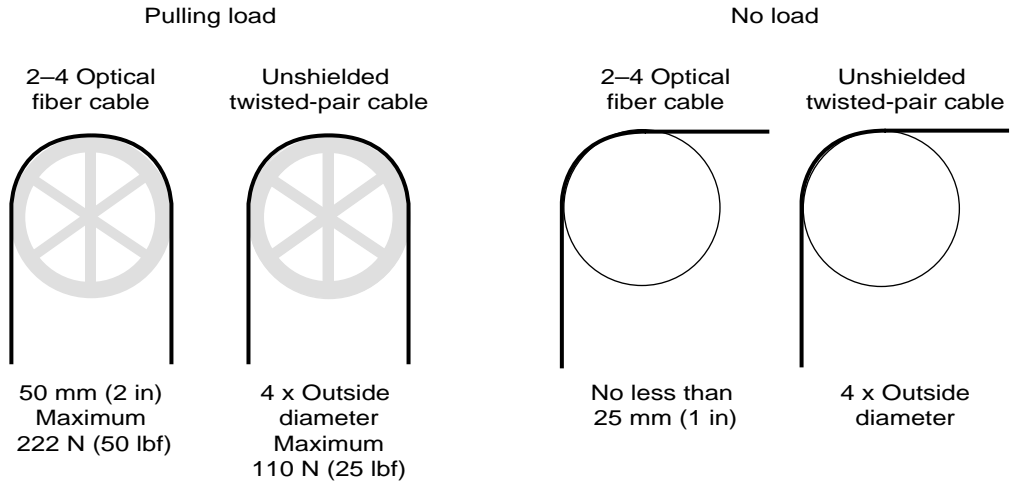
Steps—Conduit Pull, continued

**Step Pulling Horizontal Cable in Conduit**

- 3 Pull cable.
- Maintain the proper bend radius of the cable type being pulled.
  - Monitor pull force closely during installation to be sure that the manufacturer’s specifications are never exceeded.

NOTE: Maximum pull force for one 4-pair, 24 AWG [0.51 mm (0.020 in)] cable should not exceed 110 N (25 lbf). Bends and lubricants also affect performance.

Figure 4.9  
Maximum bending radius



- Avoid excessive tension and deforming of the cable when going around corners or bends.
- Leave enough slack in the TR to reach the farthest corner and add the distance from floor to ceiling. This allows service slack to be stored within the TR for future reconfiguration.

NOTE: Most optical fiber distribution cabinet manufacturers provide space for an additional 3 m (10 ft) of slack within their cabinets in addition to the service slack described above.

- Allow 0.3 m (1 ft) of slack after termination for copper conductor cables and 0.91 m (3 ft) of slack after termination for optical fiber at the WA telecommunications outlet/connector.
- Tie off both ends of the trailer string.

**Steps—Conduit Pull, continued**

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**Step Pulling Horizontal Cable in Conduit**

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- 4 Identify cables.
    - Once the amount of required service slack has been determined, mark the cable prior to cutting it off the cable dispenser.
    - The cable label shall be a unique identifier that is clearly visible on each end of the cable after the pull is complete. If this is a temporary label, ensure that the person who follows can understand it.
  - 5 Perform job wrap-up tasks.
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**Pulling Horizontal Cable in Ceiling Spaces**

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**Overview**

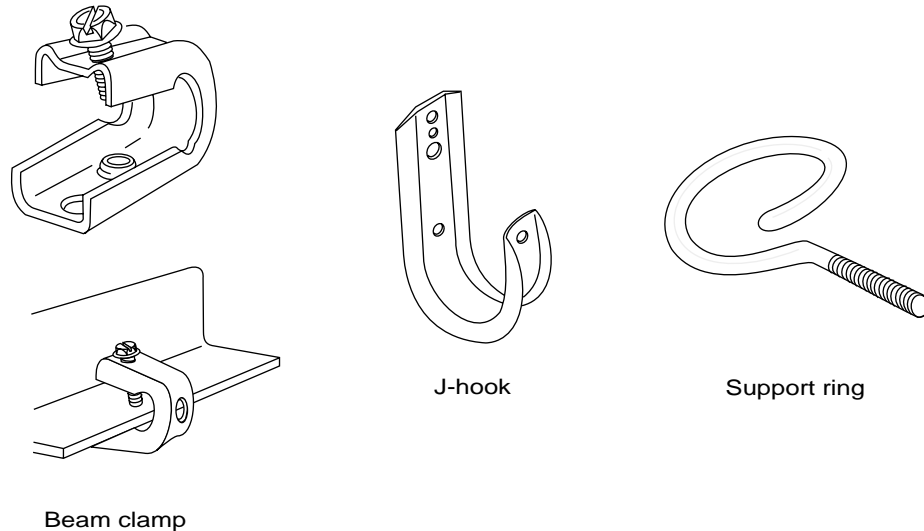
Cables installed within open ceiling spaces must be routed and supported in such a manner as to reduce or eliminate mechanical stress. They should be suspended above false ceiling tiles and away from potential sources of electrical emissions, such as fluorescent light fixtures, using hooks or supports mounted every 1.2-1.5 m (4-5 ft) and at each change of direction. No single support device should exceed the manufacturer's recommended load rating, and the pulling tension used to place a cable should not exceed the manufacturer's recommendations (see Figure 4.9).

Small supports, such as bridle rings and small J-hooks, should only be used to carry a few cables or must be fitted with a saddle to keep the support from distorting the cable. Cables must not be stretched tightly around corners or wrapped tightly with tie wraps. If structural steel members (red iron) are used to support cable, the pathway must be clear of sharp edges or corners that might nick or damage the sheath of a cable.

Remember, any physical damage to a high-performance 4-pair cable can significantly degrade performance. Proper placement techniques must be used to ensure cables not only pass initial installation testing and continue to provide high-quality links in the future.

## Overview, continued

Figure 4.10  
Beam clamps, J-hooks, and support rings



## Pull String Installation

Similar to conduit pulls, a pull string with adequate tensile strength or pull tape may be used to pull cable into place in open ceiling runs by first threading it through the supports. A gopher pole, which telescopes to various lengths, is helpful in threading the string through the supports. Use of the gopher pole limits the number of ceiling tiles that must be moved to provide access to the WA if tiles are installed prior to pulling cable. It also reduces the number of times a ladder has to be moved.

Other devices available for installing pull strings in open ceiling installations include a small crossbow or a remote-controlled toy.

**NOTE:** Do not attach tools to pull strings and throw them through the ceiling. This presents a safety hazard and may cause damage to the ceiling system, tiles, or other utilities contained in the ceiling space.

Each 90-degree bend identifies a pull point, which requires a cabling installer at that spot to assist in pulling the cable. Using a pulley can help minimize labor.

**Steps—Installing Pull String**

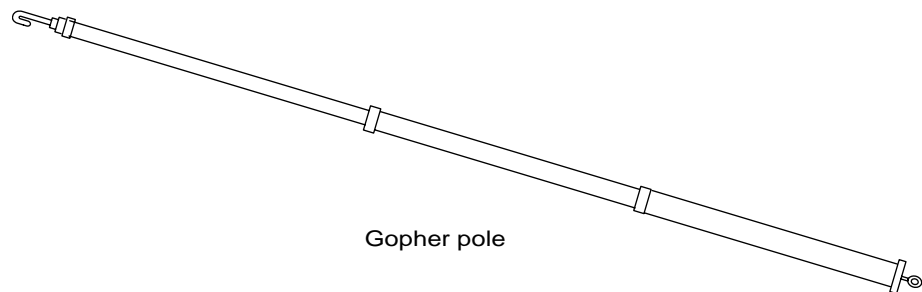
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**Step Installing Pull String in Open Ceiling**

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- 1 Determine tensile strength of string.
  - Pull string has a tensile strength rating that appears on the box.
  - Tensile strength ratings range typically from 330 N to 880 N (75 to 200 lbf).
- 2 Route string through the ceiling area.
  - Select an appropriate extender tool that will reach the required distance. Telescoping poles reach from 1.83 to 7.62 m (6 to 25 ft).
  - Attach the pull string to the hook on the end of the extender tool and pull back.

Figure 4.11  
Extension tool



## Steps—Open Ceiling Pull

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<b>Step</b>	<b>Pulling Horizontal Cable in Open Ceiling</b>
1	<p>Verify manufacturers' specifications for cable tensile strength limitations.</p> <ul style="list-style-type: none"><li>• Read manufacturers' guidelines for instructions as to cable strength limitations.</li><li>• Excessive tension on the cable stretches the conductors inside the cable, degrading the cable's performance.</li><li>• Pay close attention to the requirements for maximum bend radius, which for 4-pair unshielded twisted-pair is equal to four times the diameter of the cable.</li><li>• For extensive quantities of cable in a ceiling environment, use cable trays or ladder racks.</li><li>• Avoid selecting paths that require exceeding the maximum cable bend radius.</li></ul>
2	<p>Attach string to cable.</p> <ul style="list-style-type: none"><li>• Tape the pull string to the lead end of the cable, along with an additional pull string for future use.</li><li>• Manually lift the cable into a position to follow the string through the open ceiling area.</li></ul>
3	<p>Precautions.</p> <ul style="list-style-type: none"><li>• Pull cable, being careful not to snag or pull the string against sharp objects, such as ceiling obstructions (heating, ventilating, and air conditioning [HVAC] duct, etc.) or ceiling grid stringers.</li><li>• Avoid creating friction that causes burns or tears in the jacket of the cable.</li></ul>
4	<p>Place cable in support devices.</p> <ul style="list-style-type: none"><li>• Lift the cables and place them in the cable supports. Once all cables have been installed into a support, close the support if required.</li></ul>
5	<p>Perform job wrap-up tasks.</p>

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## Pulling Horizontal Cable in Raceways

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### Overview

The horizontal cable installation is the cabling from the TR to the WA telecommunications outlet/connector. Pathways to the workstation location generally have some method of concealment for cable protection and visual aesthetics. Examples of the concealment methods include:

- Modular furniture raceways.
- Utility columns.
- Surface raceways.
- Floor raceways.

Many installations use a combination of pathways to reach the WA. It may be necessary to pass through a conduit, into a ceiling space, and then on to a utility column in order to complete the run. In the planning stage, the cabling installer must identify all the methods to be used and develop the cabling installation plan accordingly.

### Types of Horizontal Pulls

Some similarities exist in methods of pulling horizontal cable through the various types of pathways to the outlet. Placing cable in conduit and direct wall pulls (fishing) usually require some type of pull string or fishtape. All practices for the utilization of these pulling methods should be observed. When surface molding, furniture raceways, floor monuments, or utility columns are used, the cabling installer should follow the manufacturer's installation requirements. These pathways generally have an access method or removable cover for cable placement.

#### Conduit

Many projects provide horizontal cabling access with a conduit and J-box for installation of the cables. The conduits will run up or down the wall and stub into an access area in the ceiling or floor. In some instances, the conduit may be an extended length that is "home run" to the TR or remote access point (AP).

Installation considerations:

- Ensure the conduit has sufficient diameter for the quantity of cables to be pulled.
- Note the proper conduit fill ratio and identify the conduit entrance point to start the pull.
- Adhere to the proper cable bend radii and pulling tension on all pulls, especially at the conduit entrance and outlet box exit.
- It is desirable to leave a service slack where the cable enters the conduit.

## Types of Horizontal Pulls, continued

### Wall Fish

In some instances, there is no conduit access to the WA location. The cabling installer will be required to provide access into the wall from the top header stud and through the wall material. When a wall is fished, the drywall or wall material must be opened for the outlet, and the top of the wall, or header stud, must be drilled for cable access.

Installation considerations:

- Verify the WA telecommunications outlet/connector height. Generally, it will be at a height similar to the electrical outlet. These outlets are often installed at approximately 380 mm (15 in) to 457 mm (18 in) above the finished floor (AFF). Once the APs have been established, the cable can be fished through the wall.
- Prior to cutting the wall or header stud, the cabling installer must determine that the wall has a clear vertical pathway from the header stud to the projected outlet location.
- If a wall is constructed with a horizontal barrier between vertical studs that blocks access to the lower area of the wall, it may be necessary to use a flexible or extended drill bit to make a pathway. If that is not possible, it may be necessary to place a surface-mounted raceway.
- At the stud entry location, install a protective ring to prevent cable damage during the pull.
- The wall access location must use some type of mechanical attachment unit, such as a mud ring, receptacle box, or wallboard fastener to allow the outlet a secure mounting point in the wall material.

### Modular Furniture

WA cabling in modular furniture systems will often have vertical, horizontal, or both vertical and horizontal pathways (raceways) for cable installation. These raceways are separated by a barrier and generally used for both electrical and telecommunications cabling. Proper separation between low-voltage and high-voltage cables must be maintained.

Installation considerations:

- If necessary, remove covering panels of the raceway to access the pathway for cable installation.
- Identify the correct pathway to be used for the telecommunications cable.
- Plan for the transition from the wall, floor, or utility column to modular partitions.

**NOTE:** Most furniture access from the horizontal pathway will require some method of mechanical cable protection for exposed cables. This is generally true for the transition from wall or floor APs.

## Types of Horizontal Pulls, continued

### Utility Columns

A vertical pole is often used to provide a pathway from the ceiling or horizontal pathway area when the outlet location is not adjacent to a wall. The utility column installation should be treated the same as a conduit installation. The difference with the utility column is that it usually has a removable side cover that provides access.

Installation considerations:

- Maintain the proper cable bend radii and fill ratio.
- If the utility column is used to provide electrical power, maintain the proper separation between the telecommunications cable and the electrical cables.
- Exercise care when opening and closing these units for installation access so as not to damage the cable (pinching) or the utility column cover.

### Surface Raceways

Vertical or horizontal surface raceways may be required to gain access to the WA location. They must be securely attached to the wall and installed parallel to the horizontal or vertical building lines.

Installation considerations:

- Maintain the proper fill ratio and bend radii.
- Provide anchoring in addition to any two-sided adhesive tape provided by the manufacturer.
- Frequently the raceway will provide a removable cover for cable placement. When this cover is replaced, care must be exercised so the cables do not get pinched.

## Pulling Backbone in Vertical Pathway—From Top Down

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### Introduction

Backbone cable in the vertical riser shaft may be high pair-count cable, which is extremely heavy, or high strand-count optical fiber cable. The cable may be placed vertically directly in an open riser shaft; through cores, sleeves, or slots; or within a large conduit.

Through the initial project planning process, the cabling installer has already completed several tasks, including:

- Verifying correct types and lengths of cable are available on the job site.
- Determining access for moving and positioning cable reels, such as loading docks and freight elevators.
- Selecting the tools required for pulling the cable.
- Identifying and providing the proper safety and telecommunications equipment.
- Identifying the requirements and methods for labeling and documenting the cable pulls.

### Setting Up for the Pull

Setting up the job site and preparing for the pull involve additional tasks and considerations.

- Once a reel is brought to the top floor, it must be set up for the placing operation. It should be situated in a location that provides enough slack for the top floor once the placing operations are complete.
- A reel dolly or a set of jack stands is necessary to feed the cable. A reel brake may be required to help control the descent of the cable as it is pulled off the reel.
- Pulleys may be needed to handle the cable from the reel location to the point where it will be dropped down to lower floors. These pulleys can be attached to the overhead structure in the building and provide a pathway for the cable as it is being placed.
- In the TR where the cable will enter the vertical pathway, a bullwheel will be required to ensure that the jacket is not damaged as it enters the pathway. Place the bullwheel so that it will allow the cable to drop vertically into the pathway. Bullwheels must be attached to the building structure, thereby preventing any lateral movement. Lateral movement will cause the cable to become misaligned with the vertical pathway and could damage the outer jacket.

### Setting Up for the Pull, continued

- A guide rope should be installed throughout the cable route. This rope is used to guide the cable through the various spaces rather than pull the cable.
- If a pulling eye was not factory installed, install a substitute device. An alternate method of pulling is the use of a pulling grip, which is a flexible wire mesh device that clamps down on the cable as tension is applied. These devices are available in various sizes based on cable diameter. Ensure that it is properly sized for the cable. Place it over the cable jacket and then tape the end to the jacket. This will prevent it from coming off should the pull be halted and the tension relaxed on the grip.
- If a wire mesh grip is not available and the pathway is large enough, the pull rope can be attached over the jacket in a series of half hitches. Place vinyl tape over the guide rope, securing it to the cable.
- The coefficient of friction may be one of the obstacles to installation of cables, especially in conduit pathways. The use of cable lubricants can significantly reduce friction and speed cable installation. Select the lubricant to be used based on the type of pull, type of conduit, cable jacket, and size of the cable. Apply the lubricant as the cable is placed, keeping in mind the pulling tension of the cable.
- Mark the backboards for cable lashing. Identifying locations on the backboards for both temporary and permanent lashing prior to the start of pulling allows immediate use during and after cable pulling. This effort will also provide for final cable backboard placement and anticipated slack requirements.

Cabling installers should be located on each floor through which the cable will pass, as well as the floor where it will terminate. They must be equipped with the proper tools to perform critical tasks during the placing operation. Some of the tools include:

- Personal protection equipment such as safety glasses, hard hats, and gloves.
- Communication equipment such as portable, handheld radios.
- Temporary restraining devices for the cable. Cable type and size will determine the necessary restraining devices. One common method of temporarily restraining cable is the use of a large hemp or manila rope equipped with an eyelet. The eyelet is attached to some secure structure in the TR. A half hitch is made in the rope, and the cabling installer pulls on the rope. The amount of tension placed on the rope will control how quickly the cable slips through the half hitch. This method allows the cable to be halted and restarted during cabling installation without losing control of the cable as it descends (with or without a reel brake).

## Installing the Cable

Once everyone and everything is in place, the cable can be installed. Communicate with members of the team, and advise them that the pull is starting. Begin to lower the cable and monitor its progress throughout the pull. Continue the placing operation until the cable is completely placed.

When the cable reaches the bottom floor, the cabling installer must temporarily restrain the cable. Beginning on the bottom floor, the cabling installer should pay out the additional slack needed in each TR. Once the slack is brought into the TR, it should be secured in its final location.

Securing the cable on each floor ensures that the weight of the cable will not become excessive at any one point. Many different devices can be used to secure the cable. One of the most common devices is the split grip, which is a wire mesh grip that is open on one side. The wire mesh grip is placed around the jacket of the cable. A pin is then weaved through the open sides of the wire mesh grip, securing them around the cable jacket.

A section of steel rod, a minimum of 13 mm (0.5 in) thick, is inserted through the loop in the end of the wire mesh grip. The cable and grip are then allowed to slide through the opening in the vertical pathway until the steel rod lies on the top of the pathway.

Another method of securing the wire mesh grip is to attach it to the building or a plywood backboard with an anchoring device.

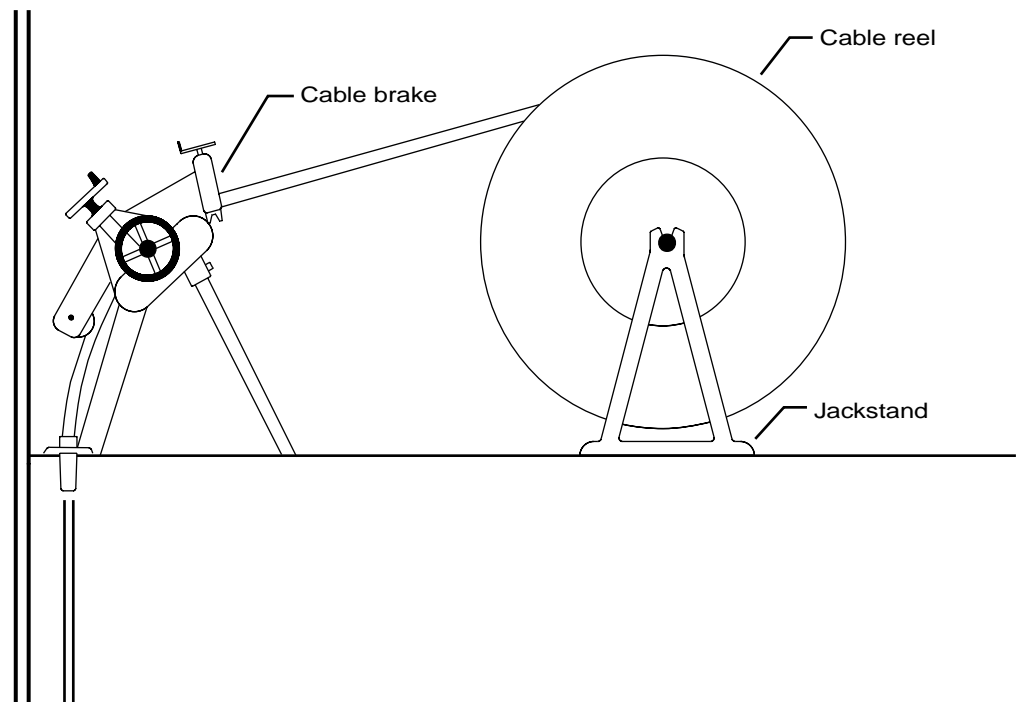
The cable should then be identified and labeled, and the documents should be updated to reflect the work operation.

After completing the work operation, the cable reel and any remaining cable can be returned to storage or prepared for salvage. If the cable was shipped on a wooden reel, the reel can be dismantled and disposed of. If the cable was shipped on a metal reel, it should be returned to the manufacturer for credit.

**Steps—Vertical (Top Down)****Step Pulling Backbone in Vertical Pathway—From Top Down**

- 1 Verify proper cable length and path.
  - Examine the vertical backbone pathway for the installation and check for a clear pathway. Avoid, if possible, a cable path with obstacles or transitions. Check vertical pathways visually and, if necessary, with a flashlight.
  - Determine the actual length of the cable run, based on information from the blueprint or by installing a pull tape equipped with sequential footage markings. This pull tape, if sufficiently sized, can also be used as the guide rope.
- 2 Move cable reels to the upper floor of the vertical feed point.
- 3 Set up the cable pulling area and put reels on a jackstand or reel dolly. Secure the WA.
- 4 Attach a cable brake to the cable, if needed.

Figure 4.12  
A cable brake attached to a cable reel



### Steps—Vertical (Top Down), continued

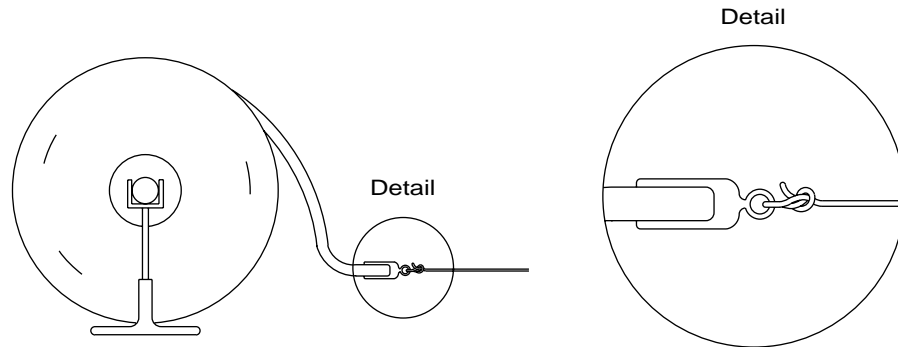
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Step	Pulling Backbone in Vertical Pathway—From Top Down
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- 5 Install and attach a guide rope to the cable lead. This guide rope will help guide the cable as it descends.

Figure 4.13  
A pull rope attached to cable lead



- 6 Attach pulleys, if required.
- Decide whether the weight (based on the size and length of cable) requires the use of pulleys and a brake to help control the gravitational pull.
  - If the cable is on a wooden reel, remove the spike that holds the cable to the reel prior to beginning cable placement.
  - Feed the cable off the reel and onto the pulleys mounted above the route to the pathway so as to support the cable to the point of entry into the vertical pathway.
  - Mount the pulley on any appropriate superstructure available at the location or on overhead steel. If none is available in the place where needed, set up a swing-set type of pulley mechanism.
  - Use a bullwheel, if necessary, to provide a sweeping arc of the cable down into the vertical shaft.

## Steps—Vertical (Top Down), continued

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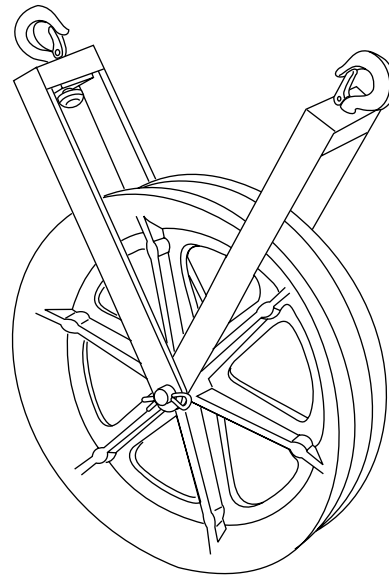
**Step Pulling Backbone in Vertical Pathway—From Top Down**


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- 6 cont. • Use a bullwheel to direct the cable into the vertical pathway, keeping the cable from scraping the edge of the floor and chafing the jacket, which damages the integrity of the cable.

NOTE: This operation may require that the bullwheel be attached to the building in three places. The three attachments will support the bullwheel and prevent it from pulling away from the pathway entrance and from moving laterally.

Figure 4.14  
Bullwheel



- 7 Communicate with coworkers for routing.
- Establish locations for coworkers to clearly view the progress of the cable descending.
  - Have constant communication between floors to notify the person controlling the cable brake of the progress being made.
  - Listen carefully for a report from a coworker who may spot a problem in the cable path that no one else can see.

### Steps—Vertical (Top Down), continued

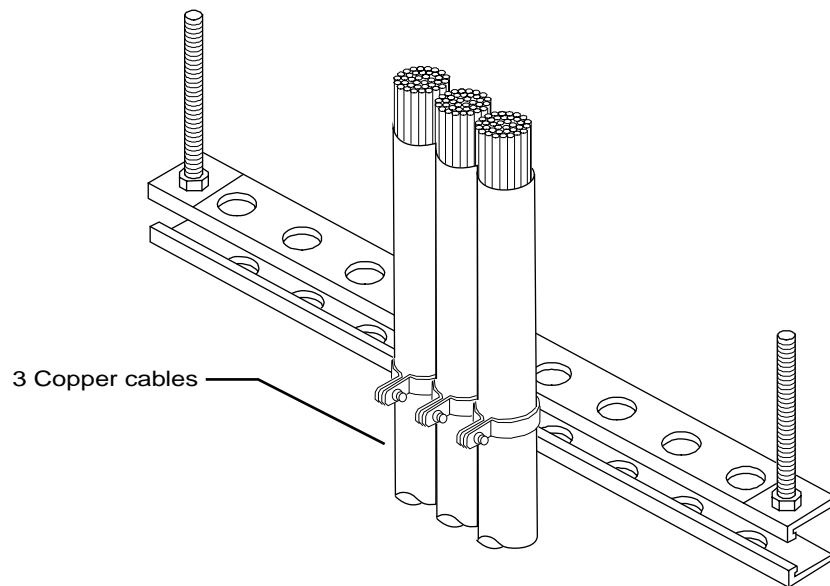
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Step	Pulling Backbone in Vertical Pathway—From Top Down
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- |   |  |
|---|--|
| 8 | <p>Drop until finished.</p> <ul style="list-style-type: none"><li>• Watch and observe the functions of any pulley in use.</li><li>• Maintain control of all pull strings or guide ropes in use.</li><li>• Stay in position as a communicator with coworkers until the drop or pull is finished. Be prepared to temporarily take up the cable should a problem develop in the placing operation and prior to permanently securing the cable on each floor.</li><li>• Secure all cables at each floor level. Cables that are extremely heavy may fall if they are not properly installed. Free-hanging cables create a serious hazard.</li></ul> |
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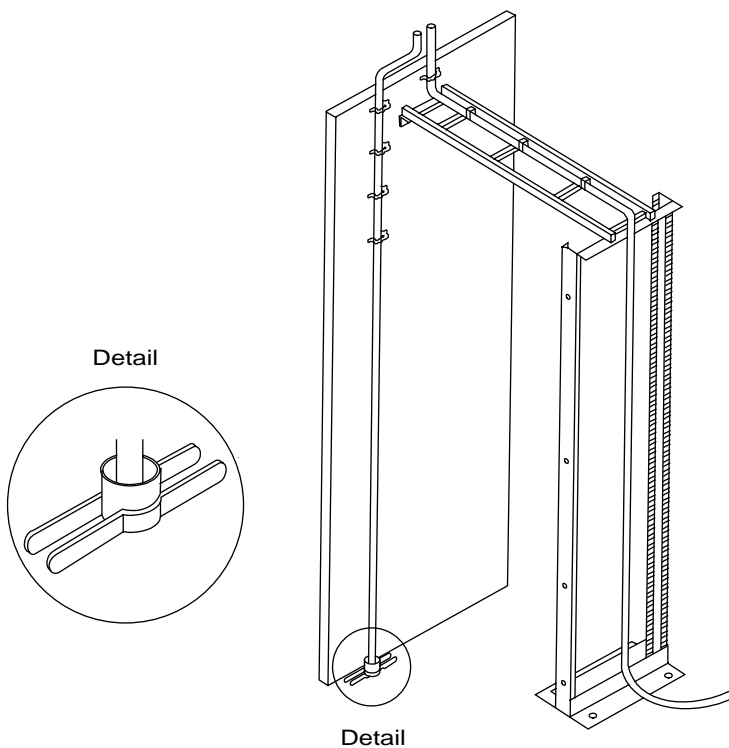
Figure 4.15  
Channel with straps



## Steps—Vertical (Top Down), continued

Step	Pulling Backbone in Vertical Pathway—From Top Down
9	Route and secure cables in vertical pathway.
10	When the vertical pathway enters a TR: <ul style="list-style-type: none"> <li>• Make a sweep of the cable toward the termination point. Do not exceed the proper bend radius of the cable. Multipair cables require a bend radius of 10 times their diameter.</li> <li>• Secure the cable in D-rings, with cable ties, straps, split, wire mesh grips, or clamps, and place in the provided cable trays.</li> </ul>

Figure 4.16  
Cable on tray from vertical pathway



### Steps—Vertical (Top Down), continued

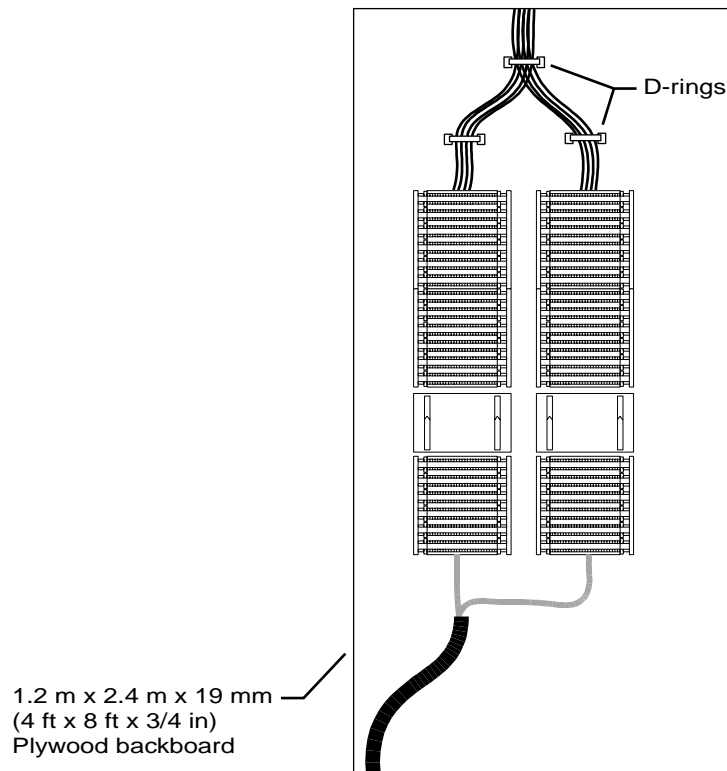
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Step	Pulling Backbone in Vertical Pathway—From Top Down
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- |             |   |
|-------------|---|
| 10<br>cont. | <ul style="list-style-type: none"><li>• Mount the cable to the wall using D-rings, cable clamps, or special-purpose cable ties designed to support the weight and type of cables to be installed.</li></ul> |
|-------------|---|

Figure 4.17  
Backboard layout with D-rings



- |    |  |
|----|--|
| 11 | Identify cable. <ul style="list-style-type: none"><li>• Place a unique identification number (from the installation drawings) at each end of the cable showing the point of origin and destination. Place a label on the cable where it enters or leaves a TR on each floor.</li></ul> |
| 12 | Document cable information on the posted floor plans. <ul style="list-style-type: none"><li>• Show clearly what kind of cable was installed.</li><li>• Show clearly which conduit was used.</li><li>• Describe the purpose of the installed cables.</li></ul>                          |
| 13 | Perform job wrap-up tasks.   |
-

## Pulling Backbone in Vertical Pathway—From Bottom Up

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### Introduction

Conditions that exist when pulling backbone cable from the top down are the reverse of those that exist when pulling from the bottom up. The first choice is to pull the cable from the top down. Sometimes, however, it is not possible to get the large spools of cable up to the top floor of a building. In those situations, specific equipment must be brought in to handle the task of hauling the cable up through the riser to the necessary heights. Because of gravity, the heavy weight of the cable makes a bottom-up installation more difficult.

Through the initial project planning process, the cabling installer has already completed several tasks, including:

- Verifying correct types and lengths of cable are available on the job site.
- Determining access for moving and positioning cable reels, such as loading docks and freight elevators.
- Selecting the tools required for pulling the cable.
- Identifying and providing the proper safety and communications equipment.
- Identifying the requirements and methods for labeling and documenting the cable pulls.

### Setting Up for the Pull

Setting up the job site and preparing for the pull involve additional tasks and considerations.

- Before pulling the cable, determine the required cable length and how the weight will be distributed. The number of floors and TRs that must be accessed are factors in the decision process.
- Once the reel is brought to the bottom floor, it must be set up for the placing operation. A reel dolly or set of jack stands is necessary to allow for paying out the cable. The reel must be situated in a location that will provide enough slack for the bottom floor once placing operations are completed.
- Cable sheaves may be necessary to handle the cable from the reel location to the point where it will be pulled up to upper floors. These cable sheaves can be laid on the floor along the route to the vertical pathway and provide a pathway for the cable as it is being placed.

### Setting Up for the Pull, continued

- In the TR where the cable will enter the vertical pathway, a bullwheel may be required to ensure that the jacket is not damaged as it enters the pathway. The bullwheel should be located so that the cable ascends vertically into the pathway. A bullwheel must be attached to the building structure to prevent any lateral movement. Lateral movement will cause the cable to become misaligned with the vertical pathway and will damage the outer jacket. This operation may require that the bullwheel be attached to the building in three places. The three attachments will support the bullwheel and prevent it from pulling away from the pathway entrance and from moving laterally.
- The pull rope chosen for this operation is critical. Manila, hemp, or double-woven Dacron<sup>®</sup> rope should be used for this operation because it does not stretch when placed under tension. It also does not deteriorate quickly when subjected to the friction (and heat caused by the friction). It has a tendency to twist as tension is applied. This will require the use of a swivel between the cable and the pull rope. The swivel will prevent the cable from twisting during the placing operation, thus damaging the jacket, the shield, and the conductors.
- If a pulling eye was not factory installed, install a substitute device. An alternate method of pulling is the use of a pulling grip, which is a flexible wire mesh device that clamps down on the cable as tension is applied. These devices are available in various sizes based on cable diameter. Ensure that it is properly sized for the cable. Place it over the cable jacket and then tape it to the jacket. This will prevent it from coming off should the pull be halted and the tension relaxed on the grip.
- If a wire mesh grip is not available and the pathway is large enough, attach the pull rope over the jacket in a series of half hitches. Place vinyl tape over the guide rope, securing it to the cable.

NOTE: This is not a recommended method of pulling cables. The placement of a rope directly around the cable, even using multiple half hitches, can provide too much pressure at a single point on the cable. This pressure can distort the conductors, changing the mutual capacitance of the cable.

- Attach the swivel to the pull rope, and then attach the cable to the swivel. Ensure the swivel is rated for the weight of the pull.

## Setting Up for the Pull, continued

- To lift a cable of significant weight, a winch is required. A winch is an electrical motor equipped with a capstan. It is secured to the building structure on the top floor. The pull rope is wound around the capstan. When the cabling installer places tension on the rope, it tightens around the capstan. Friction created by the tightening causes the rope to advance toward the cabling installer. The cabling installer can control the rate at which the rope advances, thus controlling the advance of the cable along its route.

**WARNING:** It is absolutely critical that the winch be securely attached to the building structure. If the winch is not properly attached to the building structure and comes loose, it becomes a projectile and may cause damage.

- The coefficient of friction can be an obstacle when installing cable, especially in conduit pathways. The use of cable lubricants can significantly reduce friction and speed cable installation. Select a lubricant based on the type of pull, type of conduit, cable jacket, and cable size. The lubricant should be applied as the cable is placed. When placing the cable from the bottom up, use a gel-type lubricant.

Cabling installers should be located on each floor through which the cable will pass, as well as the top floor where the cable will terminate. These individuals must be equipped with the proper tools to perform critical tasks during the placing operation.

Some of the tools include:

- Personal protection equipment such as safety glasses, hard hats, and gloves.
- Communication equipment such as portable, handheld radios.
- Temporary restraining devices for the cable. Cable type and size will determine the necessary restraining devices. One common method of temporarily restraining cable is the use of a large hemp or manila rope equipped with an eyelet. The eyelet is attached to some secure structure in the TR. A half hitch is made in the rope, and the cabling installer pulls on the rope. The amount of tension placed on the rope controls how quickly the cable slips through the half hitch. This method allows the cable to be halted and restarted during placing operations without losing control of the cable if it falls (with or without a reel brake).

## Installing the Cable

Once everyone and everything is in place, the cable can be installed. Communicate with members of the team and advise them that the pull is ready to begin. Begin pulling the cable up through the vertical pathway. Monitor its progress throughout the pull. Continue the placing operation until the cable is completely placed. Ensure that enough slack is pulled to the top floor so that it can be lowered back down to the individual floors, where it may be required, before it is permanently secured.

Once the cable reaches the top floor, the cabling installer must temporarily restrain the cable. Beginning on the bottom floor, pay out the additional slack that is needed in each TR. Once the slack is brought into the TR, the cable can be secured in its final location.

Securing the cable on each floor ensures that the weight of the cable will not become excessive at any one point. Many different devices can be used to secure the cable. The most common one used today is the split grip, which is a wire mesh grip that is open on one side. The wire mesh grip is placed around the jacket of the cable. A pin is then woven through the open sides of the wire mesh grip, securing them around the cable jacket.

A section of steel rod, a minimum of 13 mm (0.5 in) thick, is inserted through the loop in the end of the wire mesh grip. The cable is then allowed to slide through the opening in the vertical pathway until the steel rod lays on top of the pathway.

Another method of securing the wire mesh grip is to attach it to the building or a plywood backboard with an anchoring device.

The cable should then be identified and labeled, and the documents should be updated to reflect the work operation.

After completing the work operation, the cable reel and any remaining cable can be returned to storage or prepared for salvage. If the cable was shipped on a wooden reel, the reel can be dismantled and disposed of. If the cable was shipped on a metal reel, it should be returned to the manufacturer for credit.

**Steps—Vertical (Bottom Up)**

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**Step Pulling Backbone in Vertical Pathway—From Bottom Up**

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- 1 Verify proper run and cable length.
  - Examine the conduit and vertical pathway for the planned installation and check for a clear pathway. Avoid, if possible, a cable path with obstacles or transitions.
  - Use the blueprints to estimate the actual length of the cable run or verify by installing a pull tape equipped with sequential footage markings. This pull tape, if sufficiently sized, can also be used as the guide rope.
- 2 Move cable reels into place and secure the pulling area. Place the reel on a reel dolly or jack stands. If necessary, place cable sheaves along the floor to the entrance of the vertical pathway.
- 3 Determine the appropriate rope size and strength.
  - A critical factor in the success of the job depends on the strength of the rope used in the pull.
  - Check the manufacturer's specifications about the length and weight of the cable that will be installed to ensure the rope meets the strength requirements.
- 4 Install the pull rope.
  - Check to see that the pull rope, which must hoist the cable to the upper floors, is lowered down to the proper building level so that it can be attached to the cable.
    - Bring the pull rope to the upper floor.
    - Secure one end at the top.
    - Lower the rope to the bottom floor or vertical feed point.

Steps—Vertical (Bottom Up), continued

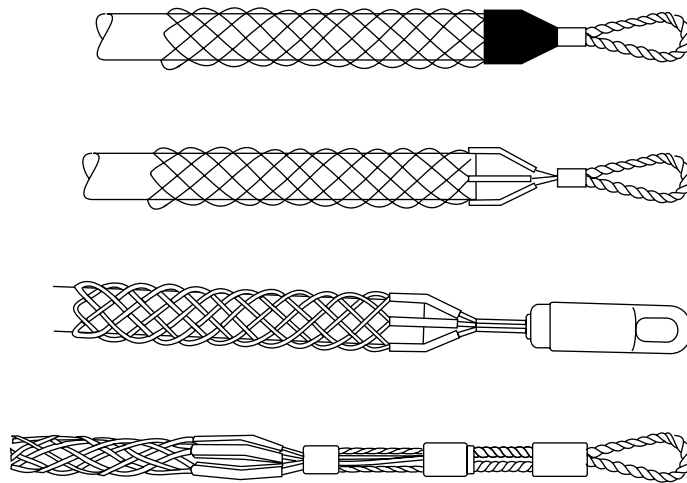
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**Step Pulling Backbone in Vertical Pathway—From Bottom Up**

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- 5 Attach the cable to the rope.
- Check the pulling end of the cable to see if it is equipped with a factory-installed pulling eye. Attach the pull rope to a swivel. Attach the swivel to the cable.
  - Use a wire mesh grip if a pulling eye is not provided on the cable.

Figure 4.18  
Wire mesh grips



- 6 Use a bullwheel, if required.
- Use a bullwheel to maintain the proper bend radius as the cable comes off the reel and is fed up into the opening.
  - The arc formed by pulling the cable under the bullwheel protects the integrity of the conductors.
  - Unlike pulleys, bullwheels do not alter the pulling force required.

**Steps—Vertical (Bottom Up), continued**

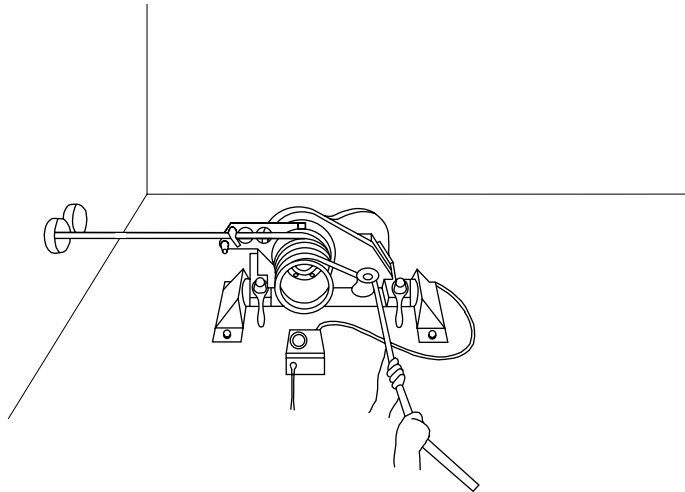
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**Step Pulling Backbone in Vertical Pathway—From Bottom Up**

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- 7 Attach winch and pulleys, if required; verify they are anchored and secured.

*Figure 4.19*  
*Winch in position and properly secured to a concrete slab*



- Confirm that the winch is at the required location.
- Verify that the winch is solidly anchored and firmly secured. Adjust winch pulley wheels to proper tension to begin tugging.
- Verify that the short, tugging motions that the winch makes will not move the equipment due to vibration.
- Verify that each pulley is positioned in a secure location and that it is firmly anchored.

### Steps—Vertical (Bottom Up), continued

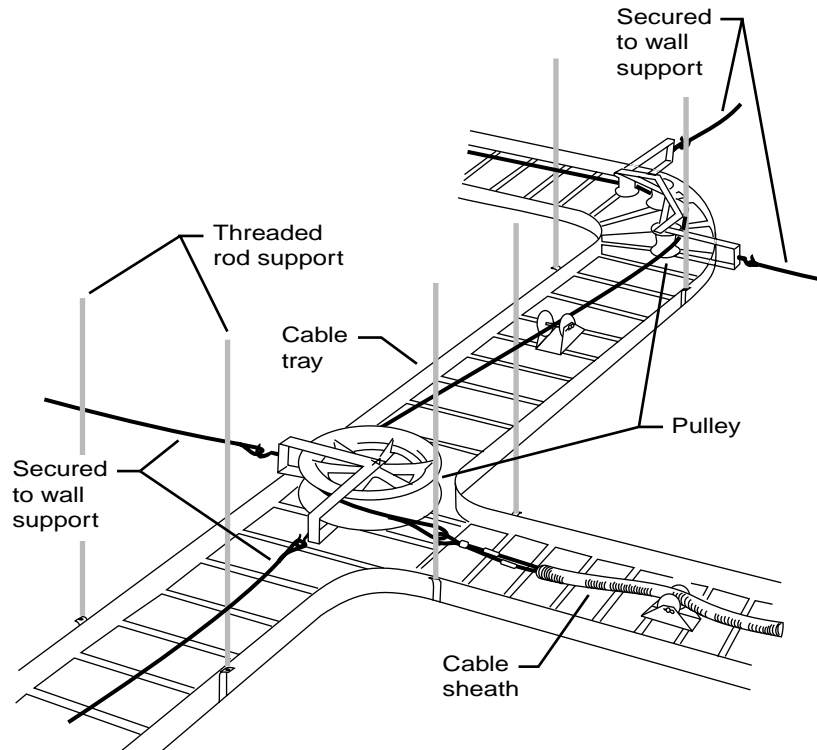
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Step	Pulling Backbone in Vertical Pathway—From Bottom Up
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- |            |  |
|------------|--|
| 7<br>cont. | <ul style="list-style-type: none"><li>• Pulling equipment must be anchored to the structure of the building (e.g., concrete anchors, steel cables, bolts).</li></ul> |
|------------|--|

Figure 4.20  
A properly secured pulley



- |   |   |
|---|---|
| 8 | <p>Lubricate cable/pipe.</p> <ul style="list-style-type: none"><li>• Obtain an approved lubricant that is not abrasive or damaging to the cable.</li><li>• Apply a liberal amount of the lubricant to the open end of the conduit.</li><li>• Apply the lubricant to the end of the cable where it is attached to the pull rope. Some dispensers are commercially available for automatically putting the lubricant on the cable as it enters the conduit.</li></ul> |
|---|---|

## Steps—Vertical (Bottom Up), continued

Step	Pulling Backbone in Vertical Pathway—From Bottom Up
9	<p>Communicate with coworkers.</p> <ul style="list-style-type: none"> <li>• As the cable pull begins, communicate with coworkers to pass on information about how things are going.</li> <li>• Ask all coworkers to call out the job status—if everything is OK or if there is a problem.</li> <li>• Encourage everyone to take responsibility for the job and to report even the slightest appearance of a problem. It is better and safer to prevent the problem than to correct or repair one.</li> </ul>
10	<p>Start winch slowly; notify personnel at the other end.</p> <ul style="list-style-type: none"> <li>• Make sure a coworker is at each end of the pull and at all midway positions. Otherwise, workers will have to move between floors. The pulling operation may have to be temporarily halted for them to relocate.</li> <li>• Notify coworkers of the conditions at the end where cable is being fed into the riser shaft.</li> <li>• Start the winch slowly so that the tugs do not come too fast and everyone can observe what is going on.</li> </ul>
11	<p>Maintain the operation until the cable is in place. Keep coworkers in position and watching for problems until the pull is complete.</p>
12	<p>Route and secure the cable, as necessary.</p> <ul style="list-style-type: none"> <li>• Secure the cable in the riser shaft.</li> <li>• Bring the cable into the TR.</li> <li>• Bring the cable toward the termination point.</li> <li>• Continue securing the cable with tie wraps or other appropriate devices to the backboard, tray, or rack.</li> <li>• Prepare the service slack, leaving slack in the cable for termination. Mount the cable to the wall, using D-rings, clamps, or ladder rack and cable ties.</li> </ul> <p>NOTE: The service slack is used to:</p> <ul style="list-style-type: none"> <li>– Help relieve tension on the cable.</li> <li>– Provide slack for future moves and changes.</li> </ul> <ul style="list-style-type: none"> <li>• The service slack should be long enough to reach the other side of the TR in case of relocated or additional equipment. Keep in mind that these cables usually require a minimum bending radius of 10 times the outside diameter of the cable for multipair copper cables and 15 times the outside diameter for optical fiber cables.</li> </ul>

### Steps—Vertical (Bottom Up), continued

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Step	Pulling Backbone in Vertical Pathway—From Bottom Up
13	Identify cable. <ul style="list-style-type: none"><li>Place a unique identification number (from the installation drawings) at each end of the cable showing the point of origin and destination. Place a label on the cable where it enters or leaves the TR on each floor.</li></ul>
14	Document cable information on the posted floor plans. <ul style="list-style-type: none"><li>Show clearly what kind of cables were installed.</li><li>Show clearly which conduit was used.</li><li>Describe the purpose of the cables installed.</li></ul>
15	Perform job wrap-up tasks.

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## Pulling Backbone—Horizontal

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### Overview

Horizontal backbone cable is used to interconnect TRs. Horizontal backbone multipair cable may or may not be installed in conduit between TRs.

Cable support mechanisms are required to provide whatever protection is necessary to keep the cable free of excessive tension. As noted earlier, excessive tension will often cause damage to the pairs inside the cable.

Horizontal backbone cable runs may be supported by beam clamps, cable trays, lay-in raceway, or trapeze system. Because of the heavy weight of the bulk cables, it is imperative that the load handling capabilities of the pathway support system are adequate to handle the installation.

ANSI/TIA/EIA-569-A, *Commercial Building Standard for Telecommunications Pathways and Spaces*, guidelines require cable pulls to be no longer than 30 m (100 ft) between pull points. Maintaining proper pulling tension is essential. Pulling too hard may damage the cable.

## Overview, continued

High pair-count backbone cables must be placed individually to manage their weight. Placing high pair-count backbone cables presents the same problems as pulling from the bottom up. Additional changes in direction will increase the pulling tension required. The coefficient of friction increases because the entire weight of the cable is horizontal and creates friction with everything it contacts. Open-type supports, such as cable trays and ladder racks, preclude the use of lubricants. As a result, pulleys may have to be employed to overcome the problem of friction.

Through the initial project planning process, the cabling installer has already completed several tasks, including:

- Verifying correct types and lengths of cable are available on the job site.
- Determining access for moving and positioning cable reels, such as loading docks and freight elevators.
- Selecting the tools required for pulling the cable.
- Identifying and providing the proper safety and telecommunications equipment.
- Identifying the requirements and methods for labeling and documenting the cable pulls.

## Setting Up for the Pull

Setting up the job site and preparing for the pull involve additional tasks and considerations.

- Horizontal backbone installations sometimes require the use of pulling equipment, such as a pulley or a winch. A winch is an electrical motor equipped with a capstan. It is securely attached to the building structure. The pull rope is wound around the capstan. When the cabling installer places tension on the rope, it tightens around the capstan. Friction created by the tightening causes the rope to advance toward the cabling installer. The cabling installer can control the rate at which the rope advances, thus controlling the advance of the cable along its route. In other installations, a cabling installer can manually perform the tugging.
- The pull rope chosen for this operation is critical. Manila, hemp, or double-woven Dacron® rope should be used because it does not stretch when placed under tension, nor does it deteriorate quickly when subjected to friction and heat. However, it does have a tendency to twist as tension is applied. To prevent this, use a swivel between the cable and the pull rope. The swivel prevents the cable from twisting during the placing operation and prevents damage to the jacket, shield, and conductors.

### Setting Up for the Pull, continued

- If a pulling eye was not factory installed, install a substitute device. A wire mesh grip that is properly sized can be installed on the cable. This prevents it from coming off should the pull be halted and the tension be relaxed on the grip.
- When a wire mesh grip is not available and the pathway is large enough, the pull rope can be attached over the jacket in a series of half hitches. Vinyl tape is placed over the guide rope, securing it to the cable.
- If the pathway is too small to use half hitches, a pulling eye can be installed by using the conductors. To do this, remove a section of the outer jacket, shield, and inner jacket. Separate the conductors into two equal groups. Weave the two groups back onto themselves, forming an eye on the end of the cable. Once the eye is formed, install vinyl tape over its entire length, including a section of the outer jacket. By using this device, tension will be evenly dispersed over each wire in the cable as well as the jacket.
- Attach the swivel to the pull rope; attach the cable to the swivel.

Cabling installers should be equipped with the proper tools to perform critical tasks during the placing operation. Some of the tools include:

- Personal protection equipment such as safety glasses, hard hats, and gloves.
- Communications equipment such as portable, handheld radios.

### Installing the Cable

Once everyone and everything is in place, the cable can be installed. After informing members of the cabling team that the pull is starting, begin pulling the cable up the horizontal pathway. Monitor its progress throughout the pull, and continue the placing operation until complete. Ensure that enough slack is pulled to the last TR.

Cable should be identified and labeled, and the documents should be updated to reflect the work operation. Documentation is an essential part of the job and includes labeling the cable and updating the building plans to specifically indicate the cable installed by the cabling team.

When the work operation is complete, return the cable reel and any remaining cable to storage or prepare for salvage. If the cable was shipped on a wooden reel, the reel can be dismantled and disposed of. If the cable was shipped on a metal reel, it should be returned to the manufacturer for credit.

## Steps—Horizontal Backbone

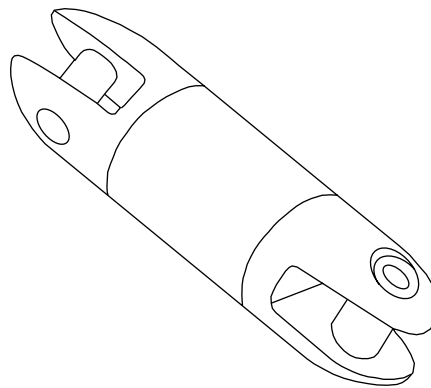
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### Step Pulling Backbone—Horizontal

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- 1 Install and attach pulling mechanism to the cable.
  - If possible, use only manual strength to pull the cable.
  - When more power is required, use a winch.
  - Attach the pull rope to the winch.
  - Use a swivel to prevent the cable from twisting as it is pulled forward.

*Figure 4.21*  
*Swivel to prevent cable twisting*



- 2 Attach pulleys, if required.
  - Decide whether pulleys are required to advance the cable during the pull or to stabilize it.
  - Pulleys also help guide cables around obstacles.
- 3 Communicate with coworkers.
  - As the cable pull begins, communicate with coworkers to pass on information about how things are going.
  - Ask all coworkers to call out the job status—if everything is all right or if there is a problem.
  - Encourage everyone to take responsibility for the job and to report even the slightest appearance of a problem. It is better and safer to prevent a problem than to correct or repair one.

## Steps—Horizontal Backbone, continued

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Step	Pulling Backbone—Horizontal
4	<p>Pull the cable until it is in place.</p> <ul style="list-style-type: none"><li>• Carefully monitor the cable’s progress to the last location.</li><li>• Maintain control of any pulley that may be in use.</li><li>• Maintain control of all pull ropes that may be in use.</li><li>• Stay in position as a communicator with coworkers until the pull is finished.</li></ul>
5	<p>Route and secure the cable in TRs, if necessary.</p> <ul style="list-style-type: none"><li>• Route the cable into the TR.</li><li>• Route the cable to the termination point.</li><li>• Secure the cable with tie wraps or other appropriate devices to the backboard, tray, or rack.</li><li>• Prepare the service slack, leaving slack in the cable for termination. Mount it to the wall using D-rings, clamps, or ladder rack and cable ties.</li></ul> <p>NOTE: The service slack is used to:</p> <ul style="list-style-type: none"><li>– Help relieve tension on the cable.</li><li>– Provide slack for future moves and changes.</li></ul> <ul style="list-style-type: none"><li>• The service slack should be long enough to reach the other side of the TR in case new equipment is needed. Keep in mind that these cables usually require a minimum bending radius of 10 times the outside diameter of the cable for multipair copper cables and 20 times the outside diameter for optical fiber cables.</li></ul>
6	<p>Identify cables.</p> <ul style="list-style-type: none"><li>• Place a unique identification number (from the installation drawings) at each end of the cable showing the point of origin and destination. Place a label on the cable where it enters or leaves each TR.</li></ul>
7	<p>Document cable information on the posted floor plans.</p> <ul style="list-style-type: none"><li>• Show clearly what kind of cables were installed.</li><li>• Show clearly which conduit was used.</li><li>• Describe the purpose of the installed cables.</li></ul>
8	<p>Perform job wrap-up tasks.</p>

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## Pulling Optical Fiber Cable

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### Introduction

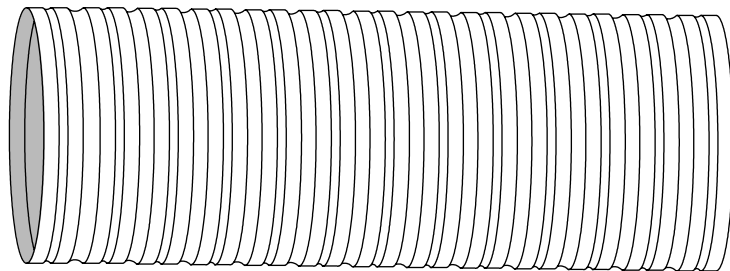
Optical fiber is one of three types of cable suitable for backbone systems. Optical fiber cable is more rugged than generally perceived. However, just as with copper cable, care must be taken when pulling optical fiber so as not to exceed the cable bend radius or the manufacturer's recommended pulling tension. Most optical fiber cable manufacturers provide maximum pulling tension based on cable construction.

Within buildings, the predominant placement of optical fiber cable is in the backbone between TRs. However, the use of optical fiber cable to the desktop is increasing to meet the increased bandwidth requirements of imaging technology and high-speed networks.

Regardless of whether the application is backbone or horizontal, optical fiber cables may be installed in innerducts as an indicator that fiber cable is present. This method of installation also tends to reduce the pulling tension required, especially when multiple innerducts are installed in conduit.

Plenum- and nonplenum-rated innerducts are available in a variety of colors. Although usually purchased with a pull rope preinstalled inside for attaching the fiber cable to be pulled, innerducts are also available without pull ropes. The pathway of a fiber cable must be free of sharp bends and turns. Normally, innerducts are placed inside conduit, through sleeves, or in cable trays. Care should be taken to ensure that the properly fire-rated innerduct is being installed.

Figure 4.22  
Innerduct



**NOTE:** Innerduct is not a recognized pathway but rather a pathway within a pathway. All cables installed in innerduct must have the proper sheath rating for the area in which they are installed. All material installed in a plenum area must be plenum rated. Do not install nonrated cable in plenum innerduct.

As in copper cable installations, communication among coworkers is essential to ensure the pulling function progresses properly without excessive stress or tension on the cable.

## Steps—Optical Fiber

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**Step Pulling Cable—Optical Fiber**

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- 1 Ensure that only tested and accepted lengths of optical fiber cable are installed.
  - Verify that there is fiber continuity while the cable is on the reel. In order to do so, the cable must be ordered with access to both ends of the fiber on the reel. Maintain the test results for inclusion in the client's documentation package.
  - Test the optical fiber cable for continuity. This can be done by shining a light source (such as a flashlight) into the fiber cable or using a power meter and light source or OTDR. A bare-fiber adapter or mechanical reusable splice is necessary to connect either the power meter and light source or OTDR to the unterminated fiber on the reel.

**WARNING:** Never look directly at the end of a previously installed optical fiber cable because of the possibility that a laser light source (which is not visible to the human eye) may be present. This can cause permanent damage to the retina of the eye.
- 2 Install and secure innerducts.
  - Verify the application (plenum or nonplenum) and place the innerducts, depending on the specific location (vertical shaft, cable tray, or open ceiling), with the appropriate support. If secured with tie wraps in a plenum area, use plenum-rated tie wraps.
  - Innerduct can be ordered with or without a pull rope already placed inside. If ordered without a rope, follow the procedure for installing a pull string in a conduit.

**Steps—Optical Fiber, continued**

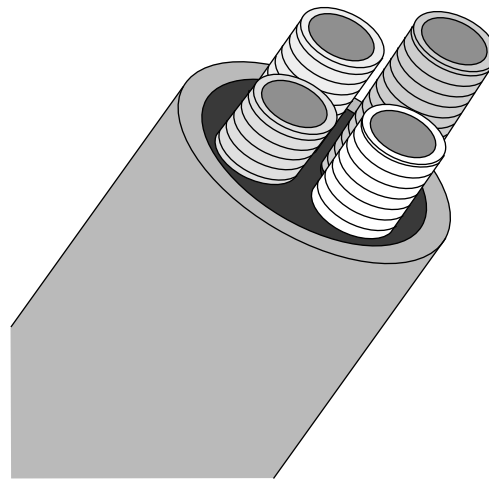
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**Step Pulling Cable—Optical Fiber**

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- 2 cont.
- If the requirement is to place innerducts within a conduit, determine the size and number of innerducts permitted. Innerducts are classified by outside diameter (OD), whereas trade-size conduits are classified by inside diameter (ID). This fact allows a total of four 25 mm (1 in) innerducts to be placed inside a 103 mm (4 trade size) conduit.

*Figure 4.23*  
*Four-inch conduit with four one-inch innerducts*

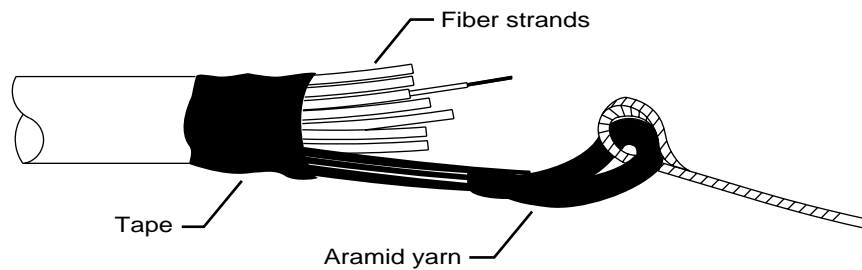


- 25 mm (1 in) innerduct is the usual size placed within buildings; however, 32 mm (1.25 in), 38 mm (1.5 in), and 50 mm (2 in) innerducts are available for larger fiber cables.

Steps—Optical Fiber, continued

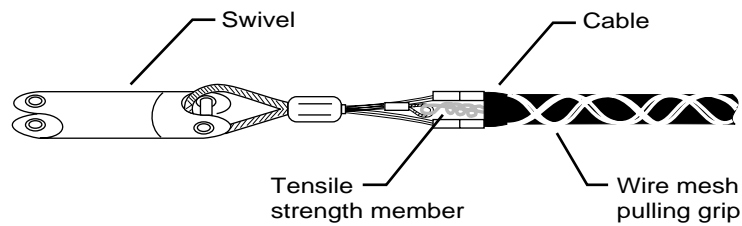
Step	Pulling Cable—Optical Fiber
2 cont.	<ul style="list-style-type: none"> <li>Attach the optical fiber cables to the pull rope for pulling of the optical fiber cable through the innerduct. Two methods of connection are commonly used. The most common is to remove the sheath for about 300 mm (12 in) length from the fiber cable and place the exposed aramid yarn strength member through a loop in the rope. Secure it with tape, as shown in the following figure.</li> </ul>

Figure 4.24  
Connecting aramid yarn



- The second method is to place the optical fiber cables in a multiweave, wire mesh grip of the appropriate size that has a swivel pulling eye to which the pull rope is attached.

Figure 4.25  
Multiweave wire mesh grip with swivel pulling eye



- Install without innerduct.
  - When optical fiber cable is installed without an innerduct, ensure that the run is as straight as possible.
  - At transitions, be sure that a coworker is placed at such points to relieve excessive tension during the pull. This ensures that the optical fiber cable does not rub against obstructions that can nick or cut the jacket.

## Steps—Optical Fiber, continued

Step	Pulling Cable—Optical Fiber
4	<p data-bbox="573 373 683 401">Pull fiber.</p> <ul style="list-style-type: none"> <li data-bbox="573 422 1463 485">• Feed the optical fiber cable into the innerduct. Normally, the optical fiber cable can be pulled by hand.</li> <li data-bbox="573 506 1463 562">• Do not exceed the recommended pull tension or the recommended bend radius of the optical fiber cable.</li> </ul>
5	<p data-bbox="573 583 906 611">Always leave a service loop.</p> <ul style="list-style-type: none"> <li data-bbox="573 632 1430 695">• The service loop is used to relieve all tension on the optical fiber cable and provide slack for future moves or changes.</li> <li data-bbox="573 716 1463 877">• Always bring the optical fiber cable with the innerduct into a point of termination using the grommets provided in the optical fiber cabinet. Secure the optical cable to the cabinet, ladder rack, cable tray, or backboard. The optical fiber strands should be stored and dressed inside the cabinet.</li> <li data-bbox="573 898 1463 1024">• The optical fiber cable service loop should be long enough to reach the other side of the TR in case relocated or additional equipment is encountered in the future and the fiber must be relocated within the TR. The service slack stored inside the cabinet should be 3 m (10 ft).</li> </ul>
6	<p data-bbox="573 1045 1382 1073">Secure the cable to the cabinet per the manufacturer's specifications.</p> <ul style="list-style-type: none"> <li data-bbox="573 1094 1479 1192">• All fiber cables should be anchored in the termination cabinet by using the aramid yarn of the cable to act as a strain relief, as stated in the manufacturer's instructions.</li> <li data-bbox="573 1213 1479 1312">• Care should be taken not to overtighten tie wraps around optical fiber cable when dressing. Keep them loose enough so that they can be turned from side to side using finger pressure.</li> <li data-bbox="573 1333 1479 1486">• Maintain proper bend radii during and after the cable pull. For instance, the bend radius requirements of some optical fiber cables are 10 times a cable's OD when the cable is at rest and 20 times a cable's OD when the cable is under stress. These values may be 15 times and 30 times the cable's OD for some cables.</li> </ul>
7	<p data-bbox="573 1507 748 1535">Identify cables.</p> <ul style="list-style-type: none"> <li data-bbox="573 1556 1446 1612">• Place a unique identification number (from the installation drawings) at each end of the cable showing the point of origin and destination.</li> </ul>

### Steps—Optical Fiber, continued

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<b>Step</b>	<b>Pulling Cable—Optical Fiber</b>
8	Document the job on the posted floor plans. <ul style="list-style-type: none"><li>• Indicate clearly what type of cables were installed (i.e., 24-strand, plenum-rated multimode fiber).</li><li>• Show clearly which conduit was used and which innerduct, if applicable.</li><li>• Describe on the floor plan the purpose of the installed cables (e.g., backbone from main cross-connect [MC (campus distributor [CD])] to third floor TR).</li></ul>
9	Perform job wrap-up tasks.

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