CORNING

Duct Installation of Fiber Optic Cable

P/N 005-011
Issue 17

1. Safety Precautions

1.1 Confined Space Precaution

WARNING: Follow all OSHA regulations concerning confined space entry and work.

1.2 Lead Exposure Warning

WARNING: Lead dust may be released into the manhole atmosphere any time the sheath of older lead sheath cable is disturbed. When working in manholes, precautions must be taken to limit the amount of exposure to lead. Strictly observe your company's lead handling procedures to eliminate this hazard. Failure to do so may result in serious, long-term health problems.

1.3 Cable Handling Precautions

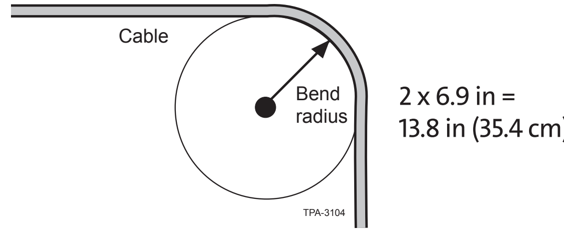
CAUTION: Care must be taken to avoid cable damage during handling and placing. Fiber optic cable is sensitive to excessive pulling, bending, and crush forces. Any such damage may alter the cable's characteristics to the extent that the cable section may have to be replaced. To ensure all specifications are met, consult the specific cable specification sheet for the cable you are installing.

Corning Optical Communications cable specification sheets are available which list the maximum tensile load for various cable types. The maximum pulling tension for stranded loose tube cable and ribbon cable is 600 lbF (2,700 Newtons). Refer to the cable specification sheet for the specific allowed tension for each cable.

Corning Optical Communications cable specification sheets also list the minimum cable bend radius both "Loaded" (during installation) and "Installed" (after installation). The following formulas may be used to determine general guidelines for installing Corning Optical Communications' fiber optic cable; however, refer to the cable specification sheet for the listed minimum bend radius:

From GR-20 and ICEA-640: Minimum Bend Radius Requirements			
Operation		Installation	
MBD	20 x OD	MBD	40 x OD
MBR	10 x OD	MBR	20 x OD
If MBR > 216 fibers			
MBD	30 x OD	MBD	40 x OD
MBR	15 x OD	MBR	20 x OD
NOTE: *Corning® RocketRibbon™ extreme-density cable (1728- and 3456-fiber) exceeds these requirements.*			
Operation		Installation	
MBD	30 x OD	MBD	30 x OD
MBR	15 x OD	MBR	15 x OD

Example: To arrive at a working bend radius for cable installation, multiply 15 times (15 x) the cable outside diameter.



Cable Diameter = 0.46 in (11.8 mm)

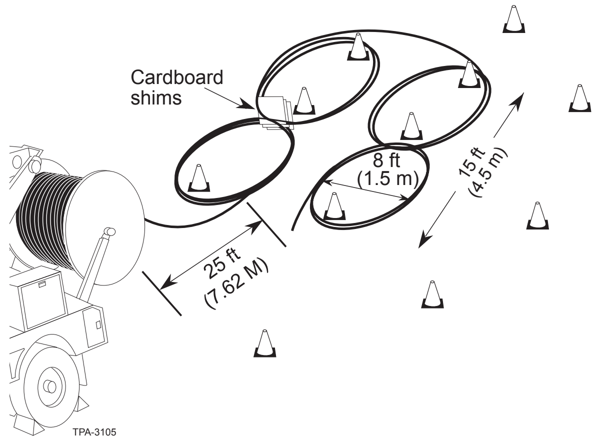
15 x 0.46 in = 6.9 in (177 mm)

Minimum Working Bend Radius = 6.9 in (17.7 cm)

To find the minimum diameter requirement for pull wheels or rollers, simply double the minimum working bend radius.

Whenever unreeled cable is placed on the pavement or surface above a manhole, provide barricades or other means of preventing vehicular or pedestrian traffic through the area.

The figure-eight configuration should be used to prevent kinking or twisting when the cable must be unreeled or backfed.



Fiber optic cable should not be coiled in a continuous direction except for lengths of 100 ft (30 m) or less. The preferred size for the figure-eight coil is about 15 ft (4.5 m) in length, with each loop 5 ft (1.5 m) to 8 ft (2.4 m) in diameter.

Traffic cones spaced 7-8 feet apart are useful as guides during coiling. When coiling long lengths of cable, care should be taken to relieve pressure on the cable at the crossover of the eight. This can be done by placing cardboard shims at the crossover or by forming a second figure-eight coil.

!	**WARNING:** Automated figure-eight machines that coil fiber optic cable on a drum may exceed cable design limits by exceeding torsion, tension, and bend radii limitations. Do not use automated figure-eight machines when installing fiber optic cables with a central tube design or any loose tube cable having one or more layers of corrugated steel armor. Use of these machines may result in the cable's jacket being breached and the armor being exposed.

Fiber optic cable which passes through manholes containing petroleum-based waste will require special protection. Some petroleum products will deteriorate the cable's polyethylene sheath. Consult your company's practices regarding manholes and petroleum-based waste for specific instructions on how to remove the petroleum. Install innerduct that is impervious to future petroleum exposure.

!	**CAUTION:** Never use liquid detergent as a lubricant when placing fiber optic cable. Most detergents will promote stress cracks when used on polyethylene. Use only cable lubricants with manufacturer's approval for polyethylene sheaths.

At the completion of a day's installation, protect bare cable ends by placing a cable cap on the end of the cable, followed by several wraps of tape around each cap. This will assist the moisture-resisting material in Corning Optical Communications' loose-tube cable in preventing water ingress due to long-term exposure to moisture. If a cap is not available, a few wraps of tape placed on the tip of the cable should prevent water from entering the cable.

NOTE: *If the cable ends are not capped while exposed to the environment for long periods of time, the customer may choose (but is not required) to cut off three feet (one meter) of each cable end before splicing. This will ensure that no moisture ingress is present.*

2. Planning and Preparation

It is recommended that an outside plant engineer conduct a survey of the cable route. Manholes and ducts should be inspected to determine the optimum splice point locations and duct assignments. Identify potential problems with innerduct and cable placement at this time.

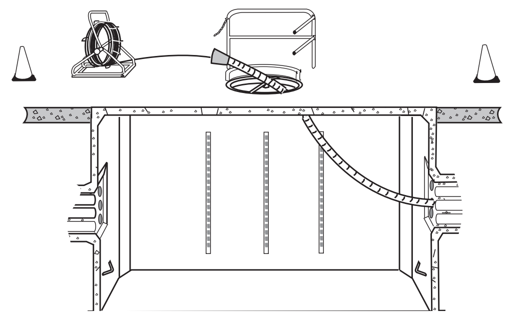
Rodding or slugging may be required to verify duct suitability and accurate length. Cable cut length is especially critical when installing factory-connectorized cables.

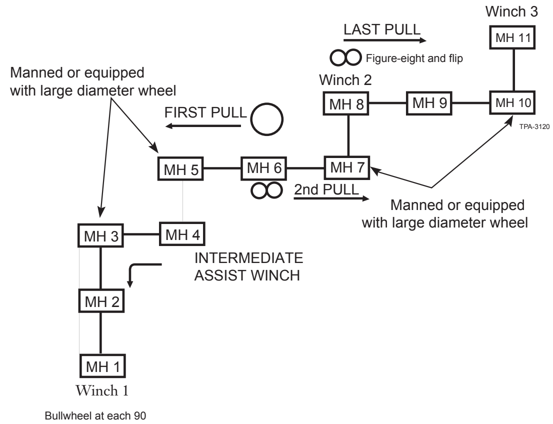
Inspect manholes in which cables will be spliced and make plans for closure and cable slack racking. Be sure to consider the accessibility of manholes to splicing vehicles.

Fiber optic cable must be protected in intermediate manholes. Carefully choose racking space so that it will provide maximum protection for the cable and maintain its minimum bend radius.

Based upon the cable route survey and the equipment/ manpower resources available, develop a cable pull plan.

Rodding





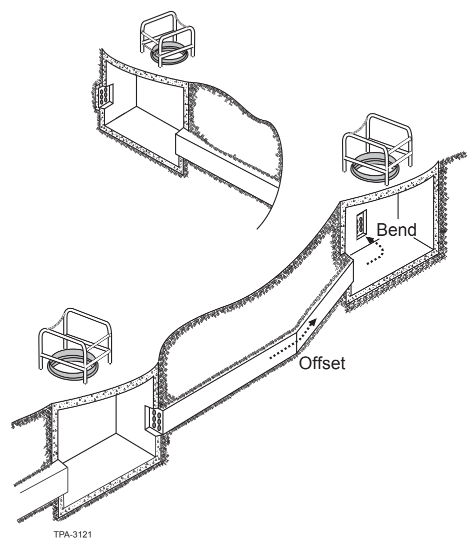
Inspect potential reel and winch locations for their suitability and make plans for installation techniques such as backfeeding or use of intermediate assist winches.

Factors to consider in developing the pull plan include changes in elevation and the locations of bends and offsets.

- For ease of installation, pull cables from higher elevation manholes to lower ones, whenever possible.
- Bends describe pronounced turns in the routing of a duct system.
- Offsets in a duct system are more gradual variations from the ideal, straight path of a duct section. Offsets can impose greatly increased pulling tension.

For example, a three foot offset in a 10-foot run of duct can add an estimated 120 lb_F of tension to a pull[1].

To minimize the effect of bends and offsets, begin such pulls at the end of the innerduct section nearest the difficult area.



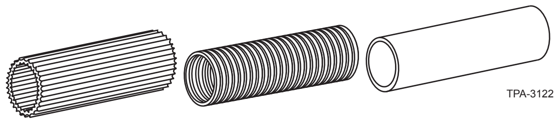
[1]John Anderson, "Assist Device Proves Itself In Long F O Pulls" Outside Plant, March 1986, p 40.

3. Installation Equipment and Accessories

3.1 Innerduct

Innerduct is a way to subdivide the duct and to provide for future cable pulls. Three 1.25-inch inside diameter (I.D.) innerducts can usually be pulled into a 4-inch duct. Proper size and installation of the innerduct is critical for ease of cable installation.

Innerduct is available in ribbed, corrugated, and smooth-walled constructions of polyethylene or PVC material. Corning Optical Communications' fiber optic cable is compatible with all major brands of innerduct. Consult your company's practices for innerduct specifications.



Fill ratios are calculated by comparing the area of an inner diameter cross-section of the innerduct to the outer diameter cross-section area of the fiber optic cable. Larger diameter innerducts (which result in smaller fill ratios) will normally reduce pulling tension.

To calculate a fill ratio, use the following formulas from the chart. For a quick calculator, see www.corning.com/cablesystems/fillratio

Formulas Used to Calculate Fill Ratio

First Cable	Second Cable	Third Cable
$\frac{d^2}{D^2} < 65\%$	$\frac{d_1^2 + d_2^2}{D^2} \leq 31\%$	$\frac{d_1^2 + d_2^2 + d_3^2}{D^2} \leq 40\%$

Legend

d = Cable Diameter
d_1 = First Cable Diameter
d_2 = Second Cable Diameter
d_3 = Third Cable Diameter
D = Innerduct Diameter

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Multiple cables may be pulled simultaneously into one innerduct. Pulling a new fiber optic cable over an existing one is not recommended due to the possibility of entanglement.

Should an innerduct become twisted during installation, the twisting (helixing) can dramatically increase pulling tension during cable installation. Corrugated innerduct has less "memory" than other types of innerduct, and may tend to lay flatter in the duct.

Innerduct often stretches during installation. Allowance must be made for the relaxation of this stretch by planning for extra slack to be pulled into manholes.

At points where innerduct will be continuous through a manhole, allow sufficient slack so that the innerduct may be secured on the manhole racks and maintain the cable's minimum bend radius.

At points where the innerduct is not continuous through a manhole, some provision must be made to provide a section to cover the cable in the manhole during and after placement. This may be accomplished through one of the following methods:

a. Couplers which "splice" innerduct sections together are available from most innerduct manufacturers. Do not use couplers which reduce the inside diameter of the innerduct.

b. Split duct may be applied to the cable during racking, see Applications Engineering Note 167, Split Duct Cable Installation Guidelines

c. A section of innerduct which has an inside diameter greater than the outside diameter of the installed innerduct may be used in a sleeve operation. This section of innerduct must be slid over the innerduct coming from the entrance duct BEFORE the pull-line is installed. The section of larger innerduct must be long enough to reach from the entrance duct to the exit duct while passing around the periphery of the manhole where it will be racked, plus an additional 9 ft (3 m) on each end which will be inside the duct bank after racking.

After placement, all innerduct must be capped or plugged to prevent moisture or foreign matter from entering until the cable installation starts.

3.2 Pull-Line

Various types of pull-line have been used successfully with fiber optic cable. Pull-lines can be of either a round or flat cross section. Selection of a pull-line will depend upon the length and conditions of the pull. Small diameter pull-line may have a tendency to cut innerduct when under tension.

Available pull-line materials include wire rope, polypropylene, and aramid yarn. For pulls using winches, materials with low elasticity such as wire rope and aramid yarn can minimize surge-induced fluctuation in pull-line tension. Consult your company's standard practices with regards to pull-line materials.

Some innerduct is available with preinstalled pull tape or line. Otherwise, pull-line can be installed by rodding or blowing. Lubrication of the pull-line may be necessary for ease of installation or to prevent the line from cutting the innerduct.

3.3 Pulling Grips

Corning Optical Communications recommends the use of a factory or field-installed wire mesh pulling grip and swivel during cable pulls. Pulling grips provide effective coupling of pulling loads to the jacket, aramid yarn, and central member of fiber optic cables.

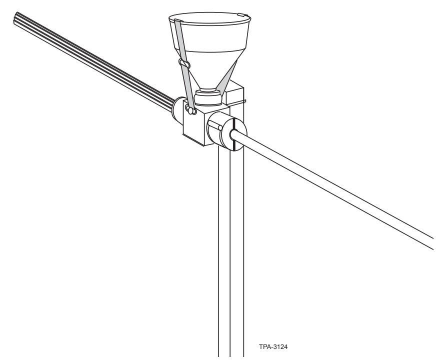
Wire mesh pulling grip

For instructions on field installation, refer to SRP 004-137, Installing a Wire Mesh Pulling Grip.

The use of a swivel between the pull-line and pulling grip is required to prevent the pull-line from imparting a twist to the cable. Check with the manufacturer for load variation on the breakaway swivel. This must be taken into consideration so that the maximum tension for the cable is not exceeded.

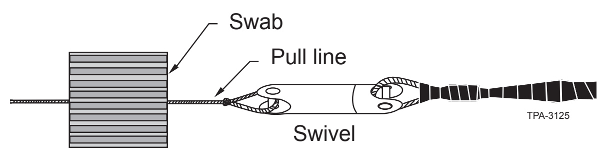
3.4 Lubricants

Cable lubricant is recommended for most fiber optic cable pulls as a means of lowering pulling tension. Short hand-pulls may not require lubricant. Considerations in choosing a lubricant are material compatibility, drying time, temperature performance, and handling characteristics.



As noted in the cable precautions, cable lubricants must be compatible with the fiber optic cable's outer sheath. Refer to the lubricant manufacturer's specifications. Use of incompatible liquids, such as liquid detergent, for a lubricant can cause long term sheath damage.

Lubricant should be applied according to the manufacturer's recommendations. Some lubricant vendors recommend an applicator to coat the cable as it enters the innerduct, others suggest distributing lubricant throughout the innerduct by pulling a swab through the innerduct as part of the pull-line placement. Pumps or gravity feed devices can also be used to inject lubricant into the innerduct.



Additional lubricant should be added before bends and known severe offsets and sections with "uphill" elevation changes.

NOTE: *Check with the manufacturer for load variation on the breakaway swivel. This must be taken into consideration so that the maximum tension for the cable is not exceeded.*

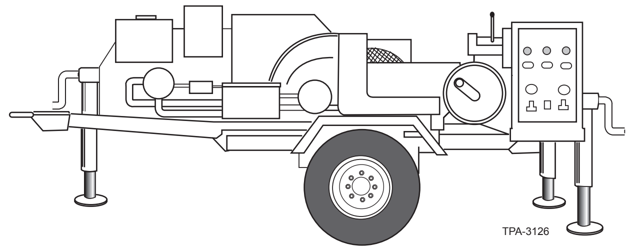
3.5 Tension-Monitoring Equipment

Fiber optic cable is subject to damage if the cable's specified maximum tensile force is exceeded. Except for short runs or hand-pulls, tension must be monitored. Refer to cable specification sheets for maximum tension. Exceeding the specified maximum tension will void the warranty of the cable product.

The use of a winch with a calibrated maximum tension is an acceptable procedure. The control device on such winches can be hydraulic or in the form of a slip clutch. Such winches should be calibrated frequently.

The use of a breakaway link (swivel) can be used to ensure that the maximum tension of the cable is not exceeded. Breakaway links react to tension at the pulling eye and should be used as a fail-safe rather than a primary means of monitoring tension.

A dynamometer or in-line tensiometer may also be used to monitor tension in the pull-line near the winch. This device must be visible to the winch operator or used to control the winch. Special winches are available that monitor the tension remotely at the pulling eye via a wire in the pull-line. Such winches may also provide a record of the tension during pulls.



NOTE: *Carefully select equipment that maintains bend radius. Not all outside plant equipment is well-suited for fiber optic cable installation.*

3.6 Pulling Equipment

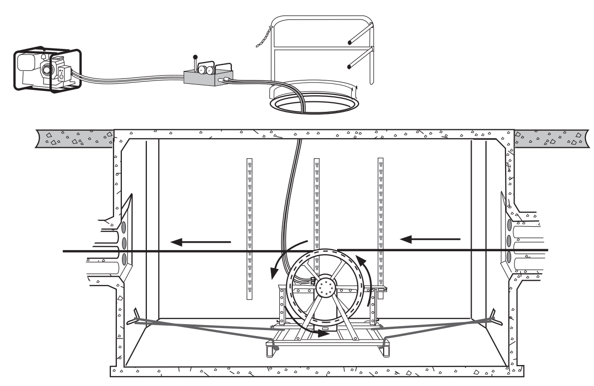
All pulling equipment and hardware which will contact the cable during installation must maintain the cable's minimum bend radius. Such equipment includes sheaves, capstans, and bending shoes designed for use with fiber optic cable. Split cable guides and split 40-in sheave wheels are available to facilitate entry and exit from manholes. Lip rollers and quadrant blocks must not be used because the rollers themselves do not meet the minimum bend radius requirements.

NOT ALLOWED! Rollers do not meet minimum bend radius.

Situations that require use of a radius-maintaining device are encountered at feed and pull manholes, at bends, and where entrance and exit ducts in a manhole are offset.

4. Installation Techniques

Various techniques are available to ease the installation of long lengths of fiber optic cable. All have been used extensively in the field.



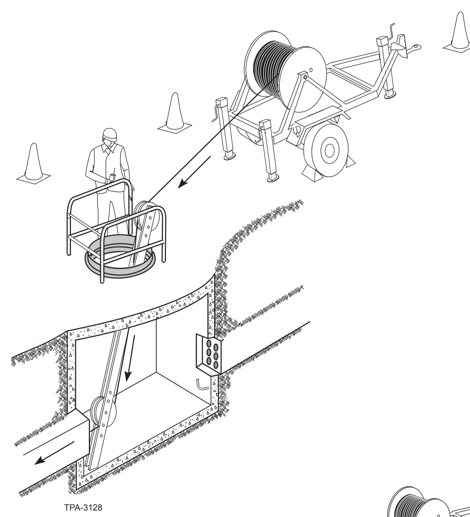
The length of cable that can be pulled in one operation will vary with duct conditions, the equipment used, pulling technique selected, and the skill of the craftsmen. Normally, a short pull [less than 3000 ft (913 m)] with two or fewer 90-degrees bends may be pulled without an intermediate-assist winch or hand assistance.

Use of multiple winches requires compatible pulling equipment and careful coordination of winch speeds. Consult the equipment manufacturer's instructions for necessary details.

4.1 Center-Pulls and Backfeeding

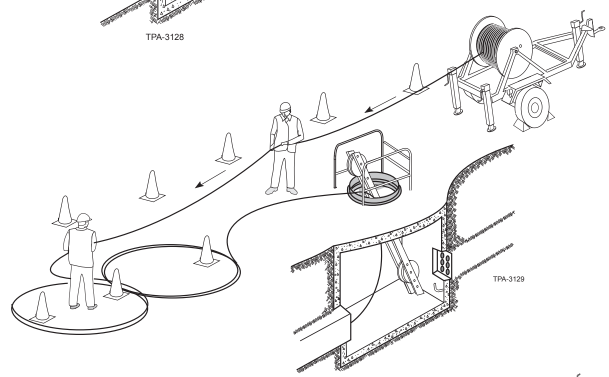
Longer cable pulls, or those involving many bends, may also use center-pull and “backfeeding” techniques.

Step 1: In a center-pull operation, set up the cable reel near the center of the duct run to be pulled. Pull the cable in one direction to the next designated splice point.

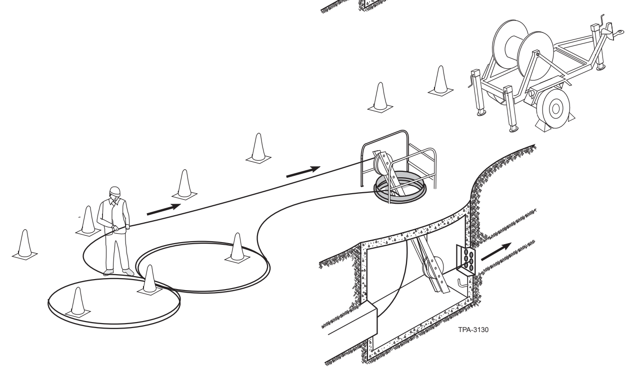


Step 2: Unreel the remaining cable in a figure-eight configuration.

Step 3: Flip over the figure-eight coil so that the pulling-eye end of the cable is on top. This can be easily accomplished by three installers, one at each end of the eight, and one at the center.



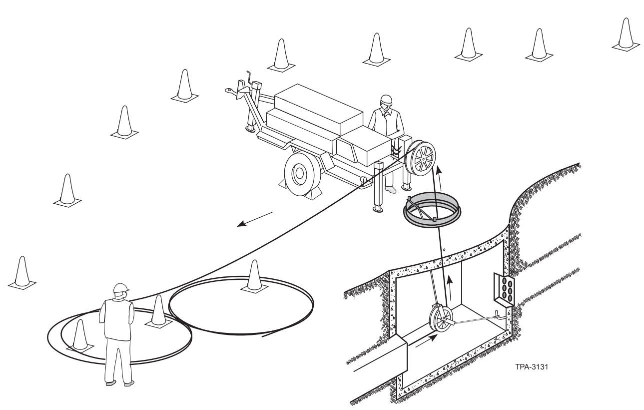
Step 4: Pull the exposed end of the cable in the opposite direction to complete the pull. Hand tending of the cable paying off from the figure-eight coil is normally required.



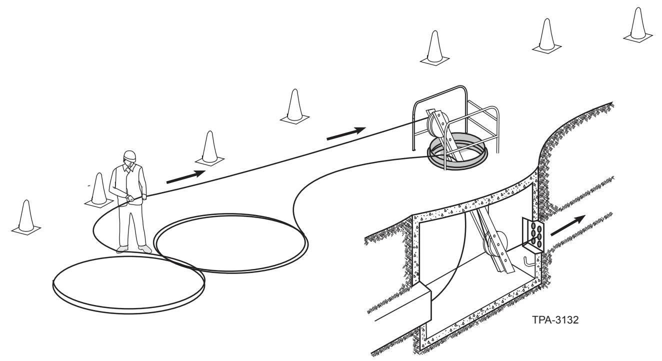
4.2 Backfeeding

“Backfeeding” may be used to provide a series of shorter, lower-tension pulls in one direction. When backfeeding, pull enough cable out of the manhole to reach the intended end point of the pull, plus racking and splicing slack. This cable should be coiled in a figure-eight as it emerges from the manhole.

Step 1: Flip over the figure-eight so that the pulling-eye end of the cable is on top. This can be easily accomplished by three installers, one at each end of the eight, and one at the center.

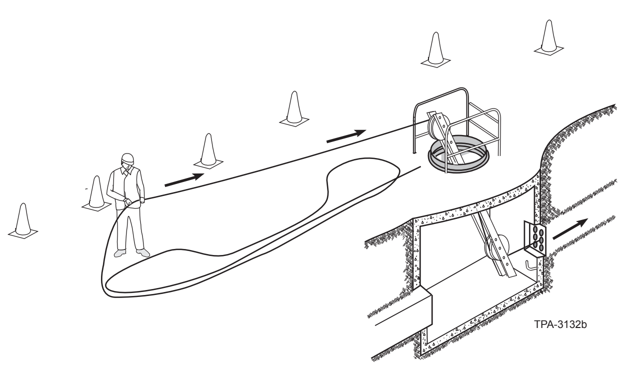


Step 2: After the pulling eye is connected to the next section of the pull-line, feed the cable by hand back into the manhole and pull it to its next destination. The cable may be pulled directly from a figure-eight by a winch, provided the capstan or sheave used at the entry manhole ensures sufficient bend radius. Hand tending of cable paying off from figure-eights is normally required.



⚠	**WARNING:** Before pulling cable directly from a figure-eight, make sure that the area inside the loops of the cable is clear of personnel and equipment. Failure to do so may result in injury to personnel or damage to the cable.

NOTE: *An alternate to the Figure-eight method is to "railroad" the cable as shown in this illustration. The method can also be viewed in the video "Railroad Method for Backfeeding Cable."*



5. Installation Procedure

This section will provide an overview of an installation operation. As noted earlier, your company's practices and local conditions may take precedence over these guidelines.

5.1 Manhole Preparation

Step 1: Prepare the manholes in the duct section where the cable is to be placed:

a. Place barricades

b. Monitor gas

c. Establish ventilation

d. Pump water

e. Inspect ladders, racks, and duct banks

Step 2: If not already in place, install the innerduct and pull-line. Tie down exposed innerduct in manholes to prevent dragging of innerduct during pulling operations.

5.2 Route Preparation

Step 1: Relocate existing utilities if necessary.

Step 2: Set up winches, monitoring devices, lubrication points, bend radius devices (sheaves, capstans, bending shoes, etc.), and means of communications along the route prescribed in the pull plan.

Step 3: Locate the cable reels at the appropriate points of the route.

Step 4: Remove reel lagging and retrieve the cable data sheets (if present) from each reel for your company's as-built records.

Step 5: Inspect the reels and equipment on which they are mounted for any bolts, nails or other protrusions that could damage the cable as it is paid off.

Step 6: Ensure that the reel trailer or jack stands are stable, and that the reel may turn freely without binding. The reel must be level to allow proper pay off of cable.

NOTE: *Jack stands can be unstable if not set up properly. Consult your company's practices if jack stands are going to be used in your installation.*

5.3 Cable Preparation

Step 1: Align the reel at the feed hole so that the cable can be routed from the top of the reel into the duct bank in as straight a path as possible. Refer to Applications Engineering Note 165 Cable Handling: Squirting, Tangling, and Storage for proper storage methods and what to do prior to installation.

Step 2: If not previously installed, attach the pulling grip to the cable, and attach the grip to a swivel. The swivel should be securely fastened to the pull-line. See the pull-line manufacturer's recommendations for appropriate knots.

Step 3: A warning marker (colored tape or similar material) may be attached to the pull-line several feet in front of the pulling grip to alert observers at manholes that the cable is approaching.

Step 4: Apply cable lubricant as required.

Step 5: Verify that communication lines are functional and crews are in place at feed, pull, and intermediate manholes.

5.4 Cable Installation

Step 1: Start the pull at a slow speed, passing the pull-line and cable over and around the capstans, sheaves, and other devices required to maintain the minimum bend radius. Begin tension monitoring with a calibrated device as soon as tension is applied to the cable. If necessary, aid the cable feed by turning the reel by hand. Ensure that the cable is fed only as fast as the pull-line is moving. Back tension on the reel will prevent too much cable being fed off.

Step 2: Once the cable has moved a minimum of 5 ft (1.3 m) into the innerduct, accelerate the pull smoothly to its intended speed [50-100 ft (15.2-30.4 m) per minute is desirable].

Step 3: Continue the pull at a steady rate. If it is necessary to stop the pull at any point, the winch operator should stop the pull, but NOT release the tension unless instructed to do so. Pulls can be easily resumed if tension is maintained on the pull-line and cable.

Step 4: The cable should be visually observed during the following situations:

a. When it passes through any intermediate manhole in which innerduct continuity is broken.

b. Where use of a radius-maintaining device is required due to a bend or offset of entrance and exit ducts.

c. At intermediate-assist winches.

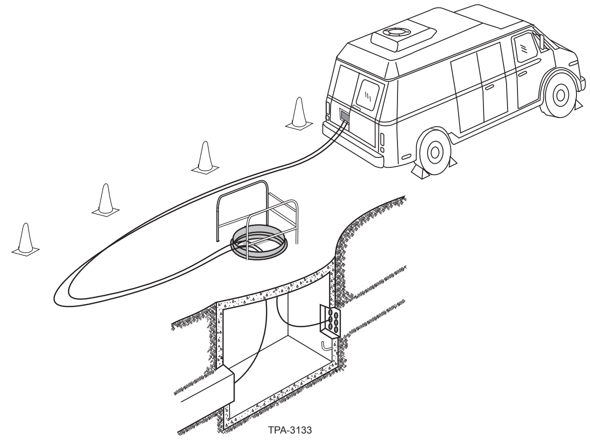
Step 5: Ensure that the bend radius is maintained, and that the cable is properly routed through the sheaves, capstans, bending shoes, etc. Stop the pull if the cable is misrouted, and correct the problem before resuming. If the innerduct is being pulled along with the cable, stop the pull and secure the innerduct with temporary cable ties.

Step 6: When the cable end reaches a backfeed point or splice point manhole, pull the cable out of the hole using a setup similar to that at the feed hole to maintain bend radius.

Step 7: After passing around the winch, the cable slack should be figure-eighted in an area where it will not be subject to damage by personnel or traffic. Follow the procedure in Step 9 for flipping the figure-eight so that the pulling grip end of the cable will be on top before the pull is resumed.

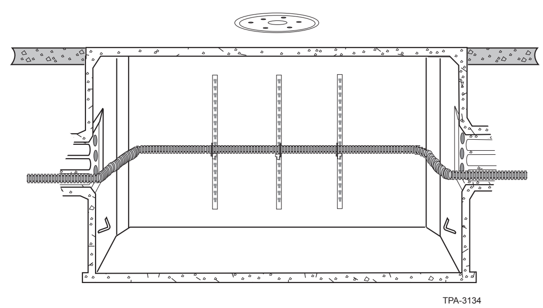
NOTE: *Pulls which have a large number of intermediate manholes will require a large quantity of cable slack. This slack must be pulled from the two end points and backfed to provide racking slack.*

Step 8: At splice points, pull sufficient slack (typically 40 ft [10 m] of slack from the lip of the manhole) to reach the intended splicing location, plus enough slack to permit closure preparation and splicing.



Step 9: Verify and record the distance markings printed on the cable for as-built documentation.

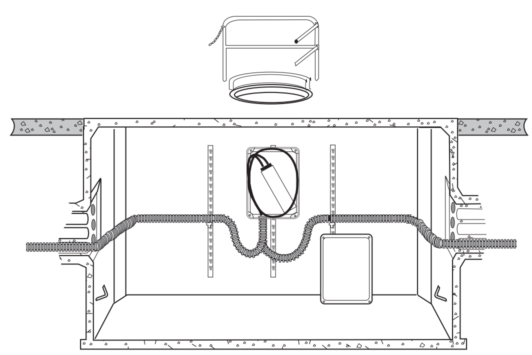
Step 10: Once the cable is pulled into place and appropriate slack is available at splice or termination points, begin securing all the innerduct to cable racks on the manhole walls. Begin racking at the center manhole and proceed to the end manholes. Maintain the cable's specific minimum bend radius.



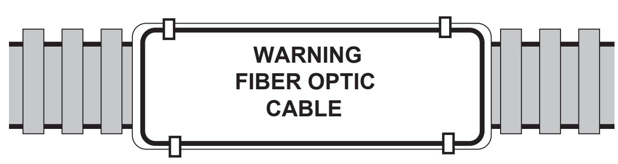
Step 11: At points where the innerduct is continuous through the manhole, push the innerduct and cable to the rack and secure with appropriate cable ties. Maintain the cable's minimum bend radius.

Step 12: If the innerduct is not continuous, rack the split duct, or the larger outside diameter section of innerduct before the pull.

Step 13: Store coiled splicing slack in the splicing manholes so that it is not likely to be damaged during later work in the manhole. If possible, store the slack in an enclosure designed to store splicing slack and a splice closure. Place an end cap on any bare cable ends to prevent moisture or dirt intrusion.



Step 14: Fiber optic warning signs should be placed on all innerduct containing fiber optic cable. Warning signs can help prevent damage resulting from the cable being mistaken for something else.



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