Fiber Optic Cable Placing – Duct

1. General

1.1 This procedure provides general information for installing Corning Cable Systems fiber optic cable in underground plant. These methods and instructions are intended only as guidelines, as each installation will be influenced by local conditions.

1.2 Methods used for placing underground fiber optic cable are essentially the same as those used for placing conventional copper cable.

1.3 Fiber optic cable is a high capacity transmission medium whose qualities and characteristics can be degraded when it is subjected to excessive pulling tension, sharp bends, and crushing forces (see 2.5, *Cable Handling Precautions*, for specifications).The number of splices in a fiber cable route should be controlled to minimize transmission loss and reduce splice labor costs. Corning Cable Systems can provide cable in continuous lengths up to 12 kilometers (7.5 miles).

1.4 This practice may contain references to specific tools and materials in order to demonstrate a particular method. Such references are in no way intended as a product endorsement.

1.5 This issue includes updated document references.

2. Safety Precautions

2.1 This section provides safety precautions which should be observed when working in manholes or underground vaults. These practices may change, or may not be suitable in a specific situation, and so are suggested guidelines only. Your company's safety precautions and practices take precedence over any conflicting recommendations given in this document.

2.2 Hazardous Gas Precautions

WARNING: *To reduce the chance of accidental injury, observe these hazardous gas precautions:*

- *Explosive gases or vapors may be present in manholes due to leaking of nearby pipes or storage tanks of liquids or gases such as propane, gasoline, natural gas, or liquified petroleum gas (LPG). In addition, explosive gases may be organically generated (i.e., methane).*
- *Never remove a manhole cover unless the area beneath it has been tested for explosive gas.*
- *Before entering any manhole, test the manhole atmosphere with an approved meter or test kit for explosive gases. Failure to do so may result in serious injury from an explosion created by the mixture of explosive gases and oxygen.*
- *To test the manhole atmosphere, follow the instructions supplied by your company for the gas detection device and observe all company rules concerning explosive limits of gases.*
- *In addition to combustible gases, life threatening hazards may be present in the form of non-combustible gases (i.e., nitrogen, hydrogen sulfide, and carbon dioxide).*

DO NOT USE ANY DEVICE WHICH CAN PRODUCE A SPARK OR FLAME IN A MANHOLE. *Do not use lanterns, heaters, or any electrically energized devices in manholes unless they are certified for explosive environments. Never connect or disconnect electric lighting, tools, or heating equipment in a manhole. Mating or unmating an electric circuit may cause an electric arc.*

⚠ : **WARNING:** DO NOT BRING OPEN FLAMES, TORCHES, LIGHTED CIGARS, PIPES, CIGARETTES, OR MATCHES INTO A MANHOLE. *Failure to follow this warning may result in a fire or explosion.*

Observe all company rules concerning ventilation purge time for manhole. As long as the manhole is open, continuous forced-draft ventilation at a MINIMUM rate of 500 cubic feet per minute should take place (Figure 1).

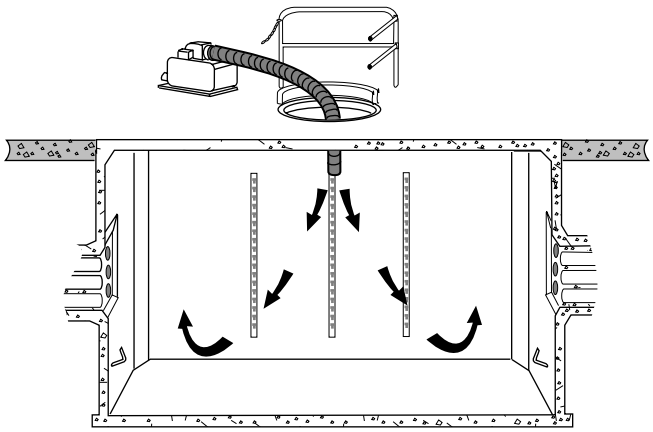

Figure 1 Manhole ventilation

2.3 General Safety Precautions

⚠ **WARNING:** *If trucks and other motorized equipment (generators, blowers, pumps, etc.) are not equipped with overhead exhausts, position such equipment so that the exhausts are directed away from the manhole opening and ventilation equipment.*

⚠ **WARNING:** *To minimize hazards to yourself and others in or near the work area, follow all company rules for setting up barricades, manhole guards, and warning signs. Any material in the vicinity of a manhole should be arranged so that it can not fall into a manhole, or unnecessarily impede pedestrian or vehicular traffic. Establish good communications between the pull, feed, and monitoring locations before starting any pull operation.*

⚠ **WARNING:***Employees normally should not enter a manhole or remain in a manhole during the placing or removing of any cable. If a craftsman must enter a manhole when an optical cable is being pulled, the craftsman should stay clear of the pulling apparatus.*

Before beginning any underground cable placing operation, all personnel must be familiar with their company's safety practices. Failure to do so may result in serious injury.

⚠ **WARNING:** *To reduce the chance of accidental injury:*

- *Inspect all manhole ladders for defects before using. Repair or replace ladders if they are found in a deteriorated or unsafe condition.*
- *Always use a ladder when entering or leaving manholes. Keep hands free of tools or materials when descending or ascending a ladder. Do not step on cables, cable enclosures, or equipment when entering or leaving manholes.*
- *Inspect pulling irons before use for significant corrosion. Make sure that the irons are securely anchored in the walls.*
- *If a cable lubricant is going to be used in the pull operation, make provisions for cleaning up any spilled lubricant to prevent slipping and possible injury.*
- *Observe standard safety precautions. Wear safety headgear, eye protection, gloves, etc. as specified in your company's practices.*

2.4 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.*

2.5 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.*

2.6 Corning Cable Systems 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 2,700 Newtons (600 lbf.).

2.7 Corning Cable Systems cable specification sheets also list the minimum cable bend radius both "Loaded" (during installation) and "Installed" (after installation). If these sheets are not available on the job-site, the following formulas may be used to determine general guidelines for installing Corning Cable Systems fiber optic cable:

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

Example

Cable Diameter = 11.8 mm (0.46 in)
15 x 11.8 mm =177 mm (6.9 in)
Minimum Working Bend Radius =17.7 cm (6.9 in)

To find the minimum diameter requirement for pull wheels or rollers, simply double the minimum working bend radius (Figure 2):

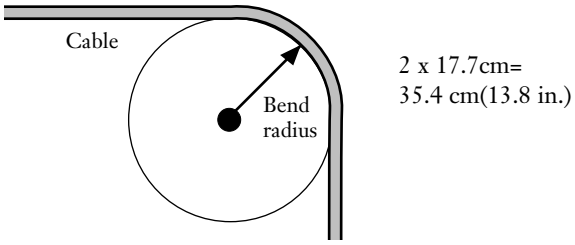

Figure 2 Bend radius

2.8 Before the installation begins, carefully inspect the cable reels for imperfections, such as nails and broken flanges, which might cause damage to the cable as it is unreeled.

2.9 Protect reeled cable from vandals or other sources of possible damage while unattended. The sections of cable intended for duct installation are produced to meet specific length requirements. Any damage to the cable sections may require replacement of the entire section.

2.10 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.

2.11 The "figure-eight" configuration should be used to prevent kinking or twisting when the cable must be unreeled or backfed (see Figure 13).

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

Traffic cones spaced 7-8 feet apart are useful as guides during "figure-eighting." When "figure-eighting"' 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."

WARNING: *It has been experimentally determined that the use of "figure-eight" machines will damage Corning Cable Systems SST cable designs. The use of this equipment on these cables is not recommended. Other similar cable designs may also be affected. Before using such a machine, contact the machine manufacturer for their recommendation on the suitability of their machine to the cable design being installed.*

2.12 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.*

2.13 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 Cable Systems 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 one meter of each cable end before splicing. This will ensure that no moisture ingress is present.*

3. Planning and Preparation

3.1 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.

3.2 Rodding or slugging may be required to verify duct suitability and accurate length (Figure 3). Cable cut length is especially critical when installing factory-connectorized cables.

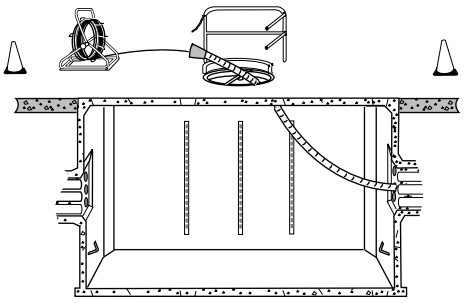

Figure 3 Rodding

3.3 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.

3.4 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.

3.5 Based upon the cable route survey and the equipment/manpower resources available, develop a cable pull plan (Figure 4).

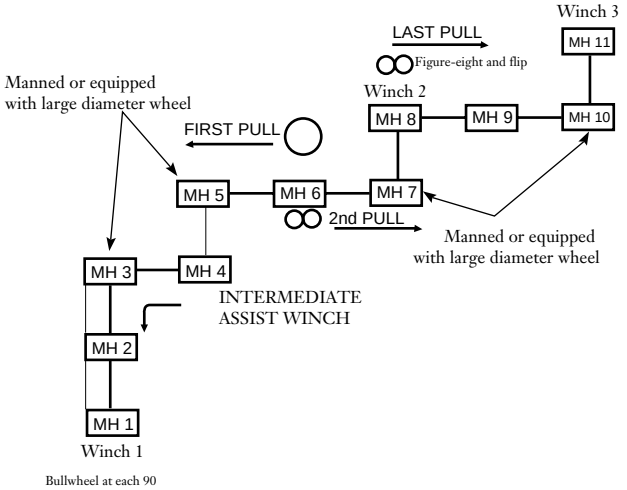

Figure 4 Cable pull plan

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

3.6 Factors to consider in developing the pull plan include changes in elevation and the locations of bends and offsets (Figure 5).

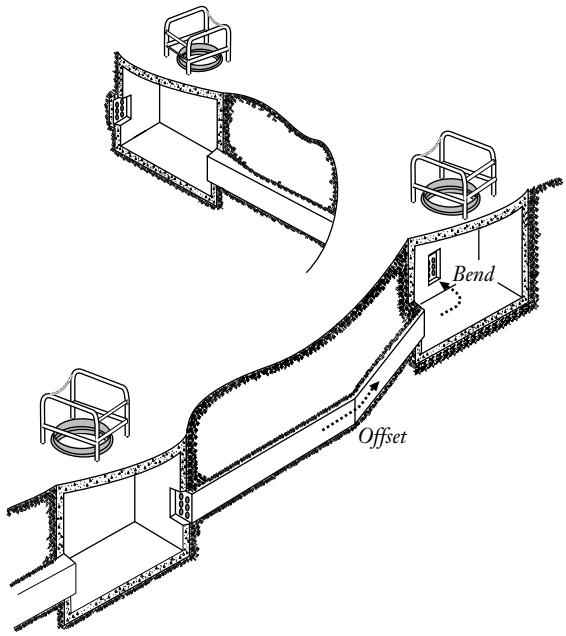

Figure 5 Offset and bend

- 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 pounds 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.

4. Installation Equipment and Accessories

Innerduct

4.1 Innerduct is semi-rigid plastic tubing commonly used in fiber optic installations to subdivide the duct and to provide for future cable pulls. Three 1.25 inch 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.

4.2 Innerduct is available in ribbed, corrugated, and smooth-walled constructions of polyethylene or PVC material (Figure 6). Corning Cable Systems fiber optic cable is compatible with all major brands of innerduct. Consult your company's practices for innerduct specifications.

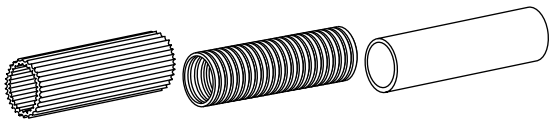

Figure 6 Ribbed, corrugated, and smooth-walled innerduct

4.3 When placing one fiber optic cable in an innerduct, Corning Cable Systems recommends the use a "fill ratio" that should generally not exceed 65%. For multi-cable installations, Corning Cable Systems recommends fill ratios in accordance with TIA/EIA 569-A, i.e., a fill ratio ≤ 0.31 for two-cable installations and < 0.40 for an installation with three or more cables.

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.

4.4 Fill ratios are calculated as follows:

a) Calculate the cross-sectional area of the cable using the formula Area= 3.14 x radius^2.

b) Calculate the cross-sectional area of the interior of the innerduct using the same formula.

c) Determine the fill ratio by dividing the cable's cross-sectional area by the interior cross-sectional area of the inner duct. If this ratio is less than or equal to 0.65 or 65%, then the cable and duct combination meets the Corning Cable Systems recommendation for fill ratio.

d) Example:
An 864-fiber single tube ribbon cable has a nominal outer diameter or 0.94 in. and is being placed in an innerduct with an inner diameter of 1.25 in. What is the fill ratio?

The cross-sectional area of this cable is the following:

Area= 3.14 x $(0.94\div2)^2$=0.69 square inches

The cross-sectional area of the interior of the inner duct is the following:

Area= 3.14 x $(1.25\div2)^2$=1.23 square inches

The fill ratio is 0.69÷1.23= 0.56 or 56%, which is under the recommended limit of 65%.

e) Using the 65% fill ration, fiber optic cables with an outer diameter of 0.80 inches or less can be pulled into a 1 inch I.D. innerduct; cables with an outer diameter of 1.0 inches or less can be pulled into a 1.25 inch I.D. innerduct; cables with an outer diameter of 1.21 inches or less can be pulled into a 1.5 inch I.D. innerduct.

4.5 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.

4.6 During innerduct placement, care must be taken to avoid excessive tension and deformation of the innerduct. Excessive pull force may cause smooth-walled and longitudinally-ribbed innerduct to "neck down," reducing its inside diameter.

4.7 Corrugated innerduct may grow larger in diameter after excessive pulling forces are used. In either case, the damaged innerduct should be replaced. Carefully follow the innerduct manufacturer's instructions and monitor pulling tensions during installation.

4.8 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.

4.9 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.

4.10 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.

4.11 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

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 3 meters (9 ft) on each end which will be inside the duct bank after racking.

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

Pull-Line

4.13 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.

4.14 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.

4.15 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.

Lubricants

4.16 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.

4.17 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.

4.18 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 (Figure 7), others suggest distributing lubricant throughout the innerduct by pulling a swab through the innerduct as part of the pull-line placement (Figure 8). Pumps or gravity feed devices can also be used to inject lubricant into the innerduct.

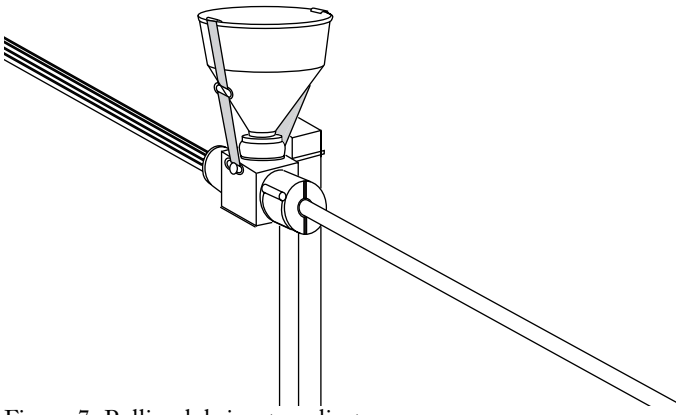

Figure 7 Pulling lubricant applicator

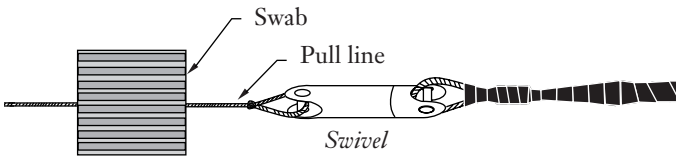

Figure 8 Pulling lubricant swab

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

Pulling Grips

4.20 Corning Cable Systems recommends the use of a GRP series (Kellems® grip) wire mesh pulling grip or a factory-installed Poulin® 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 (Figure 9).

Wire mesh pulling grip

Factory-installed Poulin grip

Figure 9 Pulling grips

4.21 Wire mesh pulling grips may be either factory or field-installed on Corning Cable Systems cable. For instructions on field installation, refer to SRP-005-040, *Installing a Wire Mesh Pulling Grip on ALTOS® Ribbon Fiber Optic Cable* or SRP-005-044, *Installing a Wire Mesh Pulling Grip on SST, SST-Ribbon™, SST-UltraRibbon™, ALTOS®,* and ALTOS® *Riser Fiber Optic Cable*s.

4.23 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 (see Figure 8). A swivel that contains ball-bearings such as the Corning Cable Systems GRP-005 pulling swivel, is recommended to prevent binding at high tensions.

Tension-Monitoring Equipment

4.24 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.

4.25 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.

4.26 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.

4.27 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 (Figure 10).

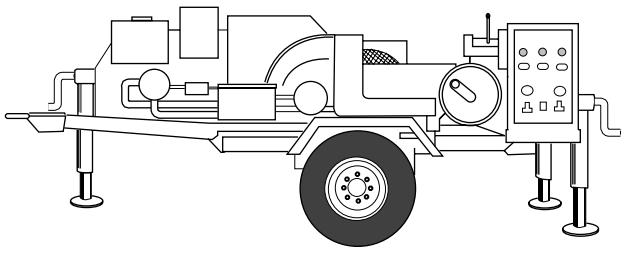

Figure 10 Winch

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

Pulling Equipment

4.28 All pulling equipment and hardware which will contact the cable during installation must maintain the cable's minimum bend radius. For Corning Cable Systems cable, see Section 2.7. Such equipment includes sheaves, capstans, bending shoes, and quadrant blocks designed for use with fiber optic cable.

4.29 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.

5. Installation Techniques

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

5.2 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 913 m (3000 ft)] with two or fewer 90° bends may be pulled without an intermediate-assist winch or hand assistance.

Intermediate Assist Winches

5.3 Longer continuous pulls can be accomplished by hand assisting the cable or by setting up intermediate-assist winches at bends and at cable access points (Figure 11). Depending upon the type of winch and/or procedure used, the cable may or may not emerge from the manhole at intermediate-assist points.

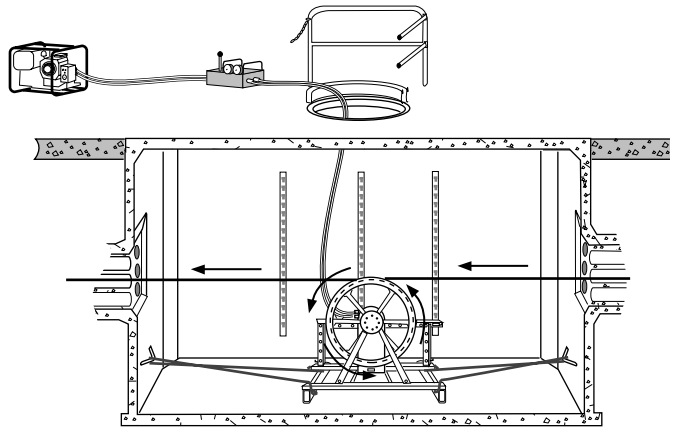

Figure 11 Intermediate assist winch

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

Center-Pulls and Backfeeding

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

5.6 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 (Figure 12).

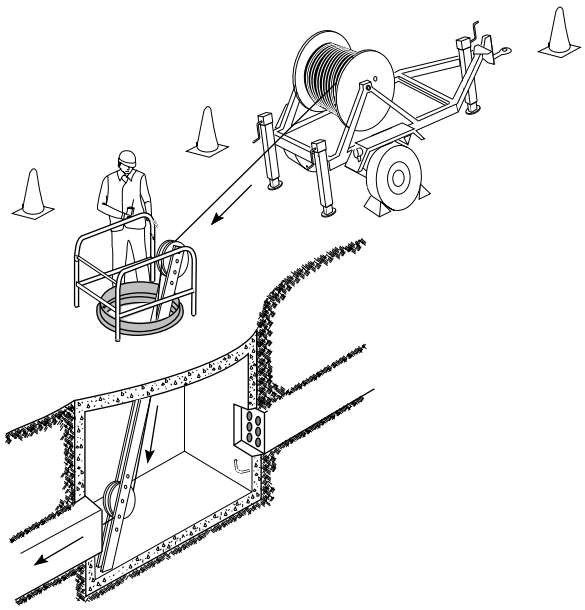

Figure 12 First step of center-pull operation

5.7 Unreel the remaining cable in a "figure-eight" configuration (Figure 13).

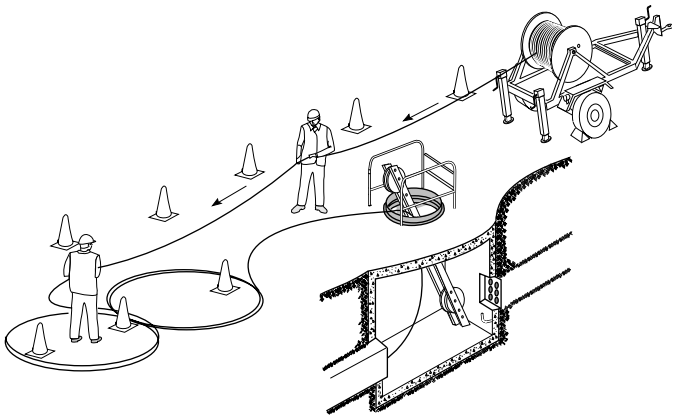

Figure 13 Unreeling cable

5.8 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" is normally required (Figure 14).

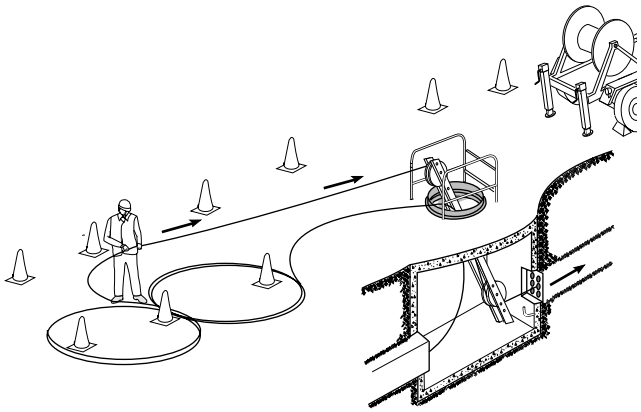

Figure 14 Completion of center pull operation

Backfeeding

5.9 "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 "figure-eighted" as it emerges from the manhole (Figure 15).

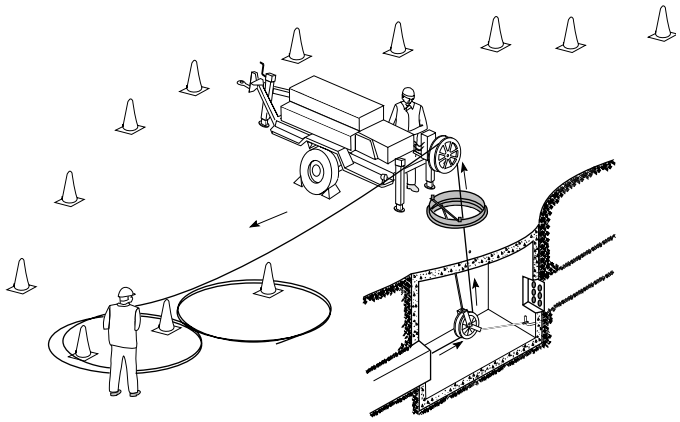

Figure 15 Pulling out cable for backfeed

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

5.11 After the pulling eye is connected to the next section of the pulling line, feed the cable by hand back into the manhole and pull it to its next destination (Figure 16). 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.

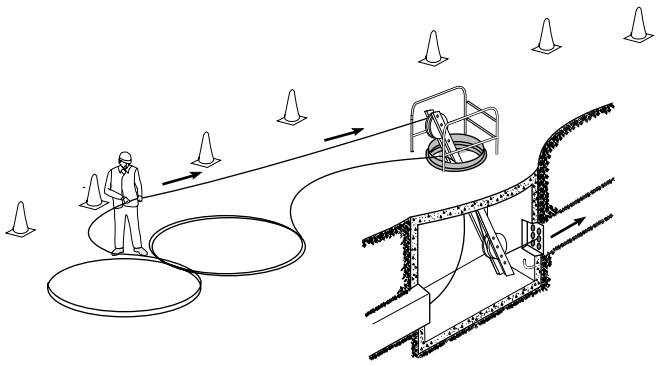

Figure 16 Completion of Backfeeding

⚠ **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.*

6. Installation Procedure

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

6.2 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

6.3 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.

Relocate existing utilities if necessary.

6.4 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.

6.5 Locate the cable reels at the appropriate points of the route.

6.6 Remove reel lagging and retrieve the cable data sheets from each reel for your company's as-built records.

6.7 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.

6.8 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.

6.9 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. Use bending shoes, sheaves, secured sections of innerduct, or other devices to control cable feed into the duct bank.

6.10 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.

6.11 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.

6.12 Apply cable lubricant as required.

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

6.14 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.

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

6.16 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.

6.17 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

6.18 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.

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

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 5.10 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.*

6.20 At splice points, pull sufficient slack (typically 10 m /40 ft of slack from the lip of the manhole) to reach the intended splicing location, plus enough slack to permit closure preparation and splicing (Figure 17).

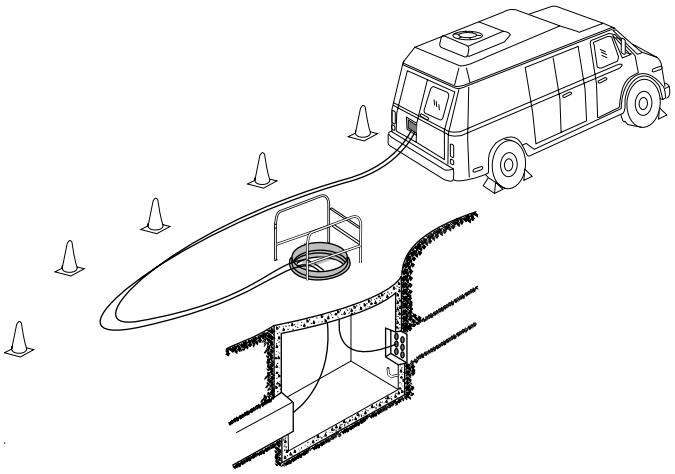

Figure 17 Splicing setup

6.21 Verify and record the distance markings printed on the cable for as-built documentation.

6.22 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.

6.23 At points where the innerduct is continuous through the manhole, push the innerduct and cable to the rack and secure with appropriate cable ties (Figure 18). Maintain the cable's minimum bend radius.

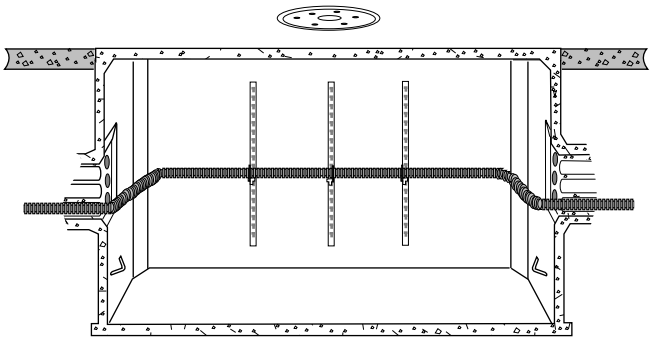

Figure 18 Racking of continuous innerduct

6.24 If the innerduct is not continuous, rack the split duct, or the larger O.D. section of innerduct before the pull.

6.25 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 (Figure 19). Place an end cap on any bare cable ends to prevent moisture intrusion.

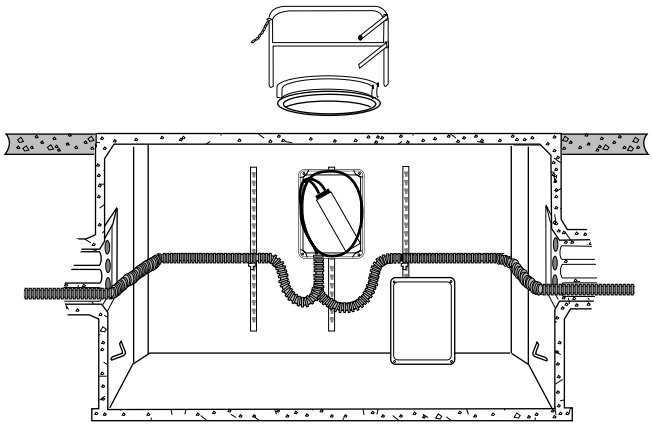

Figure 19 Slack storage in an enclosure

6.26 Fiber optic warning signs should be placed on all innerduct containing fiber optic cable (Figure 20). Warning signs can help prevent damage resulting from the cable being mistaken for something else.

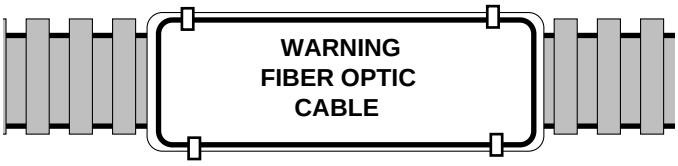

Figure 20 Warning sign on innerduct

Special Note: Fiber Optic Training Program

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