Installation Guideline for Placing Fiber Optic Cable into an Underground Duct

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A. Purpose

A.1 This procedure applies to the installation of Superior Essex fiber optic cable into an underground duct system using either a pulling method or an air blowing method. The objectives of this guideline are:

- Provide to the cable installer a general guideline for installing fiber optic cable in an outside plant underground duct facility. (It is not the intent of this procedure to cover all possible installation scenarios or conditions. Special circumstances or questions can be addressed by contacting Superior Essex Applications Engineering.)
- Prevent damage to the fiber optic cable during the set up, handling, and installation.

A.2 It is intended that this guideline be used in conjunction with procedures that describe the detailed operation of handling equipment. Equipment procedures are provided by the equipment suppliers.

B. Introduction

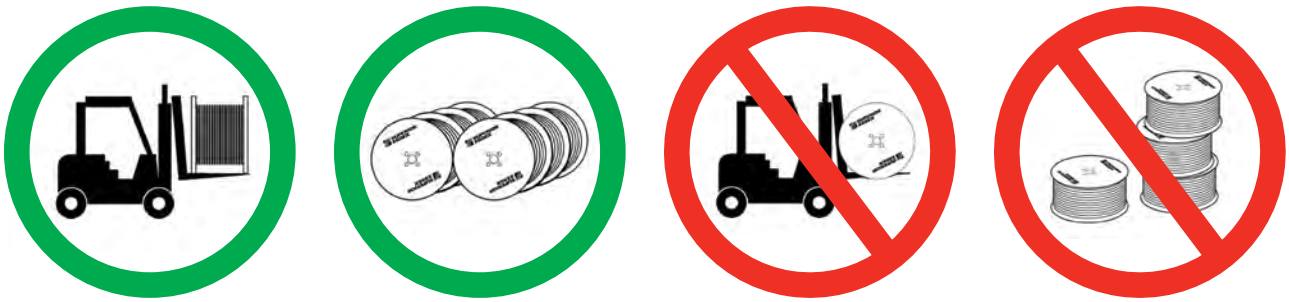
B.1 The practice of handling fiber optic cables has become much more common in recent years. Fiber optic cables are designed to withstand all typical installation and environmental stresses expected in the specific application.

B.2 Fiber optic cables can be damaged if not handled properly during the installation process. In fact, the cable installation process is the most aggressive event the cable will most likely ever be exposed to. Adherence to the cable's design limits of **pull tension, minimum bend, and crush force** during installation will ensure that the cable will perform properly throughout its full design lifetime. The greatest mistake when handling fiber optic cable is assuming that all outside plant (OSP) handling equipment is suitable for use—it is not. If in doubt prior to, or during, any fiber cable installation, contact **Superior Essex Technical Support by calling 1-877-263-2818.**

C. General Precautions

C.1 The following precautions always apply when handing fiber optic cable.

- DO NOT exceed the cable's stated **maximum pulling tension**.
- DO NOT exceed the cable's stated **minimum bending radius**.
- DO NOT exceed the cable's **maximum crush load**.
- DO NOT use detergent or petroleum based compounds as a cable lubricant.
- NEVER set a cable reel on a flange side (to prevent cable crossings during payoff).



- DO use cable lubricants that are tested and compatible with the cable jacket material.
- DO adhere to local personnel safety practices.
- DO review and follow equipment safety practices.
- ALWAYS apply caps over free cable ends to prevent water intrusion.

NOTE: Always check specific product data sheet for cable design limitations. Cables are designed based on applications. Typical Bellcore GR-20 cable designs are to the following:

Maximum Pulling Tension	600 lbs		2700 N
Maximum Long Term Tension	200 lbs		890 N
Minimum Bend Radius, under tension		20 x O.D.	
Minimum Bend Radius, zero tension		10 x O.D.	
Maximum Crush Load, for one minute	125 lbs/in		220 N/cm
Maximum Crush Load, for ten minutes	63 lbs/in		110 N/cm

C.2 Additional general safety precautions exist when working in areas of traffic congestion and in manholes.

- Proper safety cones and traffic control devices should always be used. The project manager should coordinate his work with local traffic officials. Safety zones utilizing traffic signs and cones should be placed at all working locations.
- The atmosphere of all manholes and unventilated vaults should be tested for combustible or flammable gas. Where combustible or flammable gas is detected, the work area should be ventilated and made safe before entry.
- Unless forced continuous ventilation is provided, a test should also be made for oxygen deficiency. Provisions should be made for an adequate continuous supply of air in manholes and unventilated vaults. Position gasoline and propane generators, etc., and trucks not equipped with overhead exhaust so the exhaust fumes will not blow into the manhole.
- Existing electrical cables in manholes or vaults should be inspected for exposed conductors that could cause electrical shock.

D. Reference Documents

- **D.1** Bellcore GR-20-CORE, *(General Requirements for Optical Fiber and Fiber Cable)*
- **D.2** USDA Rural Utilities Service Bulletin 1753F-601 (PE-90), *(Specification for Filled Fiber Optic Cables)*
- **D.3** USDA Rural Utilities Service Bulletin 1751F-644, *(Underground Plant Construction)*
- **D.4** USDA Rural Utilities Service Bulletin 1753F-401 (PC-2), *(RUS Standard for Splicing Copper and Fiber Optic Cables)*

E. Fiber Optic Cable Installation into a Duct using a Pulling Method

E.1 Limitations

E.1.1 Fiber optic cables must be handled in compliance with their stated design ratings to prevent short or long-term damage to the optical fibers. Handling crews must be familiar with the cable's design ratings and the critical events during installation where design limits may be approached. Review this entire procedure with operating crew prior to installation day.

E.2 Construction Planning

E.2.1 A site survey of the complete underground duct system, prior to installation, is recommended. Each manhole should be inspected for safety hazards and water accumulation. Pumps may be required to remove water.

E.2.2 It is recommended that all ducts be checked for obstructions or out of round duct. This can be accomplished by rodding the duct or by pulling a mandrel through the duct.

E.2.3 Manholes should be checked for adequate racking space for slack cable and splice closure storage. Also check manholes for adequate vehicle accessibility.

E.2.4 A pull plan can be developed from the information obtained during the site survey. Reel set up, assist winch, and "figure eight" locations should be determined based on the number of bends and elevation changes in the system. Engineering predictions can be made to estimate the achievable pulling lengths. Pulling length predictions are based on route complexity, use of lubricant, cable weight, and tensile strength of the cable. Software programs exist that aid in predicting pulling lengths.

E.2.5 In general, the following guides apply to improve ease of the pulling operation:

- Pull in a direction so that most bends and offsets are nearest payoff reel.
- Pull from higher to lower elevations.
- Where possible, set up payoff reel on same side of manhole as the duct so that the cable makes a "C" shaped curve from the reel to the duct entry.

E.3 Equipment and Materials

E.3.1 Ribbed or corrugated inner-duct provides lower friction coefficients between the fiber optic cable and the duct wall, thus enabling longer pulls. If inner-duct is to be placed in the underground ducts beforehand, consult the manufacturer's installation guidelines and specifications. As a rule of thumb, the fiber cable should not occupy more than 60% of the available area within the inner-duct. This provides sufficient room within the duct for cable installation.

E.3.2 Cable pulling lubricants are recommended for fiber optic cable installation to decrease pulling tension. Lubricants must be compatible with the fiber optic cable to prevent long-term degradation of the cable jacket. Silicon or water based lubricants are generally acceptable. Lubricants can also be applied at intermediate locations such as open manholes.

E.3.3 Pulling grips are required and must be sized for the cable diameter. Pulling grips for fiber optic cable are made of galvanized steel strand. Choose a multi-weave mesh for holding strength. A flexible eye provides easy attachment of a swivel and pull line.

E.3.4 A swivel is required to prevent the pulling line from passing any torsion or twist into the fiber cable during the pulling process. A breakaway swivel is recommended for all pulls unless the pulling equipment has a tension set limiting feature. The breakaway swivel is designed with a breakaway pin that prevents pulling tension from reaching levels that could damage the cable. Swivels are rated at different breaking loads. Check cable design limitations to select the properly rated breakaway swivel.

E.3.5 A low elasticity pull line, such as an aramid yarn or wire rope, is recommended to minimize elastic induced surges during the pulling process. Lubrication of the pull line may be desired for ease of pulling or to reduce any tendency of the pulling line to cut the inner-duct.

E.3.6 A pulling winch, or equivalent pulling device, with a calibrated maximum tension should be used. A dynamometer can be used to monitor tension of the pull line near the winch. Tension monitoring should be at or near the pulling eye and available to the winch operator during the pulling process. If available, record pulling tension to a strip chart throughout the run and save in system files.

E.3.7 Any hardware (sheaves, capstans, quadrant blocks) used in the installation of fiber optic cables must maintain the cable's minimum bend radius. The minimum bend radius during installation (dynamic) is 20 times the cable's outer diameter. The minimum bend radius during zero tension (static) cable handling is 10 times the cable's outer diameter.

E.3.8 Radio communication must be established between the cable reel, the pulling device, and all intermediate locations during the installation. This link can be provided by two-way radios and is maintained to ensure safe conditions for the fiber cable exist throughout the installation.

E.3.9 Intermediate assist winches can be used at bends or locations where the pulling tension is approaching maximum load. The use of multiple assist winches at various locations can expedite the installation. Communication between these locations is very important to coordinate winch speeds and cable movement.

E.4 Initial Conditions for Cable Pulling Method

E.4.1 Prior to commencing a cable installation event, the following actions must be accomplished:

- Duct system prints are obtained and thoroughly reviewed.
- Job area survey is complete.
- Pulling Plan and equipment set up locations are defined.
- Limitations of cable are reviewed with the handling crew.
- Installation equipment is reviewed for adequacy.
- The event is reviewed and briefed, at least one day prior, with install crew.
- All required equipment is on site day of installation event.
- Inner-duct (if used) is in place.

E.5 Duct Installation Procedure

E.5.1 Prior to installation, all traffic safety zones, barricades, and flagmen must be in place. Observe all local safety ordinances and practices.

E.5.2 All manholes in the system must be checked for harmful gases and ventilation established. Water should be pumped and any obstacles cleared. Inspect manholes for general safety conditions such as ladders, existing cables, and rack conditions.

E.5.3 If used, all inner-duct is in place. Tie down exposed inner-duct in any manholes to prevent dragging during the pulling event.

E.5.4 Set up winches, monitoring devices, lubricant equipment, and routing sheaves per the pull plan. Establish communication between reel and winch, and all intermediate locations.

E.5.5 Visually inspect each cable reel for physical damage. Ensure the cable reel inner flanges are smooth and without nails to allow free payoff of the cable. Set up the reel and reel trailer at the predetermined manhole location per the pull plan. Pay off the cable from the top of the reel. Align the reel so that the cable makes a smooth transition into the manhole and the duct system. Use sheaves or other devices to control the cable feed into the manhole and inner-duct.

E.5.6 Attach the pulling grip to the cable, if not factory installed, and attach the breakaway swivel to the pulling grip's flexible eye to prevent the cable from twisting during the pull.

Attaching the Pulling Grip

E.5.6.1 Apply the correct sized pulling grip over the cable end and mark the gripping length of the grip onto the cable. Continue to push the grip down on the cable to expose the full gripping length.

E.5.6.2 Remove the cable jacket from the outside half of the gripping length being careful not to score or damage the strength yarns over the cable core. Tightly wrap a layer of friction tape around the unjacketed portion of the cable.

NOTE: Do not use vinyl tape under the pulling grip due to its slick surface finish.

E.5.6.3 Slide the pulling grip back up over the cable end so that the cable core extends about ¼" to ½" (6 to 13 mm) beyond the grip mesh. Under the wire mesh should be about half jacketed cable and half friction tape. Tighten the grip onto the cable.

E.5.6.4 Tightly wrap over the grip with a vinyl tape. Begin the tape wrap about 1" (25 mm) below the mesh (on the cable jacket) and wrap towards the pulling eye to about 1" (25 mm) above the mesh.

E.5.6.5 Attach swivel to pulling grip eye.

E.5.7 Attach the swivel to the pull line. Place marker tape 10 to 20 feet (3 to 6 meters) ahead on the pull line to serve as an indicator that the cable end is near.

E.5.8 Apply a cable lubricant as needed.

E.5.9 Check communication between the reel, pulling device, and all intermediate locations as appropriate.

E.5.10 Begin the pull slowly, feeding the cable into the duct. Pull the optical fiber cable as steadily as possible ensuring cable is set properly on all rotating sheaves and winches to prevent exceeding minimum bend radius. Apply lubricant, as necessary, at the feed end by pouring the lubricant into the cable feed funnel. Follow the manufacturer's instructions.

E.5.11 Pulling tension should be monitored constantly. If available, record pulling tension to a strip chart throughout the installation. A soft or hard copy of the pulling tension throughout the run should be saved in the system files. Do not exceed the cable's maximum rated pulling tension.

E.5.12 Gradually increase the pulling speed to the target range of 50–100 feet/minute (15–30 meters/minute).

E.5.13 As the cable reaches the intermediate locations, make sure it is routed properly around any assist winches or sheaves. Ensure no sharp bends exist that are less than the cable's minimum bend radius. Apply lubricant as required.

E.5.14 Stop the pull, and correct, if any of the following occur:

- Cable rated tension is reached
- Cable not positioned properly on any routing sheave or winch
- Inner-duct begins to move with the cable

E.5.15 When the cable reaches the end point, stop the pull and make adjustments at all the intermediate manholes for slack storage. At cable ends and intermediate splice point locations, be sure to leave enough cable slack to easily reach an above-ground splicing vehicle plus 30 feet (9 meters) minimum.

E.5.16 Slack coils may be assembled in a continuous direction loop configuration or a "figure eight". "Figure eight" configuration is best to minimize torsion and stress build up in the cable fibers over long lengths.

- Continuous direction coiling should only be used for lengths less than 100 feet (30 meters). Do not exceed minimum bend radius of cable.
- "Figure eight" coil sizing should be approximately 15 feet (5 meters) end to end with each half loop about 5–8 feet (1.5–2.5 meters) in diameter.

Slack coils should be secured in a location to prevent damage. Fix the coils securely in place with suitable cable ties.

E.5.17 After the pull is complete, cut 10 feet (3 meters) from the end of the cable. Place a protective cap over the exposed cable end and tape it in place to prevent water intrusion. Coil each cable free end and fix it in place securely with cable ties to prevent damage.

E.5.18 At all appropriate manhole locations, rack inner-duct in place. Begin from the center manhole and work towards the system ends. It is preferred that all exposed cable coils be mounted in a rack mounted closure box designed for holding the cable coil and the fiber splice closure.

F. Fiber Optic Cable Installation into a Duct using an Air Blowing Method

F.1 Limitations

F.1.1 Fiber optic cables must be handled in compliance with their stated design ratings to prevent short or long-term damage to the optical fibers. Handling crews must be familiar with the cable's design ratings and the critical events during installation where design limits may be approached. Review this entire procedure with operating crew prior to installation day.

F.1.2 Air blowing of fiber cable into duct systems makes use of special air blowing equipment. This section is intended to be a general guideline to be used in conjunction with detailed procedures for the equipment being used.

F.1.3 Air blowing of fiber cable into duct systems requires continuous runs of inner-duct, pressure tested for integrity. Quality of inner-duct joints is critical to the success of air blowing techniques.

F.2 Construction Planning

F.2.1 A site survey of the complete underground duct system, prior to installation, is recommended. Each manhole should be inspected for safety hazards and water accumulation. Pumps may be required to remove water.

F.2.2 It is recommended that all ducts be checked for obstructions or out of round duct. This can be accomplished by rodding the duct or by pulling a mandrel through the duct.

F.2.3 Manholes should be checked for adequate racking space for slack cable and splice closure storage. Also check manholes for adequate equipment vehicle accessibility.

F.2.4 An installation plan can be developed from the information obtained during the site survey. Cable blower set up, mid-assist blowers, and "figure eight" locations should be determined based on the number of bends and elevation changes in the system. In general, the following guides apply:

- Blow cable from higher to lower elevations.
- Where possible, set up payoff reel on same side of manhole as the duct so that the cable makes a "C" shaped curve from the reel to the duct entry.

F.3 Equipment and Materials

F.3.1 Ribbed or corrugated inner-duct provides lower friction coefficients between the fiber optic cable and the duct wall, thus enabling longer blowing lengths. Inner-duct is required for use of a cable blowing system. The installation system uses a combination of high-pressure air and hydraulics to move the cable into the duct. The inner-duct system will be pressure tested during the procedure setup. As a rule of thumb, the fiber cable should not occupy more than 60% of the available area within the duct. This provides sufficient room within the duct for cable installation.

F.3.2 Cable pulling lubricants are required for when blowing fiber optic cable into a duct system. The lubricants must be compatible with the fiber optic cable to prevent long-term degradation of the cable jacket. Silicon or water based lubricants are generally acceptable.

F.3.3 Pulling grips are required and must be sized for the cable diameter. Pulling grips for fiber optic cable are made of galvanized steel strand. They feature a multi-weave mesh for holding strength. A flexible eye provides easy attachment of a swivel and air carrier unit.

F.3.4 A swivel is required to prevent the air carrier unit from passing any torsion or twist into the fiber cable during the pulling process. The air carrier unit is a part of the blower unit system and serves to carry the cable through the duct system via compressed air.

F.3.5 The cable blower equipment is typically purchased as a system. It consists of the blower unit and accessories, mount stand or trailer, source of hydraulics, source of high-pressure air, and electrical power. The cable blower system will include detailed use and procedural instructions.

F.3.6 Any hardware (sheaves, capstans, quadrant blocks) used in the installation of fiber optic cables must maintain the cable's minimum bend radius. The minimum bend radius during installation is 20 times the cable's outer diameter.

F.3.7 Radio communication must be established between the cable blower unit and the receiving end, and any mid-assist unit locations, to coordinate cable travel. This link can be provided by two-way radios and is maintained to ensure safe conditions for the fiber cable and personnel exist throughout the installation.

F.3.8 Mid-assist blower units can be used to lengthen the amount of continuous cable blown into place. Communication between these locations is very important to coordinate cable travel.

F.4 Initial Conditions for Air Blowing Method

F.4.1 Prior to commencing a cable installation event, the following actions must be accomplished:

- Duct system prints are obtained and thoroughly reviewed.
- Job area survey is complete.
- Installation Plan and equipment set up locations are defined.
- Limitations of cable are reviewed with the handling crew.
- Blower equipment and procedures are reviewed for adequacy.
- The event is reviewed and briefed, at least one day prior, with install crew.
- All required equipment is on site day of installation event.
- Inner-duct is in place.

F.5 Duct Installation Procedure

F.5.1 Prior to installation, all traffic safety zones, barricades, and flagmen must be in place. Observe all local safety ordinances and practices.

F.5.2 All manholes in the system must be checked for harmful gases and ventilation established. Water should be pumped and any obstacles cleared. Inspect manholes for general safety conditions such as ladders, existing cables, and rack conditions.

F.5.3 Place blower unit(s), hydraulic and air supply equipment per the installation plan and equipment documentation. Establish communication between blower and receiving end, and all intermediate locations.

F.5.4 Visually inspect each cable reel for physical damage. Ensure the cable reel inner flanges are smooth and without nails to allow free payoff of the cable. Set up the reel and reel trailer at the predetermined manhole location per the install plan. Pay off the cable from the top of the reel. Align the reel so that the cable makes a smooth transition through the blower and into the duct system.

F.5.5 Attach the pulling grip to the cable (see Section E.5.6 above), if not factory installed, and attach the swivel to the pulling grip's flexible eye to prevent the cable from twisting during the evolution. The swivel will later attach to the air carrier unit.

(For steps F.5.6 through F.5.12, refer to detailed equipment procedures. Below steps are provided as general information only)

F.5.6 Unpack and set up blower unit(s) and accessory equipment per manufacturers' documentation. Ensure all safety guidelines are reviewed.

F.5.7 Pressure-test the inner-duct to verify integrity per blower manufacturer's documentation.

F.5.8 Prepare the inner-duct for receipt of cable per blower manufacturer's documentation.

F.5.9 Perform a final inspection of equipment and cable setup and check communication between the blower/reel, receiving end, and all intermediate locations as appropriate.

F.5.10 Operate the cable blower unit(s), per blower manufacturer's documentation, to install the cable into the duct system. Ensure cable's minimum bend radius and crush limits are not exceeded. Ensure blower tractor unit is not allowed to continue to operate when cable motion stops. Continued operation of tractor on a motionless cable my result in jacket damage.

F.5.11 As the cable reaches any intermediate locations, make sure it is routed properly. Ensure no sharp bends exist that are less than the cable's minimum bend radius. Apply lubricant as required.

F.5.12 When the cable reaches the end point, stop the blower and blower tractor per blower manufacturer's documentation. Break down blower units per manufacturer's documentation.

F.5.13 Make adjustments at all the intermediate manholes for slack storage. At cable ends and intermediate splice point locations, be sure to leave enough cable slack to easily reach an above-ground splicing vehicle plus 30 feet (9 meters) minimum.

F.5.14 Slack coils may be assembled in a continuous direction loop configuration or a "figure eight". "Figure eight" configuration is best to minimize torsion and stress build up in the cable fibers over long lengths.

- Continuous direction coiling should only be used for lengths less than 100 feet (30 meters). Do not exceed minimum bend radius of cable.
- "Figure eight" coil sizing should be approximately 15 feet (5 meters) end to end with each half loop about 5–8 feet (1.5–2.5 meters) in diameter.

Slack coils should be secured in a location to prevent damage. Fix the coils securely in place with suitable cable ties.

F.5.15 After the pull is complete, cut 10 feet (3 meters) from the end of the cable. Place a protective cap over the exposed cable end and tape it in place to prevent water intrusion. Coil any cable free ends and fix in place securely with cable ties to prevent damage.

F.5.16 At all appropriate manhole locations, rack inner-duct in place. Begin from the center manhole and work towards the system ends. It is preferred that all exposed cable coils be mounted in a rack mounted closure box designed for holding the cable coil and the fiber splice closure.

If you have any further questions or need additional information, please call **Superior Essex Technical Support at 1-877-263-2818.**