1. General

1.1 This procedure provides general information for the installation of Corning Cable Systems fiber optic cable in direct buried applications. These instructions are intended as guidelines only, as each installation will be influenced by local conditions. It is assumed that the reader is acquainted with direct buried cable operations for metallic cables.

1.2 Methods used for the direct buried placement of fiber optic cable include:
   - Plow-in (static or vibratory cable plows)
   - Trenching

1.3 Fiber optic cable is a high-capacity transmission medium with qualities and characteristics which can be degraded when it is subjected to excessive pulling tension, sharp bends, and crushing forces (see 2.3, Cable Precautions). The number of splices in a fiber cable route should be minimized to reduce transmission losses and splicing labor costs. Corning Cable Systems can provide single mode reel lengths up to 12 kilometers (7.5 miles).

1.4 This procedure may contain references to specific tools and equipment other than Corning Cable Systems’ in order to demonstrate a particular method. Such references are in no way intended as a product endorsement.

1.5 This issue includes updated fill ratio information.

2. Precautions

2.1 Safety Precautions

**WARNING:** This section provides safety precautions which should be followed when working in direct buried installations. These practices may change or may not be suitable in a specific situation, and therefore are suggested guidelines only. Your company’s safety precautions take precedence over any recommendations given in this document that are in violation of such practices.

**CAUTION** Before starting any buried cable installation, all personnel must be thoroughly familiar with Occupational Safety and Hazard Act (OSHA) regulations and company safety practices and policies.

**WARNING:** To reduce the chance of accidental injury:
- Guard and protect work areas with barricades or cones to restrict unauthorized access by vehicles or pedestrians.
- Arrange material along the route so it will not interfere with cable placement and not cause a hazard to traffic or pedestrians.
- Flags, cones, and flagmen should be used where necessary.
- Personnel should wear safety vests to increase their visibility.
- Precautions pertaining to smoking or open flames in the vicinity of vehicle fuels and oils must be observed.
- Personnel should remain clear of moving machinery.
- When plowing, personnel should not walk in front of or in between the prime mover(s).
2.3 Cable Precautions / Specifications

CAUTION: Take care to avoid cable damage during handling and placing. Fiber optic cable is sensitive to excessive pulling, bending, and crushing forces. Any damage may alter the characteristics to the extent that the cable section may have to be replaced. To ensure that all specifications are met, consult the cable specification sheet for the cable you are installing. This cable data sheet may be found under the reel lagging board or laminated protective material clearly marked with black paint.

2.4 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 is 2,700 Newtons (600 lb.).

2.5 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

2.6 Direct buried installations are often combined with duct installations to go under obstacles like roads, driveways, etc. At the transition point between the direct buried section and the conduit, the cable must be unreeled. In such cases use the “figure-eight” configuration to prevent kinking or twisting (see Figure 3).

Fiber optic cable should not be coiled in a continuous direction except for lengths of 30 meters (100 ft) or less. The preferred size of the “figure-eight” is about 4.5 m (15 ft) in length, with each loop about 1.5 m (5 ft) to 2.4 m (8 ft) in diameter. Traffic cones spaced about 1.5 m (8 ft) apart are useful as guides during “figure-eighting”.

Note: When “figure-eighting” long lengths of cable, take steps to relieve pressure on the cable at crossover of the eight. This can be done by placing cardboard shims at the crossover, or by forming a second “figure-eight” (Figure 3). If the “figure-eight” must be flipped over to obtain the pulling eye, it can be easily accomplished by three men, one at each end and one in the center. The cable can then be pulled off the “figure-eight” the remaining distance.
Planning and Preparation

3.1 Prior to initiating a direct buried cable installation, major project issues must be investigated and resolved. The following are typical issues which must be dealt with during the planning stage of the installation.

3.2 Route analysis determines the most effective and efficient method to install an optical cable system. A thorough study will help determine the feasibility and cost-effectiveness of a direct buried installation vs. other means. In order to make this decision, several areas must be examined:

- Resolve all rights-of-way along the route by checking property abstracts, mineral rights, and private property access.
- Locate all existing underground facilities, e.g., power, water, sewer, gas, phone, TV, etc.

3.3 Following selection of a route, make a topographic study covering soil analysis, erosion, rock content, rivers and streams, and other obstacles.

3.4 Determine if federal and state regulations require an Environmental Impact Study on the proposed route. If an Environmental Protection Agency (EPA) Study is required, copies of the completed study with its letter of acceptance/permission must be submitted to all applicable agencies.

3.5 Other planning considerations include the following:

- Past history of utility company relations with local residents, i.e., problems, resistance, etc.
- Research of state, county, and township requirements.
- Traffic impact.
- Coordination requirements at boundary lines.

3.6 Before beginning any cable placement, the cable route should be jointly surveyed by engineering and construction personnel. Representatives from each organization having ownership, control, or jurisdiction of the following should be present during the route survey:

- highways
- bridges
- land
- utilities
- waterways
- railroads
- rights-of-way
- other facilities

Potential problems should be identified and resolved if possible.

3.7 Route Maps: Maps accurately depicting obstacles, bridges, rights-of-way, and existing subsurface facilities should be developed from accurate sources.

3.8 Surveying: Where possible, survey and mark the route with stakes. The exact location of underground facilities should be marked and identified.

3.9 Rights-of-Way: When placing buried cable on private rights-of-way, permits must be obtained from owners before construction begins. The terms of the permit must clearly be understood by construction forces. Any circumstances encountered during construction which deviate from the terms of the permit must be brought to the attention of the Project Manager. All changes must be cleared with the property owner.

3.10 Permits and Licenses: When placing buried cable on public right-of-way, permits and state licenses will be generally required for the following:

- Plowing, trenching, or excavating on public right-of-way.
- Closing or limiting traffic on a thoroughfare.
- Attaching conduit or cables to bridges, culverts, or public structures.
- Storing materials or machinery on public property.
- Crossing highways, streets, and railroads by direct burial or by pipe pushing/road bores.
- Crossing streams, navigable waters, drainage ditches, etc.

WARNING: It has been experimentally determined that the use of “figure-eight” machines will damage Corning Cable Systems double-armored SST 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.
3.11 Notify the state Department of Transportation of any work on, under, or in the vicinity of state roads.

3.12 When the route of a cable passes under shrubs, sidewalks, paved streets, etc., it may be advantageous to bore a hole, push, or drive a pipe, instead of opening a trench or plowing through the obstruction.

Engineering Issues

3.13 **Cable Design:** Under most direct buried applications, the inclusion of armor is an advantage to increase crush and bending resistance. In addition, the armor is added protection against rodent attack. Corning Cable Systems cables are available with single or double armor sheaths.

3.14 **Cable Depth:** The depth at which buried cable can be placed will vary with local conditions as with the case of ‘freeze lines’ (depth to which the ground freezes annually). Corning Cable Systems recommends that fiber optic cable be buried a minimum depth/cover of 30 inches (77 cm). Table 1 provides suggested cover depths. Refer to your company’s guidelines where necessary.

<table>
<thead>
<tr>
<th>Location</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum cover in soil</td>
<td>77 cm  (30 in.)</td>
</tr>
<tr>
<td>Minimum cover under drainage ditches</td>
<td>91 cm (36 in.)</td>
</tr>
<tr>
<td>Minimum cover in rock (any location)</td>
<td>77 cm (30 in)</td>
</tr>
<tr>
<td>Minimum cover at roadway crossings</td>
<td>107 cm (42 in.)</td>
</tr>
</tbody>
</table>

*Deviations from desired depth should be noted on drawings

Table 1

---

**CAUTION:** Depths less than those listed in Table 1 may expose the cable to erosion or excavation damage. In conditions where these depths are not feasible or permitted, lesser depth is permissible provided additional protection in the form of concrete casements or innerduct is provided.

Additional Cable Protection

3.15 In certain installation areas, for example, in frozen ground, rights-of-way with limited access (public highways, private property boundaries), it may be more efficient to place a buried duct along portions of the route prior to cable installation. This provides an inexpensive solution to cable protection problems and can provide future flexibility in difficult installation areas.

The duct or innerduct should be rigid polyethylene or PVC with a minimum inside diameter that does not exceed a 65% fill ratio with a single cable installed; (for further details on fill ratios, refer to SRP-005-011, Fiber Optic Cable Placing-Duct).

All runs should have pull lines installed, and the cable placed by using underground plant methods. Additional methods of installing added protection include placing the cable into split innerduct as it is being direct buried or having the cable factory-installed into innerduct. These operations require no additional prime movers and may reduce time spent plowing or pulling.

3.16 When crossing unimproved roads, streets and alleys that may later be paved or hard surfaced, place the cable at a depth that retains sufficient cover following permanent grading of the road. These depths should be shown on the plans before cable installation.

Splice Points

3.17 Corning Cable Systems recommends that Outside Plant Engineers plan the cable installation to determine the optimum splice point locations. In order to reach a splicing vehicle, ensure a minimum of 10 meters (33 ft) of cable on both cable ends at each splice point (Figure 4).
3.18 At hand holes, place the cable slack horizontally in the hole. In the case of a buried splice point, coil and bury the slack vertically (in line with the cable route) (Figure 5).

![Hand hole](Image)

Figure 5 Hand hole

3.19 At specific intervals, 100 m (328 ft) of excess slack may be buried/placed within a splice point. This excess slack can provide added cable for restorations or reconfigurations without digging up large parts of the cable system.

3.20 Cable distance between splice points should be accurately determined to minimize waste. If drawings, as opposed to actual measurements, are used to determine cable lengths, then an appropriate factor should be included to allow for drawing errors (Figure 6).

**Note:** In some installations (in open, unrestricted areas, for example) it may be more efficient to allow the crew to plow until the reel is almost empty, and then establish the splice point location.

3.21 Locate and mark splice points in advance. To reduce safety hazards, preparation of each position should begin as the cable approaches in order to reduce the time that each hole remains open. If the hand holes have lockable lids, there are no restrictions, other than keeping them closed.

3.22 **Marker Signs:** The locations for permanent markers, including size and type, should be shown on the work print.

3.23 **Buried Warning Tape:** The use of a warning tape is a recommended option (Figure 7). A bright orange (preferably “ULCC” orange) warning tape with a minimum width of 7.6 cm (3 in.) may be buried approximately 30.5 cm (12 in.) below the existing grade. As a minimum, the tape should be marked “WARNING OPTICAL CABLE.”

![Warning tape](Image)

Figure 7 Warning tape

![Cable route drawing](Image)

Figure 6 Cable route drawing
3.24 **Utility Locating Service:** Corning Cable Systems recommends that installers and/or customers subscribe to a utility locating service following cable placement. This is especially important where other underground facilities are planned or exist. In several states, laws have been enacted which require calling a locating service prior to digging.

3.25 **Bonding and Grounding:** In order to maintain a high degree of safety and reliability in underground plant, maintain all applicable construction standards regarding grounding. Corning Cable Systems recommends grounding of all metallic cable elements at splice points and at building entrances; however, follow your company’s normal bonding and grounding specifications.

**Note:** Corning Cable Systems recommends grounding the metallic cable elements as the cable is installed. In the event of a lightning strike, a cable will dissipate the added charge through a path of least resistance. If the cable is not properly grounded, this path could be through the cable sheath, causing damage in the form of pinholes. This damage can degrade the reliability of the cable.

4. **Equipment**

**Cable Plows**

4.1 Cable plows are generally of two types: static and vibratory. Steerable plows, which can be offset to place the cable away from the centerline of the cable plow prime mover, are available for both types.

4.2 The selection of tracked or wheeled prime movers and their relative size for cable plows will depend on several factors:

- Local soil conditions along the route.
- Desired rate of cable placement per hour.
- Burial depth of the cable. While company guidelines should take precedence, the following are general recommendations for cable plow prime mover horsepower ratings for selected burial depths (Table 2):

<table>
<thead>
<tr>
<th>Depth</th>
<th>Horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td>91 cm (36 in)</td>
<td>100 -150</td>
</tr>
<tr>
<td>107 cm (42 in)</td>
<td>150- 225</td>
</tr>
<tr>
<td>122 cm (48 in)</td>
<td>225-325</td>
</tr>
</tbody>
</table>

Table 2

- Terrain Variance: presence of steep slopes, sand, heavy woods, etc., all of which affect how well a vehicle can move.

4.3 Figure 8 illustrates a steerable static cable plow equipped for fiber optic placement. The unit illustrated is equipped with a powered capstan drive which provides a pulling force of up to 250 lb., which helps prevent excessive pulling tension at the cable feed tube’s entry and exit.

   Capstan drive units are recommended for fiber optic cable placement by most plow manufacturers and are suitable for fiber optic cable with a diameter of 2.5 cm (1 in) or less. The unit illustrated also automatically places fiber optic warning tape at the correct depth below the grade line.

![Figure 8 Static cable plow*](image)

*Illustration based on a drawing by American Tractor Equipment Company. Used with permission.*

4.4 Figure 9 illustrates a large vibratory, or “orbital” cable plow which makes use of an oscillating plow share mounted ahead of the cable chute.

![Figure 9 Crawler-mounted vibratory plow](image)
4.5 Figure 10 illustrates a smaller vibratory plow/backhoe combination unit.

Figure 10 Medium duty vibratory plow

4.6 The attachment of proper reel carrier equipment will improve cable placement operations and safety. Hydraulic lift-assistance for the reel is recommended, as are shock-mounted reel carriers which will reduce peak cable tension. Load all carriers according to their manufacturer’s instructions.

4.7 All rollers or guides in the cable feed system which cause a change in direction of the cable path must conform to the minimum bend radius of the cable being placed (see Cable Precautions).

Small diameter rollers (fairleads) can be used as cable guides over the vehicle cab (Figure 5 and 6), provided that the feed-chute guide and cable reel are positioned so that the cable cannot be tensioned over the smaller rollers. Fairleads should be designed to prevent the cable from becoming wedged between the vertical and horizontal rollers.

**Cable Feed Chute**

4.8 Before using any cable feed-chute, check its manufacturer’s specifications to make sure that the chute’s critical dimensions and clearances are compatible with the cable you are placing. The chute must have a 50 cm (20 in) minimum radius. Figure 11 illustrates suggested cable feed-chute dimensions.

4.9 The cable path inside the feed-chute must be free of burrs, sharp edges, or excessively rough surfaces. Welds should be smooth. A cable will feed smoothly through a chute with the recommended bend radius, provided the chute is adequately maintained and kept clear.

**CAUTION:** Never attempt to plow more than one cable through a single feed-chute. The feed-chute fill ratio should not exceed 50%, (i.e., the cable’s area must be not more than 50% of the chute area).

4.10 If a steerable plow is employed in an offset mode, the cable must be routed to the cable chute in a direct path by a roller/cable guide system designed for offset operation as shown in Figure 8, or by hand-feeding as shown in Figure 10.
Trenchers

4.11 The selection of a trencher is dependent on the required depth and width of the trench, soil type, and desired speed. Various trencher types are available to cover every situation which may be found in the field. For example, a route may traverse a suburban area where a large tracked machine cannot be used. On the other hand, in rocky or solid rock areas, a large machine capable of rock sawing may be necessary. In many cases various machines or each route may be required.

Support Vehicles

4.12 All vehicles which support the installation equipment by transporting personnel, materials, and equipment, must be capable of traversing the same terrain as the prime movers. This includes the cable handling vehicles which are required to lay cable into trenches or provide cable for the plows (Figure 12).

Figure 12 Support vehicle

5. Plowing Operations

5.1 Improper preparation, setup, and operation of equipment can lead to fiber optic cable damage. The following guidelines should be followed for direct burial of fiber optic cable by static or vibratory plows.

5.2 Conduct an on-site, pre-construction meeting with the engineer, placing crew, property owners, underground facilities personnel, D.O.T. personnel, and other necessary/involved parties.

5.3 Clearly mark the route for equipment operators.

5.4 Establish a means of communication between the equipment operator and the supervisor monitoring the cable placement and route. This communications link must be able to override equipment noise.

5.5 The starting point should be a splice pit or hole excavated to the proper depth and other dimensions. Reel off sufficient splice slack (10 M) at this point to reach a splice vehicle. Start the plow at the required depth from this splice pit.

5.6 A ripping pass to the depth required by the drawings is desirable and should be made before plowing the fiber optic cable to make sure that the route is clear between splice locations. The ripping pass is made in the same direction that the cable is to be plowed. In some situations, it may be necessary to make more than one ripping pass, or to rip deeper than the required depth.

5.7 Always start the plow tractor’s movement slowly and gradually increase its speed after all cable slack is taken up from the cable delivery system.

5.8 Plow attitude and depth must be changed gradually. Such changes should be made only while the plow’s prime mover is under way.

5.9 Do not plow with the share set at extreme forward angles unless operating a share designed for this purpose.

5.10 Grade off abrupt changes in terrain along the cable path ahead of the plow.

5.11 Plowing operations must be observed continuously for obstructions, proper feeding of the cable, proper depth, following of the marked route, and safety of the crew.

Note: A line can be painted on the plow share for the operator to monitor plowing depth.

5.12 Stationary operation of a vibratory plow for excessive periods of time can damage the cable through kinking or abrasion. If you encounter an underground obstacle, shut off the vibratory plow and excavate the cable to expose and remove the obstacle.

![CAUTION: Do NOT raise the plow share to the surface if the plow is not moving. The cable to the rear of the feed-chute must be excavated and slack pulled to prevent kinking the cable over the exit chute before raising the plow share.]

![CAUTION: Under no circumstances should the plow be backed or the share moved to the rear with cable in the chute. Failure to follow this warning can damage the cable.]

5.13 Do not plow with the share set at extreme forward angles unless operating a share designed for this purpose.
6. Trenching Operations

6.1 Clearly indicate the route of the cable trench on construction plans. Make every effort to follow instructions as to depth, cover, and location, and to minimize inconvenience to the public or private property owners. Avoid damaging tree roots, shrubs, or other vegetation on the premises.

6.2 Care must be taken to dig a straight and level trench to the drawing specifications. The trench should be as narrow as possible to avoid unnecessary handling of earth. When the trench is dug by hand, the operation may be expedited by the use of a grading plow to excavate the top portion of the trench.

6.3 The minimum depth for a trench with backfill for fiber optic cables is 91 cm (36 in).

6.4 Backfill soil depth should be from 23-30 cm (9-12 in).

Following cable placement, place additional backfill soil approximately 53-69 cm (21-27 in) below the trench rim. The indigenous soil can then be used for complete fill. Place a warning tape 30 cm (12 in) below the trench rim.

Figure 14 provides views of a typical filled trench.

⚠️ CAUTION: Use clean backfill when the surrounding soil is too rocky to place around the fiber optic cable without subsequent damage. Backfill material must be sand or sandy loam free of large rocks or objects.

7. Construction Guidelines — Plowed and Trenched Installations

7.1 The following guidelines are applicable for both plowed and trenched-in cable installations.

7.2 Mark the exact position of the cable(s) as quickly and accurately as possible. Use permanent landmarks, i.e., streets, highways, railroads, survey markers, etc., as references for distance measurements.

Update the “as-built” drawings frequently, if not daily, depending on the amount and nature of work completed. This record keeping will eliminate guesswork later on caused by catch-up efforts, and ensures accurate information. Assign one person or team this task for consistency.

7.3 When it is necessary to remove base paving materials or shrubs, keep them separate from other excavated materials so that they may be reused if possible. Do not remove more pavement than is necessary.
7.4 Restoration of plowed or backfilled surfaces may be accomplished by driving a crawler tractor or heavy truck over the plow furrow. The use of a vibratory roller is also an effective means of restoring the ground. Restoration of sod and other special conditions must be handled on an individual basis. Open trenches, holes, or splice pits should be refilled as soon as possible.

7.5 Place permanent, company-approved markers beside the cable route immediately to warn against possible “dig-ups” in the future. Follow your company’s standard practices in terms of marker type, distance between markers, etc. (Figure 15).

⚠️ CAUTION: Use extreme care when sinking markers—crews have been known to sever their own fiber optic cable during marker placement.

Figure 15 Warning marker

7.6 Registration of the cable route with the state and local governments after its completion will provide additional protection from accidental damage to the cable. Such registration provides future projects access to the cable route information.

7.7 Following installation of the cable, the section may be checked with an OTDR for possible increases in attenuation due to pressure or breaks. Any cable ends left for future splicing must have their protective caps reinstalled and sealed with tape prior to burial.

8. Post-Installation Inspection

8.1 The final step in completing a direct-buried cable installation is a thorough inspection of the entire route from start to finish. Engineering personnel and involved parties should examine the “as-built” drawings for conformance to the engineering plans, codes, regulations, and general accuracy.

8.2 Inspect the construction area above ground to ensure the following:

- Restoration has been accomplished.
- Permanent markers have been installed immediately beside the cables.
- Road bores, if used, are properly completed and will not collapse a portion of the road.
- Debris and trash have been removed from the site.
- Other instructions specific to the installation have been completed to the drawing’s specifications.

8.3 Upon completion of this inspection, all deficiencies must be recorded and corrected by the appropriate party. All corrections should be reinspected by the concerned personnel. Request a letter of acceptance from each party; i.e., D.O.T, EPA, property owners, government agencies, right-of-way owner, etc., when the project is complete.

Corning Cable Systems reserves the right to improve, enhance, and modify the features and specifications of Corning Cable Systems’ products without prior notification.

All trademarks are the property of their respective holders

Corning Cable Systems is ISO 9001 certified. © 2002 Corning Cable Systems LLC. All rights reserved.

Printed in U.S.A.

Corning Cable Systems LLC
PO Box 489
Hickory, NC 28603-0489 USA
For US and Canada 1-800-743-2673
International 828-901-5000
FAX: 828-901-5973
http://www.corning.com/cablesystems