CORNING

Direct-Buried Installation of Fiber Optic Cable

P/N 005-012
Issue 9

1. Precautions

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).
- Personnel feeding cable into a feed-chute must make sure that they do not position themselves inside a cable loop.

- Hearing protection may be required by vehicle operators.
- Pre-ripping provides a safety check of ground conditions and undocumented underground facilities.
- Prime movers, due to their size and high center-of-gravity, should always have roll-over protection.
- Personnel should be cautioned not to climb on vehicles unless an approved work stand is in place.
- All splice pits, excavations, and/or trenches must be fenced off and marked properly.
- Follow all applicable safety regulations for shoring the walls of trenches and splice pits.
- The top end of the cable may extend off the reel and become a hazard. Be sure to secure loose cable ends.
- The bottom end of a cable may “squirt” beyond the reel flange, causing a possible safety hazard and/or damaging the cable. Tightening of the reel bolts and maintaining reel tension during payout may reduce the chances of this effect.
- Hard hats should be worn at all times.

2. Cable Precautions / Specifications

CAUTION: Take care to avoid cable damage during handling and installation. 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.

2.1. 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 is 600 lb_F (2,700 Newtons). Refer to the cable specification sheet for the specific allowed tension for each cable.

2.2. 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:

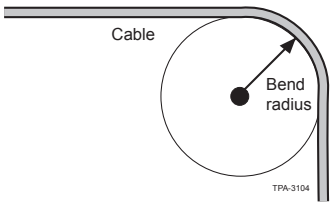
From GR-20 and ICEA-640: Minimum Bend Radius Requirements			
Operation		Installation	
MBD	20 x OD	MBD	40 x OD
MBR	10 x OD	MBR	20 x OD
If MBR > 216 fibers			
MBD	30 x OD	MBD	40 x OD
MBR	15 x OD	MBR	20 x OD
NOTE: *Corning® RocketRibbon™ extreme-density cable (1728- and 3456-fiber) exceeds these requirements.*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



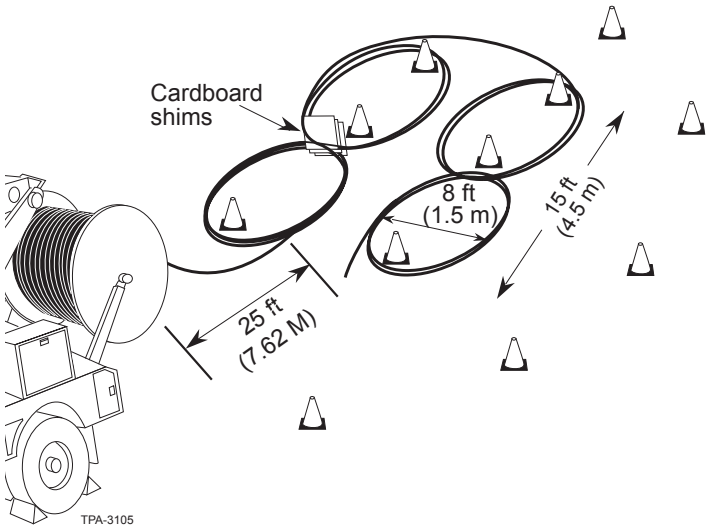
2 x 6.9 in (17.7 cm) = 13.8 in (35.4 cm)

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

2.3. 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.

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



NOTE: *When coiling long lengths of cable, take steps to relieve pressure on the cable by placing cardboard shims at the crossover, or by forming a second figure-eight. 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 coils the remaining distance.*

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.

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

2.5. 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.

2.6. 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.

2.7. 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.

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

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

2.10. 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.

2.11. 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.

2.12. Notify the state Department of Transportation (D.O.T.) of any work on, under, or in the vicinity of state roads.

2.13. 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.

2.14. Refer to Applications Engineering Note 165 Cable Handling: Squirting, Tangling, and Storage for proper storage methods and what to do prior to installation.

Engineering Issues

2.15. 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 Optical Communications' cables are available with single or double armor sheaths.

2.16. 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 Optical Communications recommends that fiber optic cable be buried a minimum depth/cover of 30 in (77 cm). The table provides suggested cover depths. Refer to your company's guidelines where necessary.

Minimum Cover of Buried Fiber Optic Cables*	
Location	Depth
In soil	30 in (77 cm)
Under drainage ditches	36 in (91 cm)
In rock (any location)	30 in (77 cm)
At roadway crossing	42 in (107 cm)
*Deviations from recommended depth should be noted on drawings	

Table 1: Minimum Cover Depths

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

2.17. 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.

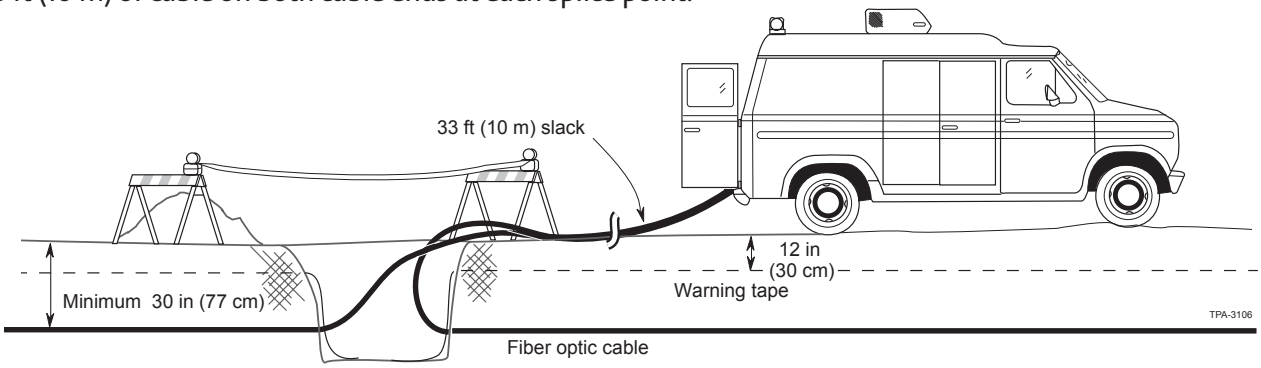
The duct or innerduct should be rigid polyethylene or PVC with a minimum inside diameter that does not exceed a 65% fill ratio with a single cable installed; (for further details on fill ratios, refer to SRP-005-011, Duct Installation of Fiber Optic Cable).

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

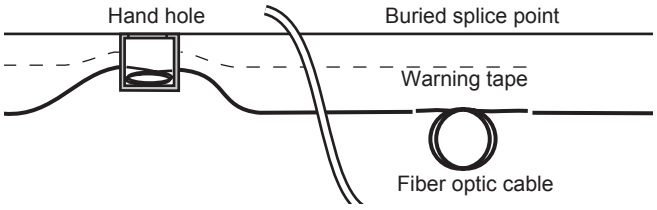
2.18. When crossing unimproved roads, streets and alleys that may later be paved or hard surfaced, place the cable at a depth that retains sufficient cover following permanent grading of the road. These depths should be shown on the plans before cable installation.

Splice Points

2.19. Corning Optical Communications 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 33 ft (10 m) of cable on both cable ends at each splice point.



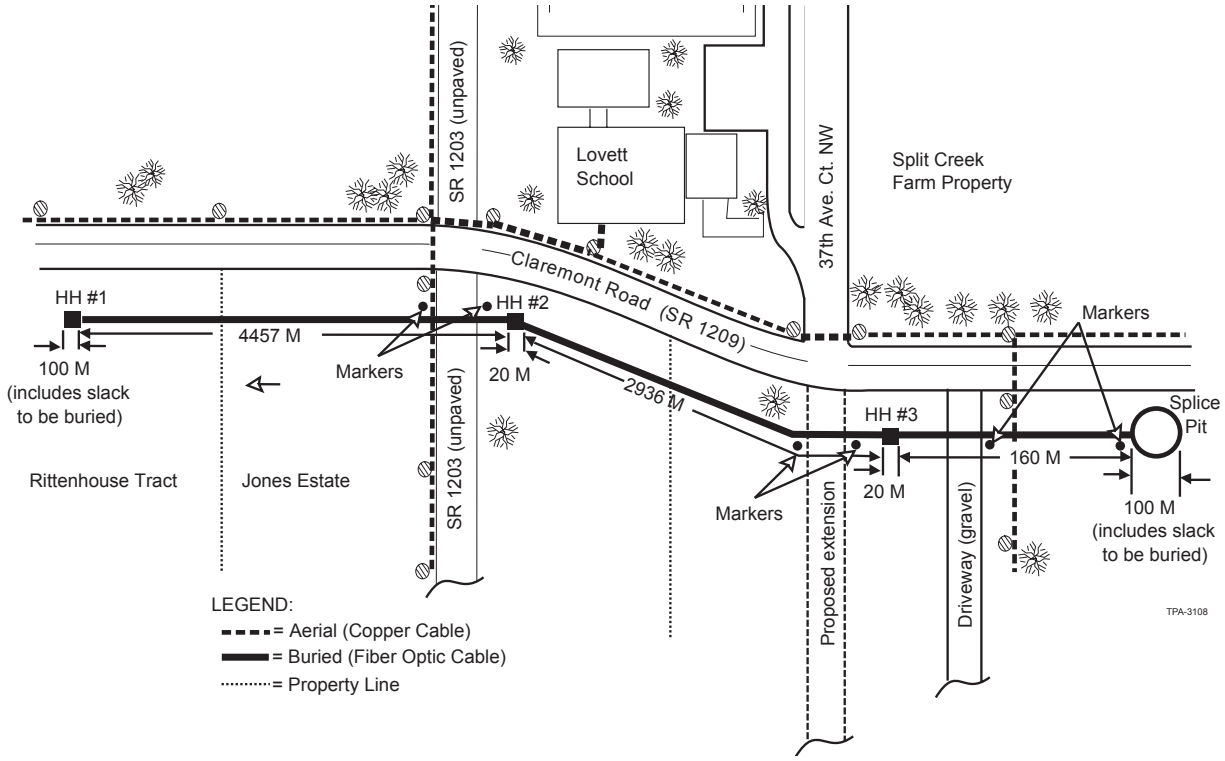
2.20. At hand holes, place the cable slack horizontally in the hole. In the case of a buried splice point, coil and bury the slack vertically (in line with the cable route).



2.21. At specific intervals, 328 ft (100 m) 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.

2.22. 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.

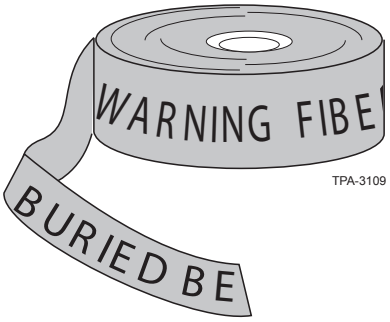
NOTE: *In some installations (in open, unrestricted areas, for example) it may be more efficient to allow the crew to plow until the reel is almost empty, and then establish the splice point location.*



2.23. 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.

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

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



2.26. Utility Locating Service: Corning Optical Communications 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.

2.27. 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 Optical Communications recommends grounding of all metallic cable elements at splice points and building entrances; however, follow your company's normal bonding and grounding specifications.

NOTE: *Corning Optical Communications 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.*

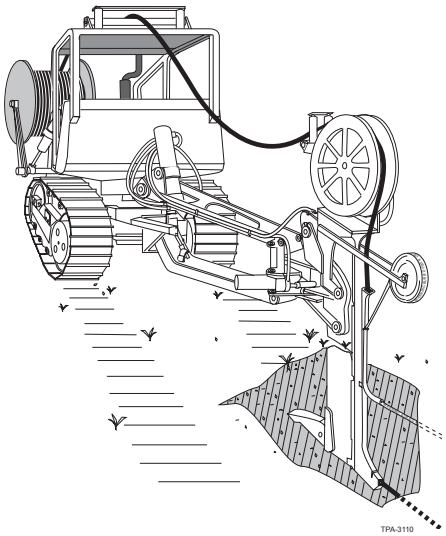
3. Equipment

Cable Plows

3.1. 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.

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

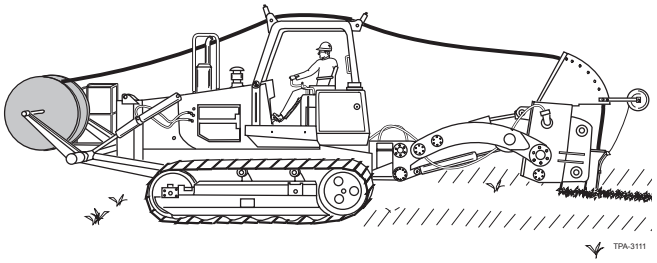
- Soil conditions along the route.
- Desired rate of cable placement per hour.
- Terrain Variance: presence of steep slopes, sand, heavy woods, etc., all of which affect how well a vehicle can move.



3.3. A steerable static cable plow equipped for fiber optic installation is shown. The unit illustrated is equipped with a powered capstan drive which provides a pulling force of up to 250 lb_F, which helps prevent excessive pulling tension at the cable feed tube's entry and exit.

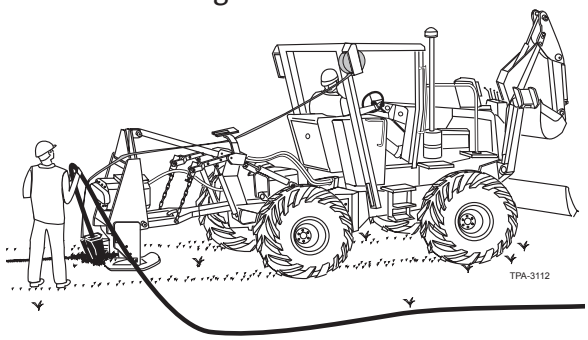
Capstan drive units are recommended for fiber optic cable placement by most plow manufacturers and are suitable for fiber optic cable with a diameter of 1 in (2.5 cm) or less. The unit illustrated also automatically places fiber optic warning tape at the correct depth below the grade line.

3.4. A large vibratory, or "orbital" cable plow which makes use of an oscillating plow share mounted ahead of the cable chute is illustrated here.



3.5. A smaller vibratory plow/backhoe combination unit is shown to the right.

CAUTION: Make sure no loops of cable are present along the path when hand-feeding cable into the chute.



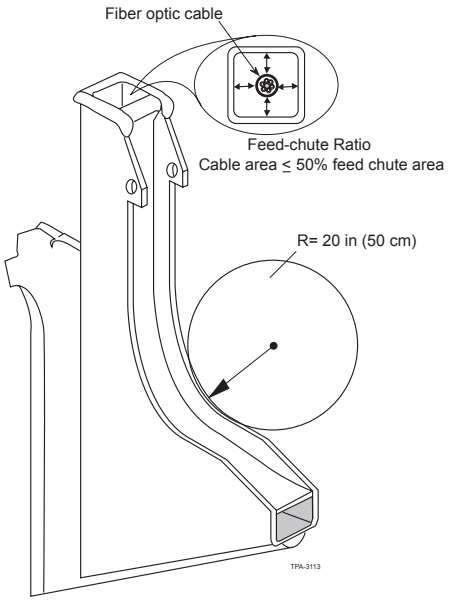
3.6. The attachment of proper reel carrier equipment will improve cable placement operations and safety. Hydraulic lift-assistance for the reel is recommended, as are shock-mounted reel carriers which will reduce peak cable tension. Load all carriers according to their manufacturer's instructions.

3.7. 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, 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

3.8. 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 installing. The chute must have a 20 in (50 cm) minimum radius. Suggested cable feed-chute dimensions are shown to the right.



3.9. 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 percent of the chute area).

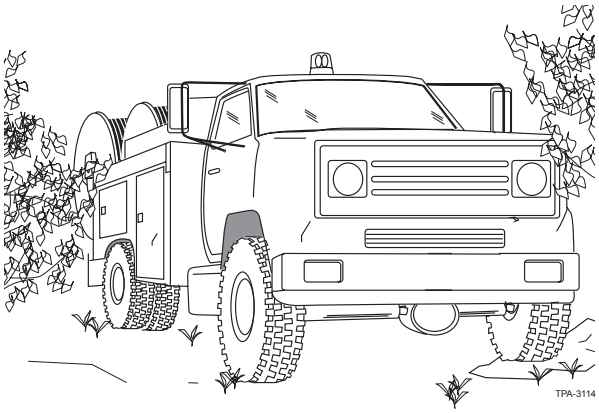
3.10. If a steerable plow is employed in an offset mode, the cable must be routed to the cable chute in a direct path by a roller/cable guide system designed for offset operation as shown in paragraph 2.1, or by hand-feeding as shown in paragraph 2.5.

Trenchers

3.11. 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 on each route may be required.

Support Vehicles

3.12. 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.



4. Plowing Operations

4.1. 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.

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

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

⚠	**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.

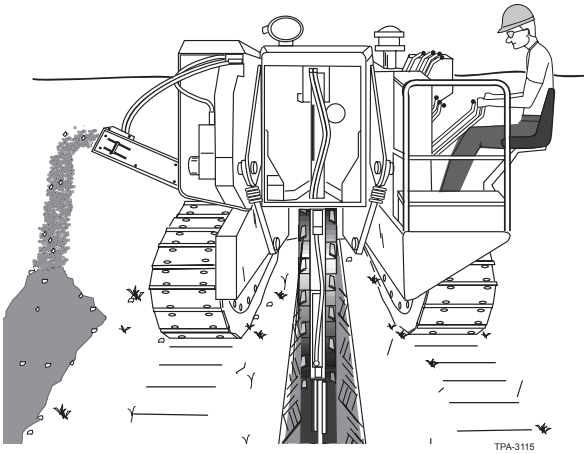
4.4. Grade off abrupt changes in terrain along the cable path ahead of the plow.

4.5. 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.*

4.6. 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.

5. Trenching Operations

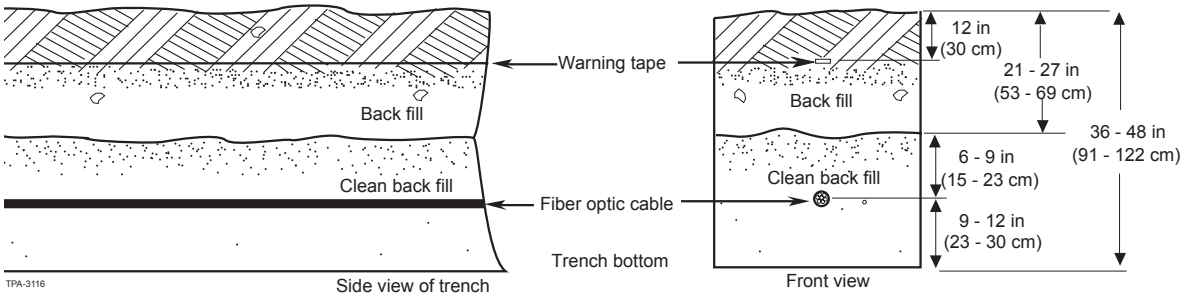


5.1. Clearly indicate the route of the cable trench on construction plans. Make every effort to follow instructions as to depth, cover, and location, and to minimize inconvenience to the public or private property owners. Avoid damaging tree roots, shrubs, or other vegetation on the premises.

5.2. 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.

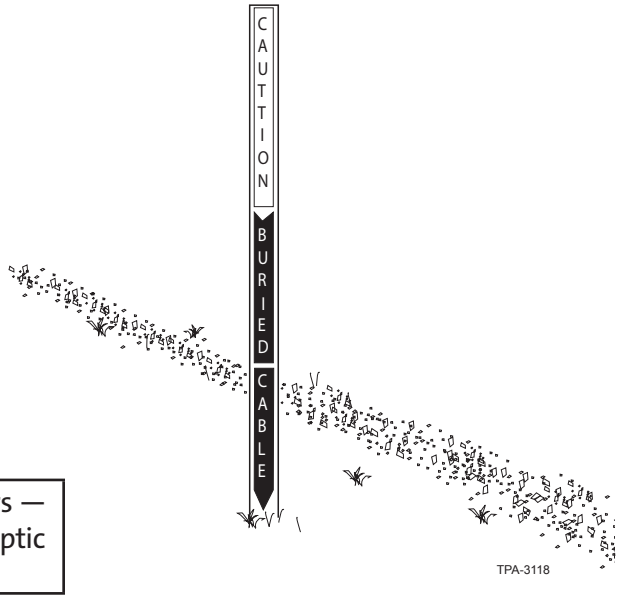
5.3. The minimum depth for a trench with backfill for fiber optic cables is 36 in (91 cm).

5.4. Backfill soil depth should be from 9-12 in (23-30 cm). Following cable installation, place additional backfill soil approximately 21-27 in (53-69 cm) below the trench rim. The indigenous soil can then be used for complete fill. Place a warning tape 12 in (30 cm) below the trench rim.



5.5. 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.

5.6. 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.



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

5.7. 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.

5.8. 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.

6. Post-Installation Inspection

6.1. 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.

6.2. 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.

6.3. 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., DOT, EPA, property owners, government agencies, right-of-way owner, etc., when the project is complete.

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