Construction manual

Broadband applications & construction manual

ConQuest® conduit products

Contents

Introduction to the ConQuest® product line

CommScope's ConQuest® product line features select grade high-density polyethylene (HDPE) conduit with value-added products such as factory pre-assembled CommScope cable in conduit (CIC) and Toneable conduit™.

ConQuest includes a complete line of empty conduit and conduit accessories, including cutters, couplings, and an environmentally safe cable pulling lubricant.

ConQuest cable-in-conduit (CIC) product family

ConQuest cable-in-conduit is factory pre-assembled HDPE conduit with CommScope's superior cable products such as QR®, Parameter III® (P3®), subscriber drop, PowerFeeder®, LightScope ZWP®, fiber-optic, and/or MultiReach® cables.

ConQuest CIC provides enhanced cable protection, saves installation time and costs, and makes cable replacements faster and more efficient. All pre-assembled CommScope cables in ConQuest conduit are pre-lubricated in the factory to facilitate easy cable replacement. ConQuest conduit provides the strength to withstand the rigors of installation, yet flexible enough to make installation quick and easy.

Eliminate pulling cable after conduit has been placed – specify cable in conduit
Utility companies and contractors are always digging on public easements. To best protect buried cable from service interruptions, request it pre-installed in a CommScope ConQuest product. These products provide a tough, high-density polyethylene conduit factory pre-installed with any CommScope cable. Cable in conduit is becoming standard procedure for broadband operators with an eye on scalability. Today, these operators are building plants that protect today's investment and make future access to cable easy.

ConQuest drop-in conduit facilitates future access to infrastructure
The buried service wire, the final leg of the outside plant, is often the most vulnerable. Home owners like to dig, landscape, repair sprinklers, etc. That's why we offer ConQuest, our own brand of conduit products, factory preinstalled with the cable of your choice.

ConQuest cable-in-conduit (CIC) products

Standard shield construction (flooded) drop cable product shown

P3 JCASS (flooded) trunk and distribution product shown

QR JCASS (flooded) trunk and distribution product shown

All-dielectric stranded loose-tube fiber product shown

ConQuest toneable conduit

ConQuest toneable conduit is a select grade high-density conduit with an integrated 18-gauge copper-clad steel (CCS) tone wire. The tonewire is attached to the outside of the conduit with a figure-eight-style web. This design provides easy access to the tone wire.

ConQuest Toneable Conduit facilitates precision locating of buried conduit by allowing a toneable signal to be transmitted across the tone wire over extended distances and depths.

ConQuest empty conduit

ConQuest empty conduit is select grade HDPE conduit with or without factory-pre-installed pull lines. Empty conduit is available with a variety of pull rope/tape options with various pull strength ratings.

Install empty ConQuest conduit for future cable placements
Sometimes conduit needs to be installed ahead of cable; such as for developing neighborhoods and for some long fiber-optic cable placements. ConQuest offers an entire package of products that provide a variety of sizes, wall thicknesses, colors and pre-installed pull lines.

ConQuest empty conduit products

Smooth wall empty conduit

Shown with polypropylene pull rope

Ribbed wall empty conduit

ConQuest toneable conduit

Copper-clad steel tone wire

Available pull ropes and pull tapes

Polypropylene pull rope (200 lb. shown)

Polyester pull tape (available in 1250 and 1800 lb.)

Quality and certification

Quality
CommScope goes the extra mile to ensure you receive quality conduit. Dimensional measurements shall be performed on samples removed from each complete length of finished conduit, unless otherwise specified. Not only will the dimensions be examined, ovality and physical appearance will also be checked. The inner and outer surface area shall contain virtually no signs of cracks, roughness; melt fracture or any other surface defect.

Even in the shipping process, CommScope goes the extra distance. CommScope uses only quality-built steel and wooden reels. These reels are engineered to withstand the rigors of being shipped across the country, yet are not too cumbersome for the end user.

ISO 9001 certified
CommScope is ISO 9001 registered and committed to a high standard of manufacturing excellence in all aspects of our operation. CommScope consistently demonstrates a commitment to designing, manufacturing, and delivering products and services that conform to the specifications and expectations of the end user.

ISO 9001 REGISTERED

Rural utilities service (RUS)
CommScope has RUS listings for all of the conduit products.

Handling

Receiving a shipment

Trouble-free unloading begins with letting your CommScope customer service representative know of any special packaging or delivery requirements (reel must be shipped on rolling edge, no shipping dock available, call before delivery, etc.). CommScope will make every reasonable effort to comply with your shipping needs.

When the shipment arrives, inspect every reel and pallet of material for damage as it is unloaded. Suspect conduit should be set aside for a more detailed inspection before the shipping documents are signed.

Damage can occur during the unloading process. Damage can also occur by dropping the reels or pallets, or improper handling of reels with a forklift.

If any damage is visible or suspected and if it is decided to accept the shipment, note the damage and the reel number on ALL copies of the bill of lading. If the damage is too extensive to accept the shipment, advise the carrier's driver that the shipment is being refused because of the damage. Immediately notify CommScope's Customer Service Department at 800-982-1708 so arrangements can be made for a replacement shipment.

Unloading ConQuest products

Unloading at a dock

Use a pallet jack or forklift to remove all products on pallets. Remove any blocking materials for the individual rows of conduit and roll the reels onto the dock. If the back of the trailer and dock are not the same height, use an appropriate loading ramp to compensate for the difference.

Be sure to inspect your shipment immediately for any damage

Unloading without a dock

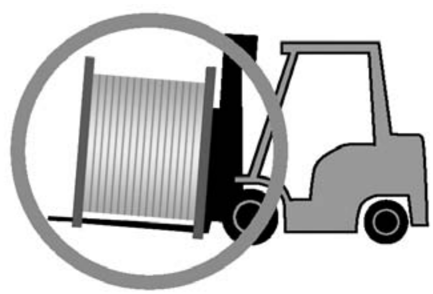
If you use a ramp, it should be strong enough to support the weight of the unloading personnel and the heaviest conduit reels. The ramp should have raised sides to prevent the conduit reels from rolling off the sides of the ramp.

The ramp should be long enough to allow control of the momentum of the conduit as it rolls down the ramp. A pulley system connected to the sides of the truck and to a shaft passing through the center of the reels can help control momentum of the rolling reels. With this method, two workers can usually control movement of the heaviest reel.

If you use a CargoMaster® crane, unstack if required and move the reels to the rear of the truck and lower to the ground with the crane.

Unloading with a forklift

When unloading or moving reels with a forklift, care must be taken. First check that the forklift can lift at least 200 lbs. more than the weight of the reel. Then verify that the forks are long enough to completely cover the distance from one flange of the reel to the other flange of the reel. Utilize the drive-on roll-off position; forks must be placed under both reel flanges as shown in the diagram, flat side of the flange facing the driver. Reels may also be lifted by placing forks through the center of the reel. Do not carry more than one reel at a time in this position. Do not attempt to pick up reel with forks on conduit. Do not attempt to lift stacked reels by the upper flange.

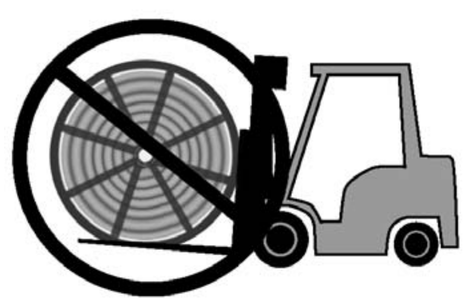


correct

DO NOT drop reels off the back of the truck onto a stack of tires, onto the ground or any other surface.

The impact may injure personnel and damage the reels, conduit and/or the cable inside.

Always use ample personnel to safely unload shipments of conduit.



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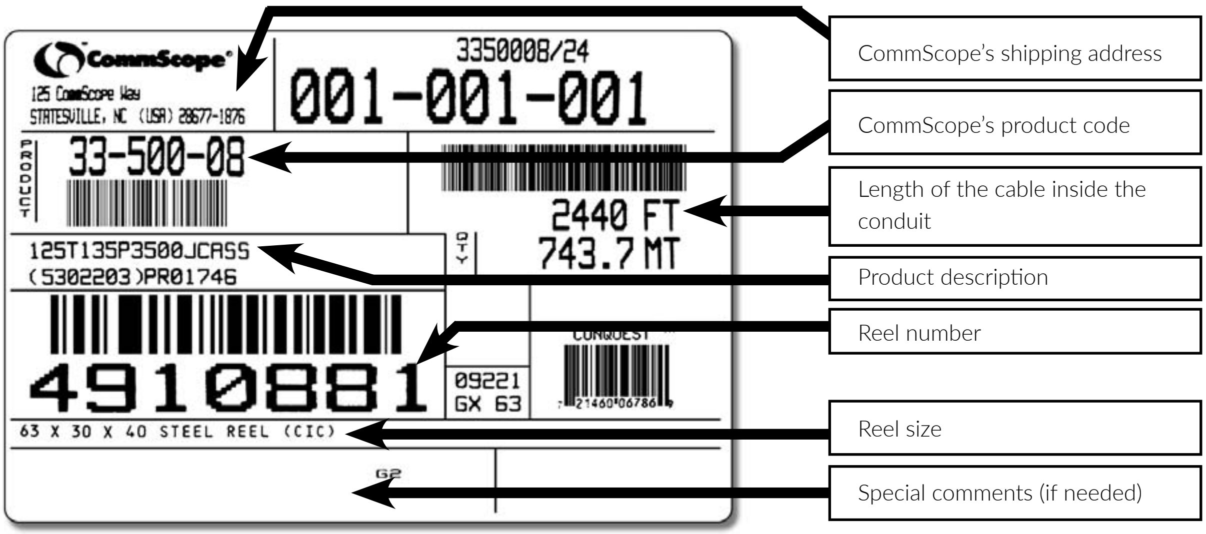
Product identification

Product identification (reel tag)

Each reel tag for CIC (as shown below) shall provide the following information and instructions:



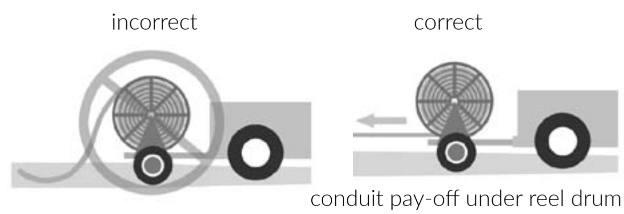
Shown: typical reel tag for CIC with P3 500 JCASS product.

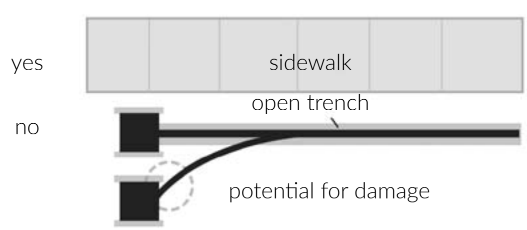
NOTE: Please reference the reel number and the five-digit number printed on the conduit, if you have a question or issue with any reel received.

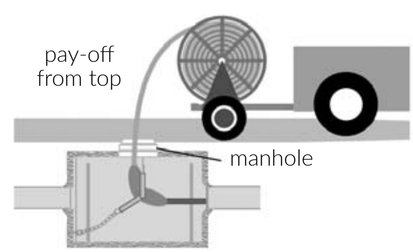
General conduit installation practices

Pay-off

When installing ConQuest, pay-off the reel from underneath and in as direct a line as possible to the trench to avoid unnecessary bending of the conduit or rubbing of the conduit against the reel flange. When feeding ConQuest into a manhole, pay-off should occur from the top of the reel with the manhole on the opposite side from the direction of pull.







Cable withdrawal

ConQuest CIC conduit is slightly longer than the coaxial cable it contains. Allow an average of 1.5 percent of cable withdrawal back toward the reel during unspooling (example: 2000 feet of conduit will yield 1970 feet of cable). Cable withdrawal will be greater as you approach the end of the reel. ConQuest conduit containing optical reach is the same length as the cable it contains. Therefore, the cable WILL NOT withdraw into the conduit during unspooling.

Cut the restraint

Prior to installation of coaxial CIC, remove the conduit end cap and cut the cable restraint. This relaxes the cable and transfers all of the pulling tension to the conduit.

When deploying fiber-optic CIC, **DO NOT remove the conduit end cap or cut the cable restraint** prior to installation.

Keep capped

Make sure both ends are capped during the installation to maintain conduit integrity. Foreign objects and debris entering an uncapped conduit can result in damage of installed cables and may cause blockage, making future cable replacements difficult.

Attaching to ConQuest

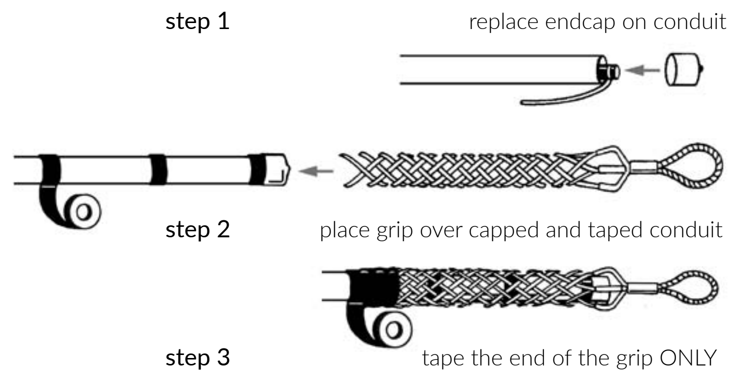
Some installation methods require an attachment to the ConQuest conduit to facilitate pulling. The following tools work particularly well for this: the “basket pulling grip,” the “thread in eye,” and expansion eye.

Basket pulling grip
When using the basket pulling grip it is important to remember: the tool is designed to compress and grip the surface of the object it is pulling.

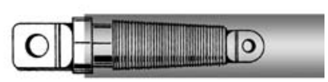
NOTE: Basket pulling grips should not be used on conduit sizes larger than 1¼ inches!

Unlike cable, conduit has an extremely rigid surface that does not allow for a good grip. In order to achieve a solid grip on conduit, a more pliable surface, like duct tape or electrical tape, needs to be applied.

Apply bands of tape at five-inch (two-centimeter) intervals from the conduit cap back to the point where the basket pulling grip will end. The tape only has to be applied in single-width bands but must be at least 1/16 inch (.03 cm) thick. Place the grip over the capped conduit and bands, then pull the grip to tighten its grasp on the conduit. To help hold the grip in place, tape needs to be applied to the conduit and then wrapped onto the end of the grip. Do not extend the tape beyond the first three inches of the end of the grip.



Inner duct pulling eye with swivel
The thread in eye provides a pulling attachment that does not produce an increase in the outer diameter of the conduit. This is an added benefit not found in other devices. The installation of this device simply requires it to be screwed into the end of the conduit. The device has an eyehole for the attachment of a winch line or attachment to a plow blade.

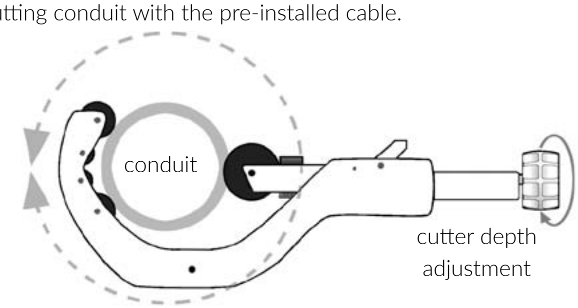


Conduit pulling eye with swivel
This tool should be considered when pulling into a directional bore. All benefits of the inner duct pulling eye apply. **Note: This tool is not recommended for pulling inner duct.**

Cutting ConQuest

Several tools have been found useful for the purpose of cutting ConQuest conduit. While selection of the tools is usually defined by the user’s preference, there are some application restrictions based on tool designs.

To cut ConQuest, open the tool and place it around the conduit at the point where the cut is to be made. While applying pressure to the conduit with the cutting edge, begin rotating the tool around the conduit—increasing pressure as you go. To provide an even cut, it is often helpful to rotate the tool in opposite directions with each full pass around the conduit. NOTE: This is the preferred method for cutting conduit with the pre-installed cable.

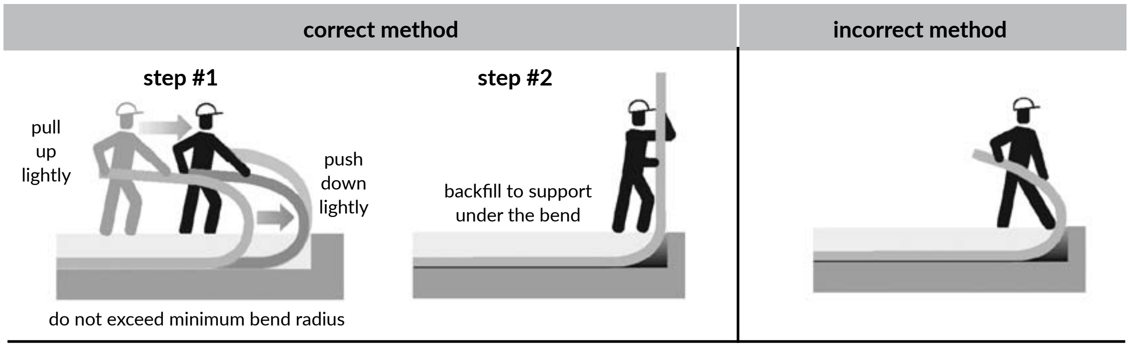


For ConQuest up to 1.25 inches (3.2 cm), use a ratchet shear (such as the CQARS1 from CommScope).

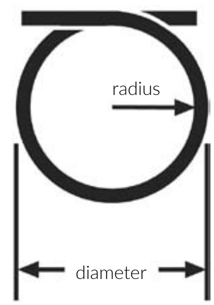
For ConQuest up to 2 inches (5 cm), use a tubing shear (such as the CQATC2QP from CommScope).

Bending ConQuest (underground)

ConQuest can be easily shaped by rolling a bend into it. Take 10–12 feet (3–3.5 meters) of conduit and pull the free end of it toward you, forming a “horizontal U.” Push into the bend lightly and roll the entire radius of the conduit forward. DO NOT bend the conduit any further if it begins to show signs of ovality, i.e. begins to bulge. **DO NOT press down on the conduit with your foot** as you bend it.



Bending radius (all)
Conduit is often routed around corners during placement and pulling tension must be increased to apply adequate force to conduit to bend the conduit around the corner.



CommScope’s specified minimum bend radius is the static (unloaded) bending radius of the conduit. This is the minimum radius to which the conduit can be bent without mechanically degrading the performance of the conduit.

The bending radius of conduit and cables during the construction process is controlled by construction techniques and equipment. Use the largest bend radius possible to help reduce overall pulling tension.

WARNING: Exceeding minimum bending radius can result in permanently ovalizing the conduit, which may restrict cable installations. Exceeding minimum bending radius of cables can damage the electrical or optical performance.

Mechanical stress

Regardless of the installation method, mechanical stress is of great concern during conduit and cable placement. Exceeding the maximum allowable pulling tension can damage conduit and cable. Pulling tensions for ConQuest conduits can be found in specifications at the end of this manual.

Pulling tension
There are three general causes that affect pulling tension during the installation of conduit or cable: conduit or cable weight, sidewall pressure, and tail loading.

Weight of the conduit or cable can be directly associated to pulling tension as a factor of force required to move an object weighing a number of pounds over a given distance. The more the conduit or cable weighs, the greater the pulling tension. The longer the distance, the greater the pulling tension.

Sidewall pressure or loading is the radial force exerted on a conduit or cable when pulled around a bend or sheave. Excessive sidewall pressure can crush the conduit or the cable.

Tail loading is the tension on the conduit or cable caused by the mass of the conduit on the reel and reel brakes. Tail loading is controlled by two methods. It can be reduced using minimal braking during the pay-off of the conduit from the reel—at times, no braking is preferred. Rotating the reel in the direction of pay-off can also minimize tail loading.

WARNING: Exceeding maximum pulling tension can result in the conduit drawing down in size. While it may recover after a period of resting, the mechanical properties of the conduit are permanently degraded, which may reduce the life expectancy of the conduit. Exceeding maximum pulling tension of cables can damage the electrical or optical performance.

Break-away swivels should be placed on the conduit to ensure the maximum allowable tension for that specific conduit or cable type is not exceeded. The swivel is placed between the conduit/cable pull member and pulling grip. A break-away swivel is required for each conduit or cable.

Underground installation methods

Conduit was designed for underground installations—making it possible to easily and quickly access buried cables that would otherwise be bounded by earth and inaccessible. Most underground environments are extreme environments. Conduit, when properly installed following the procedures outlined in this manual, will provide years of protection for the cables inside, guarding against rocks, rodents, and dig-ins.

This section of the manual provides the guidelines for the following types of underground installations

- Trenching
- Boring
- Static plowing
- Vibratory plowing
- Pull plowing
- Existing conduit
- Submarine installation

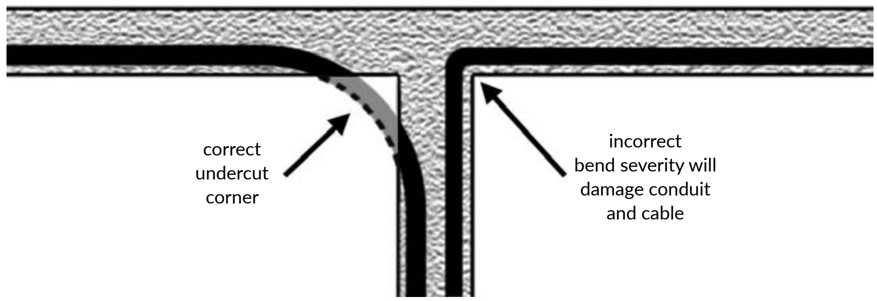
Open trench installation method

Trenching is accomplished with specialized trenching tractors that cut the trench and remove the soil in a single action. A trench can be used to place multiple conduits over long or short distances. The construction equipment manufacturer specifies detailed equipment operation and excavation procedures.

Excavate the trench to the desired depth. Remove all rocks and large stones from the bottom of the trench to prevent damage to the conduit in very rocky soil. Push some clean fill into the trench to cushion the conduit.

Supplemental trenches should be made to all offset enclosure locations. Trench intersections should be excavated to provide adequate space to make sweeping bends in the conduit.

Digging the trench
The trench should be as straight, level and as rock free as possible. Avoid curves smaller than the conduit bend radius. Undercut inside corners to increase the radius of the bend. Should there be a rapid grade change, use backfill to support the conduit.



Open trench—moving reel installation method

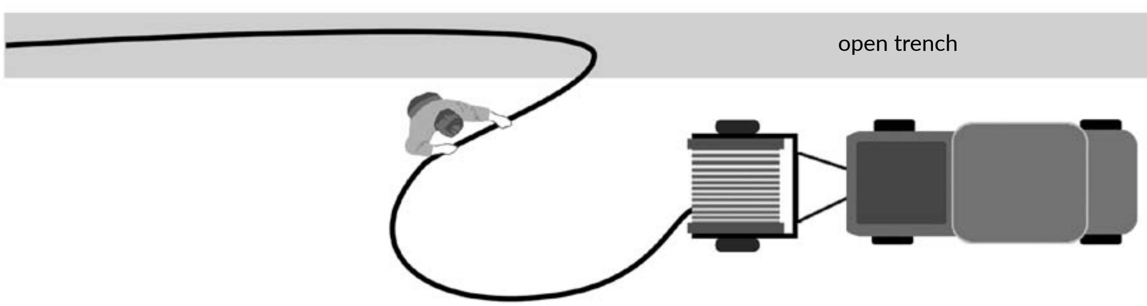
Moving reel installation
Prior to installation, make sure to account for cable withdrawal by providing adequate excess length. Make sure the conduit is capped.

NOTE: See cable withdrawal in general conduit installation practices—page 6.

Place the reel on a trailer with pay-off underneath and to the rear of the trailer. Secure the free end of the conduit outside of the trench.

NOTE: Pay-off from bottom of reel allows the conduit to lay straight in the trench

As you drive off with the trailer, have a worker feed the conduit into the trench. Do not allow the reel to overspin. When multiple conduits will be placed in trench, lay each flat and straight in the trench—do not cross over another conduit if at all possible.



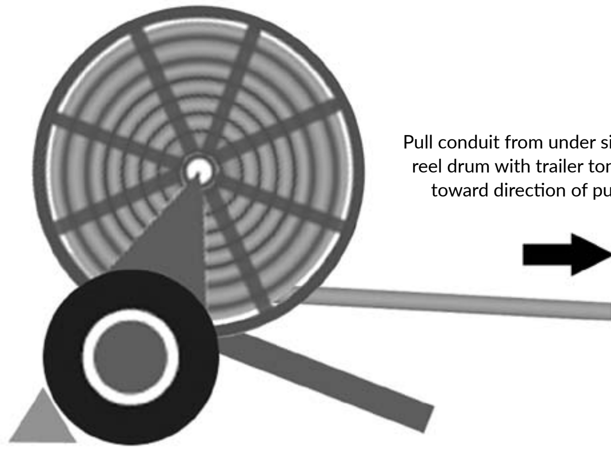
Open trench—stationary reel installation method

Stationary reel installation

Mount the reel so the conduit pays off the bottom of the reel, along the direction of pull. Make sure the conduit is capped.

Cable withdrawal can be determined as you reach the far end of the trench. **MAKE SURE YOU FIND THE END OF THE CABLE AT THE FAR END BEFORE YOU CUT THE CONDUIT AT THE REEL END.**

NOTE: See cable withdrawal in general conduit installation practices—page 6.



Open trench backfilling method

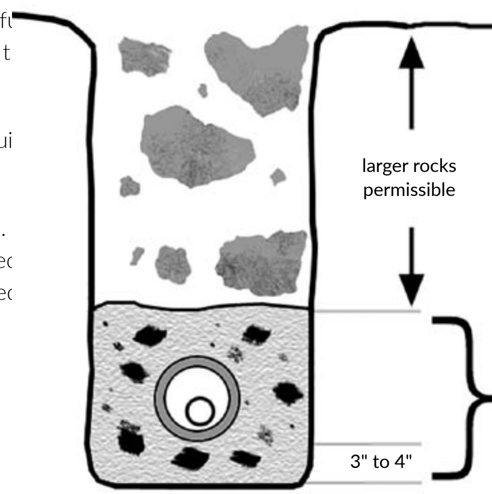
It is best to place the softest soil directly on and around the conduit. DO NOT place large rocks directly on the conduit. Allow at least 2–4 inches (5–10 cm) of dirt to cushion the conduit.

Tech tip: Backfilling in lifts of about six inches, compacting each lift before starting the next, will help prevent the trench from sinking.

Best practice to ensure long-term protection of underground facilities is to utilize sand for padding the conduit. Sand provides a more stable environment for the conduit, prohibiting damage from rocks and allowing water to drain away easily. Sand also provides protection during fu n provides warning that there is a utility present. Sand alone should not replace t s a supplemental protection practice.

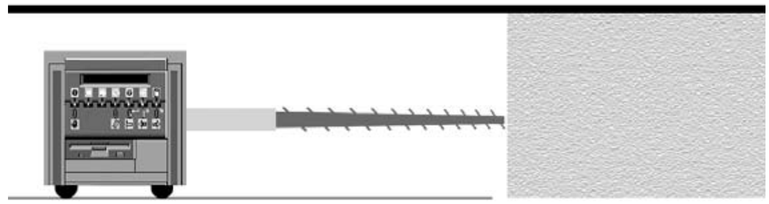
Place warning tape in the back-fill process. Fill the trench and compact as requi the trench from "sinking" later.

Conduit organizers should be used when placing multiple conduits in a trench. nd each other—by keeping the conduits in alignment, cable pulling tensions are rec using an extremely wet concrete slurry, floating of the conduit can be restrictec



Conventional boring installation method

Mechanical boring machines may be utilized to push an auger (jack and bore) to make an adequate conduit passage. The auger diameter should be 1 inch (2.5 cm) larger diameter than the conduit being installed. The equipment manufacturer should support the operation instructions for this equipment. In general practice, the setup should be done so the auger is oriented in the direction of the receiving pit.

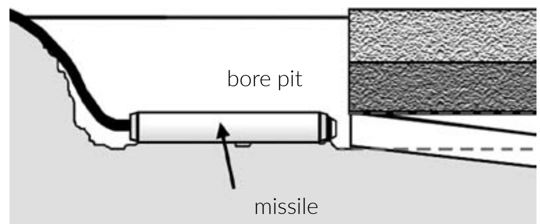


Pneumatically driven pistons (missiles) may be used as well. The missile diameter should be 1 inch (2.5 cm) larger diameter than the conduit being installed. The equipment manufacturer should support the operation instructions for this equipment. The operation of this equipment requires skills that can be acquired only through practice. Soil conditions will determine the orientation of the missile when starting it. Some examples are:

In standard soil conditions, the missile will usually be pointed down slightly to compensate for the natural tendency of it to rise, as the soil above it offers less resistance to it than the soil beneath it.

In sandy and wet soil conditions, the missile will usually need to be pointed slightly up to compensate for the natural tendency to sink, as the soil is unstable and offers little support beneath it.

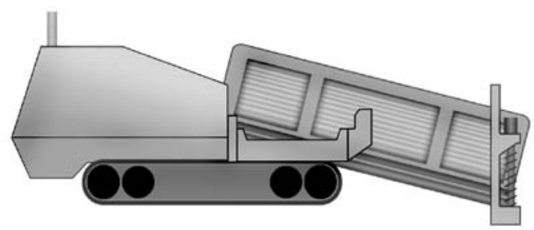
In extremely dense and hard soils, the missile will usually need to be pointed level since the soil is more uniform in density above and below.



HDD—horizontal directional bores*

Directional boring is accomplished by using a steerable drill stem. The equipment operator can control the depth and direction of the boring. Very long bore lengths can be accomplished by using directional boring devices.

Subsurface crossings are generally accomplished by digging a trench on each side of the crossing to allow guiding and retrieval of the drill stem. The construction equipment manufacturer specifies detailed equipment operation and excavation procedures.



Generally, a bore should be kept as straight as possible. The hole may be enlarged using reamers. The reamer should be at least 1.5x–2x larger in diameter than the conduit being installed. A larger "outer" conduit should be installed at strategic locations (e.g., street crossings) for use as a sleeve for smaller conduit.

After the bore is complete, attach the conduit to the drill stem with the appropriate grip and swivel. Pull the drill stem/back reamer and conduit through the bore. Longer pulls will require tension monitoring. The back reamer size will be determined by the size and number of conduits being pulled.

General process

- Set up equipment according to manufacturer's recommendations and good practices
- Do an pre-construction walkover and inspection
- Prior to drilling, mix drilling fluid in quantity required
- Excavate surface entry pit to contain drill fluid and allow for drill stem angle entry
- Use correct drill bit for ground conditions

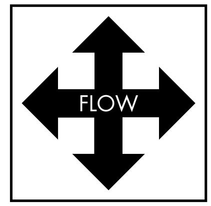
CommScope best practice recommendations

- Best practice—use reamer 2x larger than the pipe outer diameter.
- Drilling fluid—the correct fluid quantity must be mixed prior to drilling. An incorrect mix could result in high friction and fluid loss in the soil. Long pulls require a correct mix and quantity to reduce friction on the pipe.

*Source Cited: 'Horizontal Directional Drilling—Good Practices and Guidelines' published by HDD Consortium/NASTT.

The drilling square*

The factors that make a successful bore are too interrelated to be able to point a finger at any one of them as being the cause of a problem in all cases. Therefore, these factors are best placed in the form of a square. The drilling square is a simple and useful tool to remembering the four factors affecting fluid flow, which is the key to successful horizontal directional drilling.



Soil
Soil is classified in two general conditions: coarse soils and fine soils. Coarse soils are classified by material weight, not material size, as:

- Sand
- Gravel
- Rock

Coarse soils create ground conditions with high porosity and permeability. They are non-reactive, do not swell, and do not get sticky.

Fine soils are classified by moisture content:

- Clay
- Shale

Fine soils are reactive and can change with moisture content. They swell and get sticky.

Fluid
There is no universal soil; therefore, there is no universal drilling fluid. Drilling fluid provides soil stabilization, lubrication and means to carry away the cuttings and suspend cutting when fluid is not in circulation. To achieve this requires the proper blend of material for the type of soil(s) being drilled through. Your material supplier should be able to provide you with appropriate mix rates of the various materials to achieve this.

Before the materials can be mixed with water, the water must be treated for calcium and pH. Soda ash needs to be added at 1–4 lbs/100 gallons. Soda ash will decrease the calcium (hardness) and increase the pH. Water hardness should be ≤50 ppm. Soda ash will also increase the pH of the water. The water pH should be 8.5 to 9.5. This is the most important step to assure optimal hydration of the bentonite and polymers.

Bits/reamers
There are many options on bits and reamers.

Wider blades can be used for better steering in soft ground. In hard ground, stepped or tapered carbide bits may be better. Bits are designed with replaceable carbide inserts for rock (or soil that wants to act like rock). The point is that bits can be matched to the soil type.

At the exit point, observe the condition of the bit to see if any changes need to be made to the fluid or reamer selection. For example, if a bit is balled up with clay, a wetting agent probably needs to be added to the fluid to prevent stickiness. A reamer that will chop up the clay to prevent large pieces from bridging off behind the reamer may be needed. If any unexpected rocks are encountered, it may be necessary to use a fluted or spiral reamer to press them into the side of the borehole. Bit/reamer selection and possible fluid changes are all dictated by the soil.

Volume
All the right decisions up to this point could be made and still have a failure by not pumping enough fluid. In a nonreactive soil such as sand, it may be possible to produce a flowable slurry with as little as 1 to 1½ gallons of fluid per gallon of soil, especially on short shots. This can be done because sand is inert. It doesn't swell. It doesn't get sticky. Clay, on the other hand, can do both. Because of this, 3 to 4 gallons or more of fluid may be required per gallon of clay soil in order to maintain flow.

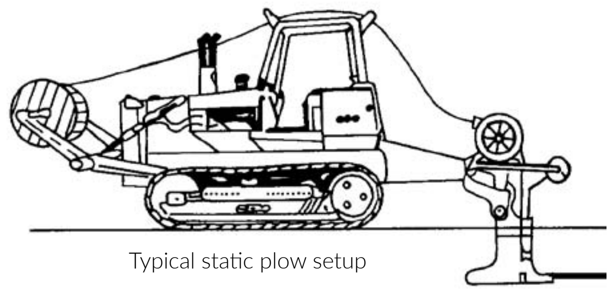
There's no universal soil. Because of this fact, there's not a universal fluid, bit or reamer. Nor is there a universal volume of fluid to be pumped per gallon of soil. Everything is interrelated.

*Source Cited: 'The Drilling Square' published by Baroid.

Static plowing method

A tractor moves slowly forward as the blade splits the earth and places the conduit at the required depth. Because terrain and soil types vary, contact your plow manufacturer for their equipment recommendation. CommScope strongly recommends a professionally engineered single- or double-feed tube plow blade with a tube at least 0.5 inch (1.25 cm) larger than the largest conduit size and a radius no smaller than the minimum bend radius of the largest conduit size. Select a plow blade with an area at least 1 inch (2.5 cm) larger than the conduit. At minimum, an operator and a helper/feeder are needed for plowing installation.

Local regulation may require (and CommScope strongly recommends) that warning tape be plowed in with the conduit. Most plow manufacturers make plow blades that bury conduit and tape at the same time.



Typical static plow setup

Dig a trench deep enough and at least twice the length of the plow blade/chute for the plow blade to enter it comfortably. A similar trench should be dug at the other end of the installation. The conduit may pay-off from the front of the tractor or from a stationary conduit reel.

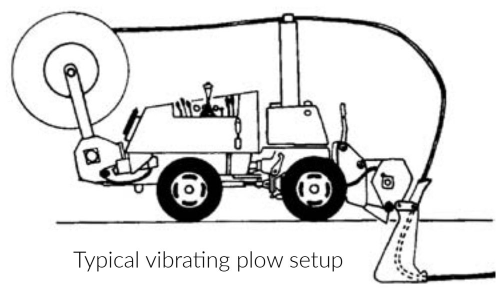
Cap or tape the conduit end. Remove the back plate from the blade and inspect the feed tube for burrs, rough surfaces and sharp edges. Clean out any dirt or rocks. Make sure the plow does not exceed the loaded minimum bend radius of the conduit. Carefully place the conduit in the feeder tube. Reattach the back plate.

Carefully pull enough conduit through the blade to allow for splicing and storage. Have someone hold the conduit end to keep it from being pulled as the tractor initially moves forward.

Make sure the reel does not run into objects that may damage the conduit. Pay the conduit over the top of the reel. Do not use reel brakes.

Vibratory plowing method

Vibratory plowing can offer substantial productivity gains over other direct burial methods. A tractor (usually smaller than that used in static plowing) moves slowly forward as a vibrating blade splits the earth and places the conduit at the required depth. Because terrain and soil types vary, contact your plow manufacturer for their recommendation. We strongly recommend a professionally engineered single- or double-feed tube plow blade with a tube at least 0.5 inch (1.25 cm) larger than the largest conduit size and a radius no smaller than the minimum bend radius of the largest conduit size.



Typical vibrating plow setup

At minimum, an operator and a helper/feeder are needed for plowing installation. Local regulations may require (and CommScope strongly recommends) that warning tape be plowed in with the conduit. Most plow manufacturers make plow blades that bury conduit and tape at the same time.

Dig a trench deep enough and at least twice the length of the plow blade/chute for the plow blade to enter comfortably. A similar trench should be dug at the other end of the installation. The conduit may pay-off from the front of the tractor or from a stationary reel along the route. In the tractor method, pay the conduit over the top of the reel. Do not use reel brakes.

In the stationary reel method, pull the conduit end from the reel to the starting trench. **Use safety cones to mark and protect the conduit from pedestrian and vehicle traffic.**

Remove the back plate from the blade and inspect the feed tube for burrs, rough surfaces and sharp edges. Clean out any dirt or rocks. Cap or tape the end of the conduit. Carefully pull enough conduit through the blade to allow for splicing, etc. Reattach the back plate. Have someone hold the conduit end to keep it from being pulled as the tractor initially moves forward. Have a worker manually feed the conduit into the plow blade once the blade is completely in the ground.

Start the vibrator after forward movement begins. Have the blade in solid contact with the earth before applying full RPM. **DO NOT VIBRATE IN PLACE FOR MORE THAN 30 SECONDS.**

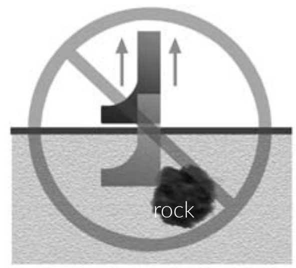
Handling obstructions

If obstructions (tree roots, large rocks, etc.) are encountered, disengage the transmission, turn the engine off and then disengage the clutch. **NEVER BACK PLOW WITH THE CONDUIT IN THE FEED TUBE**. This will damage the conduit and pack dirt in the feed tube.

Carefully dig a pit behind the blade. **REMOVE THE CONDUIT FIRST,** then remove the obstruction. Replace the conduit and proceed with the installation.

Turning
Gentle turns can be made over a distance of 5–8 feet (1.5–2.4 meters.) Never turn the blade unless tractor is moving forward. Some manufacturers make steerable blades.

Lifting the blade
If ABSOLUTELY necessary (for instance, avoiding a buried utility line), the blade can be gradually raised at a rate of 8 inches (20 cm) over a 5 foot (1.5 meter) run, lower the blade at the same rate once the underground hazard has been passed. Do not raise the blade to ground level with conduit in the feeder tube.



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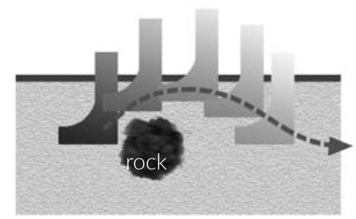


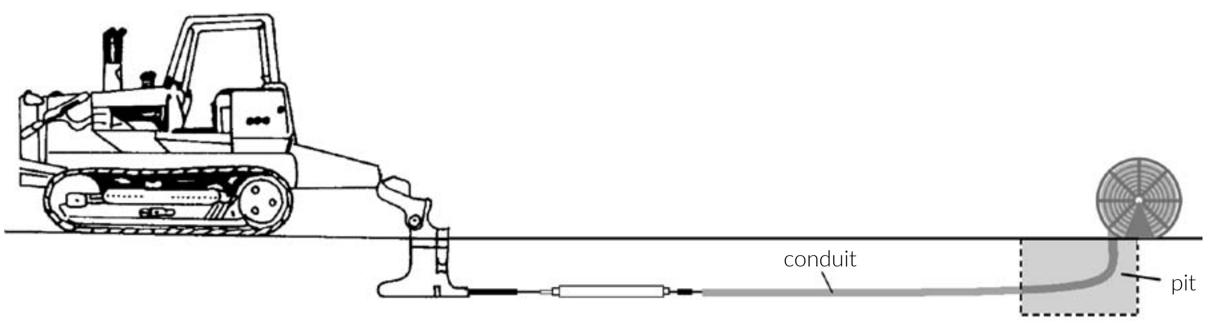
correct

Pull plow method

This method requires the use of a vibrator box attachment. Select a plow blade with a circular area at least 1 inch (2.5 cm) larger than the conduit. This expanded area will provide a path for the conduit that will reduce the amount of pulling tension associated with side wall pressure.

A tag-behind bullet can also be used. Attach the bullet to the plow blade with a short length of chain. Attach the other end of the bullet to a pulling swivel and grip to pull the conduit. Cap or tape the conduit end.

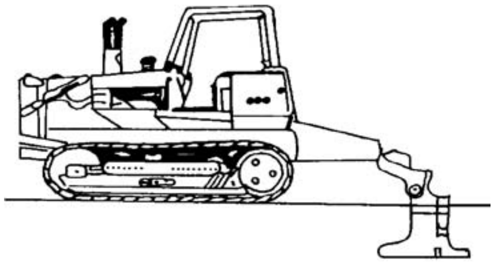
Overpulling can relieve pulling tension in longer pulls. Pull the conduit to an intermediate trench and overpull through the pit.

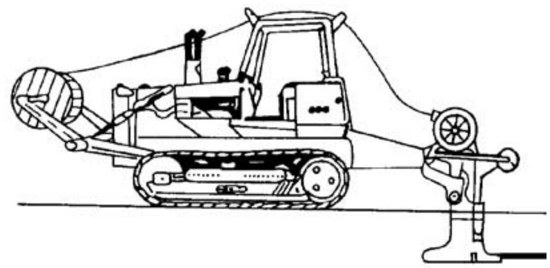


NOTE: Loose soil (such as sand) will decrease the length a conduit can be pulled due to soil collapsing around the conduit—effectively increasing the pulling tension! This same effect will also occur in wet clay-type soil.

Rip and plow method

Rip and plow using two tractors: If you anticipate obstructions (like roots and large rocks) along the installation path, you may want to consider a rip-and-plow installation. In rip and plow, a lead tractor rips the ground by pulling a plow without conduit several hundred yards/meters ahead of the tractor with the conduit. The first tractor clears the route and permits the second tractor to work more efficiently.

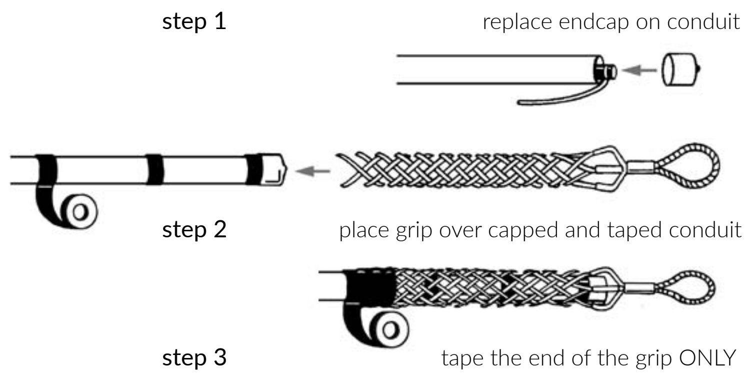




Pull plowing

Use a plow blade with a circular end approximately 1½–2 inches in diameter. This will allow conduit sizes up to 1 inch in diameter to be plowed.

Apply bands of tape at 5-inch (2-cm) intervals from the conduit cap back to the point where the basket pulling grip will end. The tape only has to be applied in single-width bands but must be at least 1/16 inch (.03 cm) thick. Place the grip over the capped conduit and bands, then pull the grip to tighten its grasp on the conduit. To help hold the grip in place, tape needs to be applied to the conduit and then wrapped onto the end of the grip. Do not extend the tape beyond the first three inches of the end of the grip.



Existing conduit installation

ConQuest products are also designed to be placed into existing conduit systems. An example is the placement of one or more conduits inside a larger conduit. Multiple conduits should be placed at the same time.

ALWAYS test and ventilate manholes prior to entering them and follow OSHA confined space requirements.

An important step that should be taken prior to this type of work is "proofing" the existing conduit. This process will ensure that all obstructions are cleared and that conduit continuity and alignment are good. It is recommended that a rigid mandrel roughly 90 percent of the inner diameter of the conduit be used to perform the proof.

Proofing conduit is typically performed by pushing a fiberglass fish with a rigid mandrel attached through the conduit. Any problem areas felt by the person pushing the mandrel can be marked on the fish so the distance to the problem is recorded, and can be located and repaired with greater ease. If the mandrel makes its way through the conduit without any difficulties, the conduit has proofed out and no repairs should be necessary.

Specialized equipment is required for existing duct installations. Sheaves, bending shoes, rolling blocks (45 and 90 degrees) and straight pulleys are used for protection of the conduit. It is important that they all meet the proper radius for the conduit size. The use of a pulling lubrication will greatly reduce the surface tension and stress on the conduit when pulling conduit into an existing conduit. The use of ball-bearing swivels is also required for attaching the winch line to the conduit harness system.

On long routes and routes with multiple turns, it is important to consider mid-assist locations. There are different ways of providing mid-assist for conduit pulls. Typically, the use of a winch such as a come-a-long or a vehicle winch is required. The introduction of mid-assist wheels has made conduit pulling an easier task, requiring less manpower and communication than traditional winching. Mid-assist wheels also provide greater production capabilities.

The stress of pulling conduit through existing conduit will vary with the length of the route, the number of turns, the condition of the conduit, and the amount of lubrication used. The effects of the stress will cause the conduit to elongate (or stretch) in proportion to the amount of stress, but typically less than 2 percent of the total length placed. For this reason, it is important to pull past the conduit slightly. At least one hour needs to be allowed for the conduit to "relax" before cutting and trimming.

Mark the winch line 50 feet before the attachment to the conduit; this will provide advance notice of the arrival of the conduit and prevent injury or damage to the equipment.

Submarine construction

Occasionally there will be a need to install conduit underwater, crossing a tidal basin, lake, or river. While conduit is suitable for this application, it requires special installation procedures to address the buoyancy of the conduit.

A logical route must be planned based on what is believed to be down there awaiting the conduits. Then a route survey must be done to determine actual terrain conditions, and the route adjusted accordingly before beginning construction.

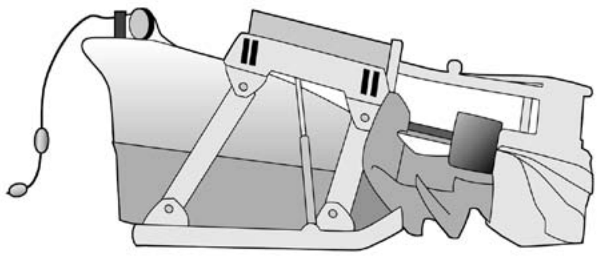
Research is required before a conduit lay is even planned and regulatory approvals must be obtained.

Submarine plowing method

There are two basic methods of submarine construction used, sub-aqueous terrain plowing and floor surface placement.

Sub-aqueous terrain plowing

Construction with this method can be accomplished with one of several technologies designed for this special task. Installation with this method can eliminate the issues of buoyancy if the conduit is buried deep enough. It also offers the best protection from fishing activity, boat anchors, tidal and current effects, and other submarine hazards. Burial depths need to be varied based on the soil conditions to provide adequate protection.



Self-propelled bottom crawling vehicles are operated in the same manner as track-driven plows. These are land-based bulldozers with a sealed diesel engine outfitted with special snorkeling equipment for the air intake and exhaust manifold. While most are operated manually, there are a growing number of remote-controlled units being employed.

Large sled-type conduit plows are designed to be towed by a powerful boat. This has been the standard plowing method for many years. Plowing may be started and completed on the shoreline. Shoreline finishes can be completed using a tractor to finish the pull in water too shallow for the boat from the shore.

Jet-assisted plows are similar to the sled-type plows and are also towed by a powerful boat. The difference is that jet-assisted plows use forward-aiming high-pressure water jets to fluidize the soil and rear-aiming low-pressure water jets to direct the fluidized soil to the rear. The forward water jets “open” the trench for the conduit to be placed in before the fluidized soil pushed back by the rear jets settles and starts the backfill process.

Floor surface placement

In this method of construction, the conduit is placed on the floor of the body of water. Conduit must be weighted to increase its displacement volume to overcome the effects of buoyancy.

This chart lists the displacement volume for ConQuest conduits.

Conduit size	Displacement volume
1 inch	.0094 cubic feet
1.25 inches	.0150 cubic feet
1.50 inches	.0197 cubic feet
2 inches	.0308 cubic feet

This chart lists the weight per cubic foot of water the conduit displaces.

Water type	Pounds per cubic foot
Fresh	62.43
Salt	63.99

So how much weight is needed?
To calculate the weight needed to overcome buoyancy the appropriate displacement volume is first multiplied with the appropriate weight per cubic foot of water to obtain the gross buoyancy of the conduit.

The next step is to factor in the weight of the conduit and the cable, which will offset some of the buoyancy. Conduit weights can be found in the specifications section. Cable weights for CommScope cables can be found in the cable catalog. Subtract the per foot weight of the conduit and the cable from the gross buoyancy to obtain the net buoyancy.

The answer...
In slow-moving or non-tidal waters where there is no prop-wash or dragging anchors, multiply the net buoyancy per-foot by 4 times to obtain the anchor weight.

In fast-moving and tidal waters, multiply the net buoyancy per foot by 10 times to obtain the anchor weight.

What to use...
Buoyancy compensation can be accomplished using:

- Class C-type galvanized strand(s) lashed to the conduit with dielectric lashing to retard corrosion

Or by anchoring with:

- Cinder blocks
- Concrete bags
- Sand bags

Placement of the weight must be equally distributed and meet minimum interval requirements to prevent the buoyant sections of conduit from bowing between anchor locations. Spacing is dependent on the expected turbulence of the water. In fast-moving and tidal waters, anchor weights should be spaced in the shorter recommended interval.

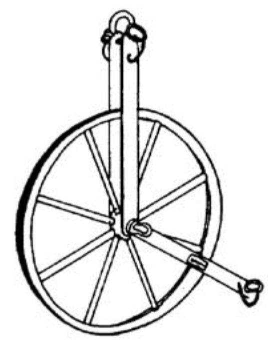
The appropriate interval of anchor weights for conduit sizes 1.25 inches and smaller is 2–3 feet. At 2-foot intervals the anchor weight is multiplied by 2 for each anchor. At 3-foot intervals the anchor weight is multiplied by 3 for each anchor.

The appropriate interval of anchor weights for conduit sizes 1.50 inches and larger is 3–4 feet. At 3-foot intervals the anchor weight is multiplied by 3 for each anchor. At 4-foot intervals the anchor weight is multiplied by 4 for each anchor.

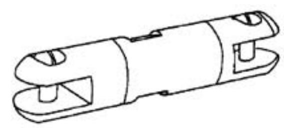
Underground equipment

Shoe, cable
This equipment is used to route conduit through manholes while the conduit is being pulled into place. Placement of the cable shoes will prevent the rubbing of the conduit on obstacles within the manhole.

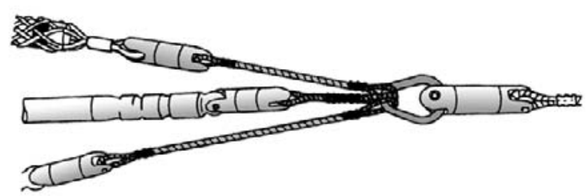
Sheave
This equipment is used to facilitate the movement of conduit that is being pulled into place through a manhole. Sheaves are free wheeling and accordingly add little drag to the conduit that is being installed. The placement of the sheave will prevent the rubbing of the conduit on obstacles within the manhole.



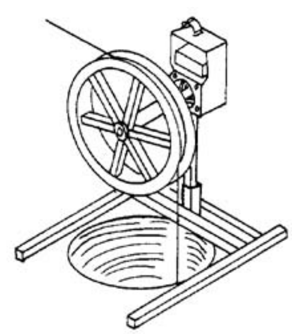
Breakaway swivel
Used to prevent excessive pulling tension. It is designed to break should it exceed a preset tension limit.



Pulling sling
Used to prevent both excessive pulling tension and twisting of conduits in multiple-conduit installations. It is designed to break should it exceed a preset tension limit.



Winch, cable
A cable winch is a powered capstan used to pull cable. This equipment will often be used as an intermediate assist in pulling cables or conduits that are very long or have considerable drag.



Come-a-long
This equipment is used to facilitate the movement of innerduct that is being pulled into place through existing conduit.

NOTE: See Appendix for additional conduit cutting tools, couplers and accessories

Pulling cable into conduit

There are many variables to consider when pulling cables, and each pull is considered unique. The most important variable to consider is the maximum pulling tension of the cable, which may be found in one of CommScope's product catalogs.

To determine how far cable may be pulled without exceeding the maximum pulling tension, the following factors must be considered:

- **The route geometry,** which consists of:
  - The number of bends
  - The angle and direction of the bends
  - The location of the bends
  - The distance between the bends
- **The fill percentage of the cable(s) in the conduit**
- **The number of cables being pulled in the conduit**
- **The configuration of the cable being pulled in the conduit**
- **The friction between the cable and the conduit**
- **The back tension created at the setup**

These variables may be used to help calculate an ESTIMATED pulling tension. It is important that proper construction techniques and a breakaway swivel rated for the maximum pulling tension of the cable are used to ensure that the maximum pulling tension is not exceeded. The use of a breakaway swivel will also help minimize the effects of twisting force. Twisting forces are created by the pull rope (or tape) and by the cable.

Route geometry

Route geometry is an important contributor to pulling tension. The lowest pulling tensions are found in straight sections of conduit. Low sidewall pressure (LSWP) occurs in horizontal straight sections of conduit. SWP is caused by the weight and friction of the cable against the conduit, with a minimal amount of force being applied to the cable's jacket. **For calculating LSWP see page 37.**

In bends, the amount of force applied to the cable jacket increases exponentially. This is known as high sidewall pressure. The more severe the bend radius of the conduit the higher the sidewall pressure will be. The effects of high sidewall pressure (HSWP) can include rope burn-through in the bend and cable damage. **WHUPP!®** cable pulling lubricant will help reduce pulling tensions and rope burn-through by greatly reducing friction. **For calculating HSWP see page 38.**

It is much easier to pull through the greatest number or most severe bends first and then through the longest straight sections.

Conduit should be placed as flat and level as possible to maintain low pulling tensions. When the conduit is installed on an incline, typically due to terrain features, pulling tensions may be reduced by pulling the cable down hill, working with gravity rather than against it.

Fill percentage

The fill percentage, sometimes referred to as fill ratio, is the amount of space that cable(s) occupy inside the conduit as a percentage of the inner diameter of the conduit.

The greater the fill percentage the higher the sidewall pressure will be. This is critical when constructing the conduit run. Bends should be made more gradual when fill percentages are high. ConQuest cable-in-conduit products are typically designed not to exceed 30 percent fill. Recommended practices suggest that fill percentages should be at or below 60 percent.

Multiple cables

It is preferred for each cable to have its own conduit—though, often, multiple cables must be placed in a single conduit. Installing multiple cables or installing a single cable in a conduit with existing cables requires some special planning. Recommended practices suggest that multiple cables be pulled together.

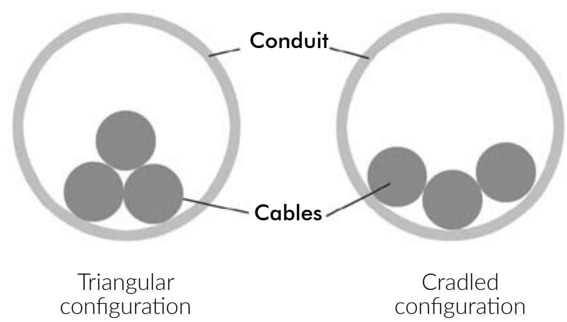
The fill percentage must be considered to ensure there will be room enough for all of the cables, particularly in the bends. **NOTE:** Refer to Fill Percent Calculation Table in the Appendix.

Another important consideration is the configuration of the cable in the conduit. There are two defined configurations for multiple cables: **triangular** or **cradled**.

A cable configuration is considered triangular when the conductors maintain a triangular pattern in the conduit. A cradled configuration is when the cable has a random lay in the duct and is preferred.

The cradle configuration will permit higher fill percentages and lower pulling tensions. A pulling harness should be used when multiple cables are pulled in together. A swivel should be used to connect the pull rope to the harness and each cable should be connected to the harness with its own breakaway swivel. This method will prevent triangular configurations.

The lowest maximum pulling tension value of the cables being installed should be used in pull tension calculations being made for multiple cable installations.



Pulling multiple cables

Slings or harnesses are designed to attach multiple cables or innerducts to a single pull line. They can be built for any number and size of cable/inner duct.

Back tension

Back tension is the amount of force needed to pull cable directly from the reel. Since the amount of cable on the reel, the weight of the reel and the friction of the reel on its setup through bar will vary, it is difficult to provide a rule of thumb for back tension. Attaching a spring scale or dynamometer to the cable and then pulling the cable with the measuring device can determine back tension.

The best method for reducing back tension is to have a reel tender (worker) to assist the reel with spinning and pay-off. **Do not pull cable from reel by hand.**

Reel braking
If required, use an arbor brake with very light pressure—just enough to prevent the reel from over-spinning. Alternate—use a wood board such as a 2 x 4. Do not use hands to stop a spinning reel—serious injury could result.

NOTE: It is recommended to use a piece of lumber (2 inches x 4 inches / 5.08 cm x 10.16 cm) to stop or regulate the spinning reel.

Pull calculations

Maximum pull lengths, pulling tension at the end of a straight section of conduit, pulling tension at the end of a bend, and sidewall pressure can be calculated quite easily. However, it is important to remember that these calculations are only estimates. This is due to the significant variances in construction practices and lack of accounting for:

- Undulations, rising, falling, and straightness of the straight sections of conduit
- Cable stiffness
- Lubrication, coefficients of friction, foreign debris in conduit

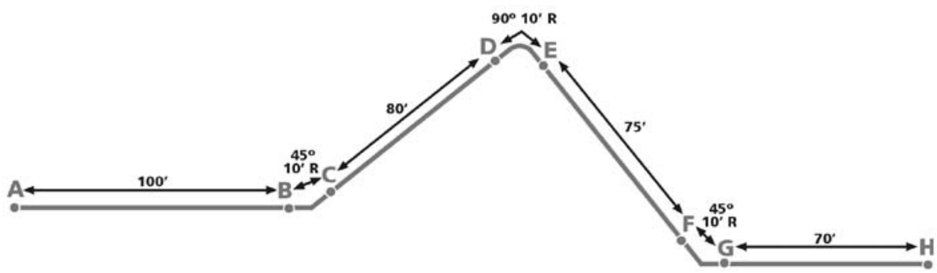
Calculating a complete run
An example provides a clear illustration of how to calculate a complete run and understand the effects of bends on pulling tensions and sidewall pressure. Calculations have been performed in both directions. In the first calculation, the run has the reel set up at point "A" with the cable being pulled from point "H". The second calculation is the opposite with the reel set up at point "H" and the cable being pulled from point "A". The cable used is QR715. The formulas used for calculating this run are located in the Appendix.

The resulting calculations for this run are:

Pulling from A to H = 64 pounds pulling tension

Pulling from H to A = 54 pounds pulling tension

NOTE: The direction of pull and distances between bends can have a dramatic impact on pulling tensions.



Aerial installation

There are many applications for aerial conduit, some of which are road crossings, rail crossings, trolley line crossings, and water crossings. Aerial conduit provides an efficient means for supporting cable and is easily accessed without requiring encroachment in hazardous or difficult spaces.

When selecting aerial conduit, it is important to consider the environment where it will be placed. Constant direct exposure to UV radiation and ozone deteriorates the life of plastics such as polyethylene, the material used to manufacture conduit. Colored conduit has a lower tolerance to UV exposure and will have a shorter life. It is strongly recommended for aerial applications that black conduit be used. Black has a much higher tolerance to UV exposure and will provide a much longer life of usefulness than other conduits.

It is strongly recommended that black conduit be used for aerial applications.

Back-pull/stationary reel method

The back-pull/stationary reel method is the usual method of aerial conduit placement. This method is also best suited for locations where the strand changes from the field side of the pole to the street side of the pole and where there are excessive obstacles to work around. The conduit is run from the reel up to the strand then pulled in a direction away from the reel and is held aloft by the cable blocks and rollers. Once the section of conduit is pulled into place it is lashed and then cut.

Set-up chute placement

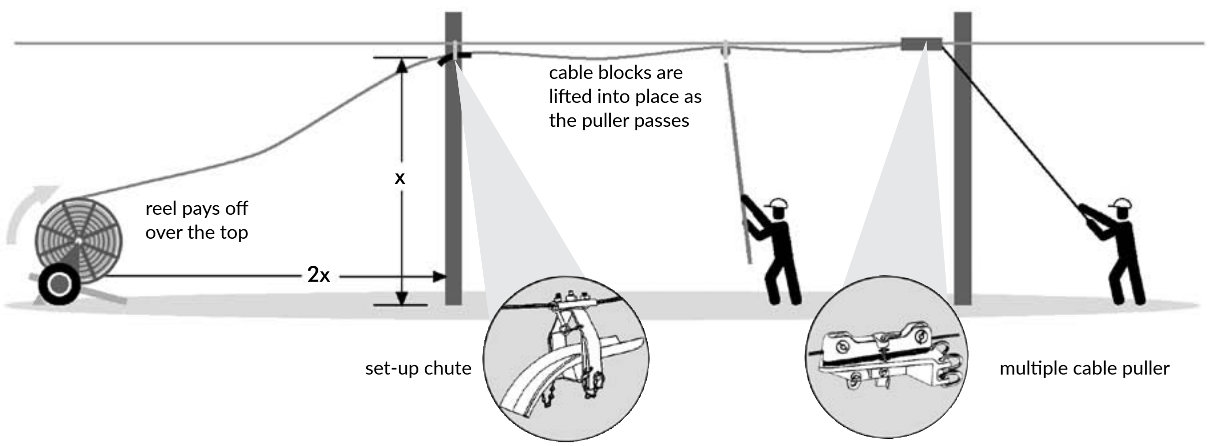
The set-up chute should be positioned on the first pole of the conduit route or attached to the strand at the first pole. Placement of the set-up chute should keep the conduit from rubbing on the reel or pole. Either a 45 degree or 90 degree corner block may be used as a set-up chute.

Trailer set-up

The trailer should be positioned in-line with the strand and twice the distance of the set-up chute to the ground from the set-up chute. This prevents the conduit from rubbing on the pole or reel or binding on the chute. If the trailer cannot be positioned there, move the set-up chute and the trailer to an adjacent pole.

The conduit should pay-off the top of the reel. The pay-off of the conduit from the reel should cause a downward force at the hitch of the trailer.

Chock the trailer wheels. Adjust the reel brakes as needed. **Place protective barriers and cones as needed to protect pedestrians.**



Cable puller set-up

Place an appropriate cable grip on each conduit. Secure the grip to the conduit with tape to keep the conduit from backing out of the grip should the pulling tension be relaxed.

Place the cable puller on the strand and close the puller gates to secure the puller to the strand.

Attach a hand-pulling line to the cable puller, or a pulling line from the cable puller to a winch. Place cable blocks to support the conduit as it is pulled. The cable puller has an internal brake that prevents the cable puller from moving backwards on the strand when the pulling tension is released. **Do not overspin the reel—keep the conduit wraps tight.**

NOTE: Basket grips are typically used on 1 inch and smaller sizes of conduit. Screw-in or expansion pulling eyes should be used on 1¼ inch and larger conduits.

Passing the cable puller at poles

Pull the cable puller to the pole and release the tension in the pulling line. Pass the conduit across the pole face and the pole/line hardware, and attach the cable puller back to the strand. Place cable blocks on each side of the pole.

At corner block locations, pass the cable puller to the opposite side of the pole and route the conduit through the corner block.

Cable block/corner block placement

Place corner blocks at all corners greater than 30 degrees in the pole line. **NEVER PULL CONDUIT OVER THE END ROLLERS OF CORNER BLOCKS** as they will flatten and deform the conduit.

At corners less than 30 degrees, cable blocks can be placed on the strand several feet from and on each side of the pole/line hardware. The cable blocks should allow the conduit to move through the corner without undue bending or drag.

Power winching methods

Power winching a pull line to install conduit is a method often used when the pole line is obstructed or is in extremely rough terrain because the pull line can be placed without tension concerns. In winching, the pull line is attached to the cable puller and run along the strand. Roller blocks should be placed along with the pull line. Once the pull line is run, it is attached to the conduit.

Carefully tension the pull line and begin pulling. Adjust the reel brakes to prevent undue pulling tension. Real-time tension monitoring is required. Radio communications between the lineman observing the pull-out and the winch operator is required. Intermediate conduit handling may be required as the pulling grips approach cable and corner blocks.

Installation—overlashing existing cable

Overlashing conduit onto existing cable plant is similar to installing conduit onto new strand. However, there are some unique aspects.

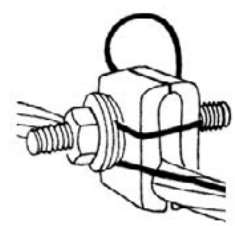
A sag and tension analysis should be performed to see if the new load will overwhelm the strand.

Use special overlash cable puller blocks and continuously maintain and monitor the pulling line tension. Overlash cable pullers do not have a strand brake and will be pulled backward on the span by the tension in the conduit being pulled.

Use cable blocks designed specifically for overlash applications. Place them onto the cable bundle with a cable block lifter and lift the conduit with a cable lifter. During lashing, remove the cable blocks from the cable bundle with a cable block lifter. **DO NOT PUSH THE CABLE BLOCKS in front of the lasher as that may damage existing cables.**

Attach the lashing wire clamp

Place the lasher on the strand. Wrap the lashing wire twice around the strand in the same direction as the twist in the strand and in the lay of the strand. Pass the lashing wire between the washers of the lashing wire clamp (bugnut) without overlapping the wire. Wrap the wire around the clamp to the post on the opposite side of the clamp and wrap it twice around the post. Cut the wire and tuck it between the halves of the lashing wire clamp.



lashing wire clamp (bugnut)

NOTE: It is essential that double lashing wire is used when lashing conduit, and it is recommended that two lashing runs be made over street, railroad, trolley, and water crossings.

Place the conduit within the lasher. Pull the lasher toward the reel with a rope. It is important to minimize the sag on conduit as it enters the lasher. Leave the cable blocks in place until the lasher is close enough to support the conduit. As the lasher approaches cable blocks, either remove them with a cable block lifter or push the cable blocks to the next pole by utilizing a cable block pusher.

Passing the lasher at the pole

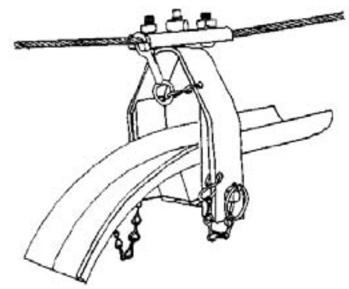
Pull the lasher toward the pole to be passed. Attach a lashing wire clamp to the strand. Remove the lasher from the strand and move it across the pole-face to the strand and cable on the opposite side of the pole.

Put the conduit into the lasher. Close the gates to prevent the lasher from being pulled backward along the strand. Cut the lashing wire from the lasher and secure the lashing wire to the lashing wire clamp. Make sure the lashing wire does not loosen from around the conduit. Attach the appropriate straps and spacers as needed. At the back end of the lasher, attach a lashing wire clamp to the strand about to be lashed. Attach the lashing wire to the clamp. Continue lashing as before.

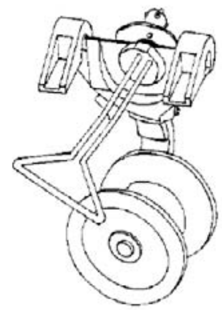
Carefully rotate the conduit reel to take up any excess conduit slack prior to lashing each section.

Aerial equipment

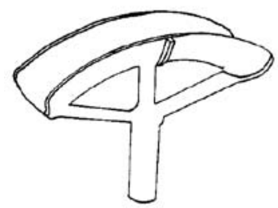
Set-up chute
A set-up chute is used to guide the conduit from the reel trailer to the strand.



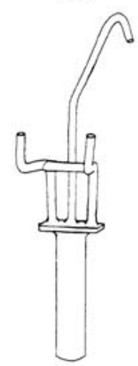
Single roller block
Used to support conduit prior to lashing.



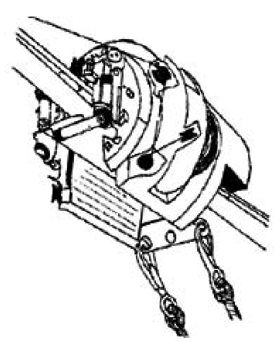
Cable lifter
This tool may be used to lift conduit into place and is helpful to ensure that the conduit being lifted is not damaged by exceeding minimum bend radius.



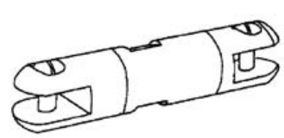
Cable block lifter
Used in conjunction with a lay-up stick to place assorted cable blocks mid-span.



Lasher
Traditionally used to lash cable to strand it may also be used for lashing conduit to strand. Lashers are somewhat specific to cable and strand size—improper lasher size or adjustment can prohibit installation of conduit to strand.



Breakaway swivel
Used to prevent excessive pulling tension. It is designed to break should it exceed a preset tension limit.



Toneable conduit product overview

CommScope toneable conduit utilizes an embedded 18 AWG tone wire to facilitate conduit location once installed. The 18 AWG copper-clad tone wire is applied to the outside of the conduit during the manufacturing process. The tone wire is embedded in a layer of HDPE for corrosion and electrical protection. Narrow webbing connects the wire to the conduit for ease of access for splicing. A cross-section of toneable conduit is shown in figure 1.

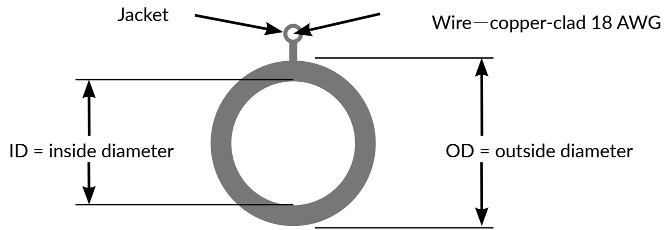


Figure 1

Toneable conduit is available in ¾-inch through 2-inch diameters. Specifications are shown in Table 1.

It is important to note that the tone wire is for location testing only, and is for signal location transport up to five watts of power. Using insulation leakage test devices is not recommended, as the wire is not rated for high voltage (these test sets can reach up to 1000 volts) or high amps.

Coupling

Conduit size	CU-clad wire size AWG	Outside diameter (inches)	Wall thickness (inches)	Nominal inner diameter (inches)	Min. bend radius unsupported (inches)	Max. pulling tension (lbs)	Weight (lb/ft)
3/4" SDR 11	18	1.050 ± 0.005	0.095 ± 0.020	0.84	20	687	0.128
1.00" SDR 13.5	18	1.315 ± 0.007	0.097 ± 0.020	1.101	26	894	0.166
1.25" SDR 13.5	18	1.660 ± 0.008	0.123 ± 0.020	1.394	34	1,425	0.263
1.50" SDR 13.5	18	1.900 ± 0.010	0.141 ± 0.020	1.598	38	1,867	0.344
2.00" SDR 11	18	2.375 ± 0.012	0.216 ± 0.026	1.917	48	3,515	0.642
2.00" SDR 13.5	18	2.375 ± 0.012	0.176 ± 0.021	2.002	48	2,917	0.534
2.00" SCH 40	18	2.375 ± 0.012	0.154 ± 0.020	2.047	48	2,579	0.473

Table 1

Continuity tests while the conduit is on the reel can be performed with a volt-ohm meter. Continuity testing after the conduit has been placed can be performed according to the following procedure: Place a locator transmitter at one end of the run, and connect directly to the wire, use a halo clamp around the conduit, or set the transmitter over the location of the buried conduit and turn it on. Go to the far end and see if the locator signal can be picked up with the receiver. If so, continuity exists. If not, follow the signal away from the transmitter until it disappears. That signifies either a break in the wire or a depth beyond the locator capability.

CAUTION The tone wire may develop induced foreign voltage during certain field conditions. Adjacent or parallel power lines may cause a voltage level that can be hazardous. Always test for foreign power prior to stripping or working with the tone wire, using acceptable test equipment. The wire is 18 AWG copper-clad steel rated at 30.041 ohm/1,000 ft. 68°F.

To install ConQuest toneable conduit, employ standard HDPE conduit installation procedures. When conduit needs to be coupled, be certain to over-pull the two ends by a minimum of two feet so the tone wire can be spliced at the coupled joint.

To couple the conduit and splice the tone wire to maintain electrical continuity, these procedures are recommended:

The tone wire should be separated from the conduit end for a minimum length of 12 inches + 2.5x the length of the coupler. For example, if the coupler being used is five inches long, it should be separated from the conduit end for a minimum of 24.5 inches: 12 inches + (5 inches x 2.5). This is shown in Figure 2.

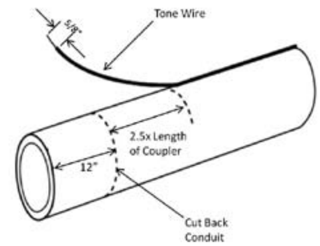


Figure 2

Separate the tone wire jacket from the conduit using a utility knife, as shown in Figure 3. Make the cut as close to the conduit wall as possible, to not leave a ridge on the conduit when coupling the conduit. This is best accomplished by scoring the jacket at the conduit several times. Generally, on the third or fourth pass of the knife, the wire jacket will completely separate. Attempting to separate the tone wire jacket from the conduit in one pass will usually result in the knife cutting the jacket up into the tone wire, which could result in future corrosion.

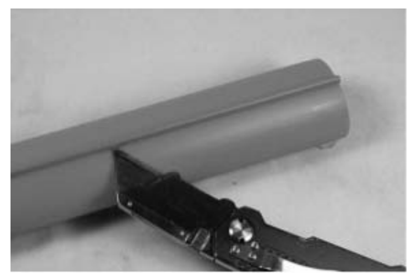


Figure 3

If a ridge remains after separating the tone wire from the conduit, shave any remaining HDPE with the knife until smooth. Shave the conduit for a length of 10 inches, which should be enough for the coupler length requirements. Should the coupler be longer than this, continue shaving the ridge until it matches half the length of the coupler.

In order to splice the tone wire, begin by cutting the conduits perpendicular with conduit cutters 12 inches from the end, as shown in Figure 4, so there is a clean face for coupling the conduit. The ends of each conduit should now overlap slightly to allow coupling of the conduits.

Figure 4

Join the conduits with an approved coupler according to the manufacturer's directions. Strip back 5/8 inch of the HDPE jacket from around the tone wire (Figures 5 and 6).

Figure 5

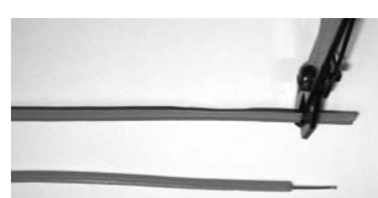


Figure 6

CommScope recommends the use of large direct-bury waterproof connectors for joining the tone wires and providing environmental protection (Figure 7). These can be purchased off the shelf at most home improvement stores. They should be UL Listed as a 486D wire connector system for use with underground conductors for use in damp or wet conditions.

Insert the tone wires into the gel-filled connector fully onto both wire ends, and twist (clockwise) until it becomes tight (Figure 8).

Fold the excess slack of the tone wire back onto the conduit, and tape or tie wrap to the conduit (Figure 9).

Figure 7

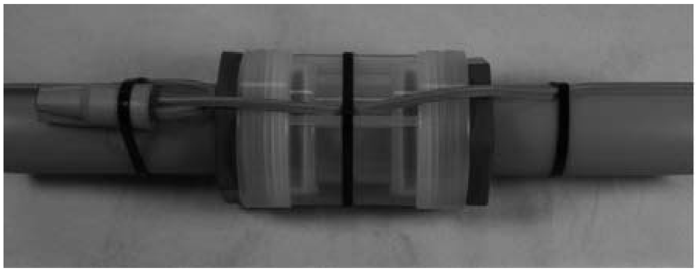


Figure 9

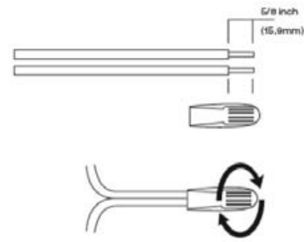


Figure 8

The function of toning

Toning is a method of using a generated signal, or “tone”, that is transmitted over a conductor so the portion of the conductor buried below the earth can be located without digging.

The tone is produced at a very low frequency with a transmitter tuned to a particular frequency. The frequency range available on the transmitter varies between manufacturers but often ranges from 400Hz to about 80KHz. Transmission power is often variable and is usually controlled in a range of 0.033 watts up to 5.0 watts. A “radio” receiver tuned to the transmit frequency is then used to precisely locate the energized wire.

The setup requires that a transmitter be attached to the conductive material that will act as an “antenna” and that a ground plane be established at the end of the antenna to close the circuit.

Why locate?

- Buried cable assets need to be found by the network owner, not by a backhoe operator
- Prevent service disruption and repair costs to conduit wall

Benefit:

- Eliminates hidden costs

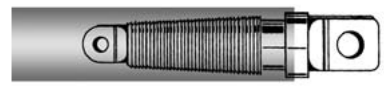
Appendix
Conduit cutting tools and accessories

Basket grip/pulling grip

This reusable grip, woven from strands of stainless steel, acts like "Chinese finger cuffs" and compresses upon being relaxed. It provides an evenly distributed hold on the conduit or cable.

Innerduct puller

This equipment is often used for innerduct pulls because they do not increase the outer diameter of the conduit.



Ratchet shears

Used to cut conduits up to 1¼ inches (3.175 cm) in diameter.

Tubing cutters

Used to cut conduits 1 to 2 inches (2.54 to 10.16 cm) in diameter.

Scissor shears

Used to cut conduits up to 1¼ inches (3.175 cm) in diameter.

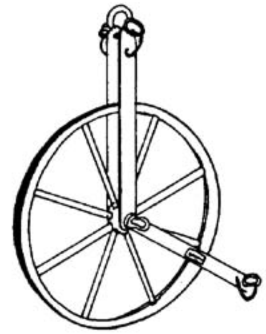
Pipe saw

Used to cut conduits 2 inches (5.08 cm) and larger.

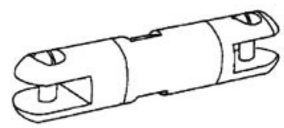
Underground equipment

Shoe, cable
This equipment is used to route conduit through manholes while the conduit is being pulled into place. Placement of the cable shoes will prevent the rubbing of the conduit on obstacles within the manhole.

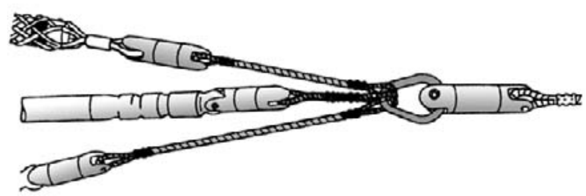
Sheave
This equipment is used to facilitate the movement of conduit that is being pulled into place through a manhole. Sheaves are free wheeling and accordingly add little drag to the conduit that is being installed. The placement of the sheave will prevent the rubbing of the conduit on obstacles within the manhole.



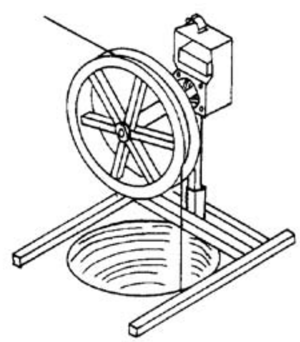
Breakaway swivel
Used to prevent excessive pulling tension. It is designed to break should it exceed a preset tension limit.



Pulling sling
Used to prevent both excessive pulling tension and twisting of conduits in multiple-conduit installations. It is designed to break should it exceed a preset tension limit.



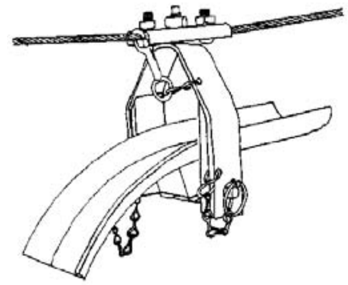
Winch, cable
A cable winch is a powered capstan used to pull cable. This equipment will often be used as an intermediate assist in pulling cables or conduits that are very long or have considerable drag.



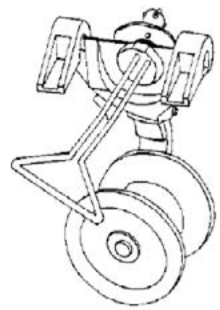
Come-a-long
This equipment is used to facilitate the movement of innerduct that is being pulled into place through existing conduit.

Aerial equipment

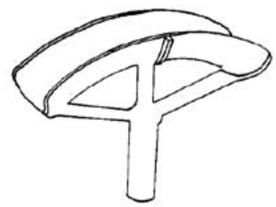
Set-up chute
A set-up chute is used to guide the conduit from the reel trailer to the strand.



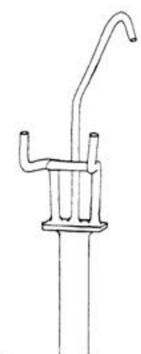
Single roller block
Used to support conduit prior to lashing.



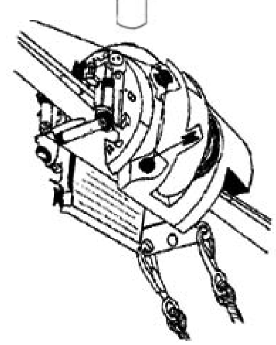
Cable lifter
This tool may be used to lift conduit into place and is helpful to ensure that the conduit being lifted is not damaged by exceeding minimum bend radius.



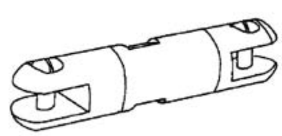
Cable block lifter
Used in conjunction with a lay-up stick to place assorted cable blocks mid-span.



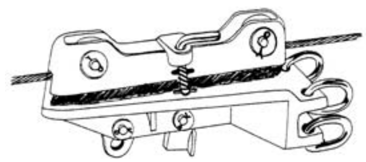
Lasher
Traditionally used to lash cable to strand, it may also be used for lashing conduit to strand. Lashers are somewhat specific to cable and strand size—improper lasher size or adjustment can prohibit installation of conduit to strand.



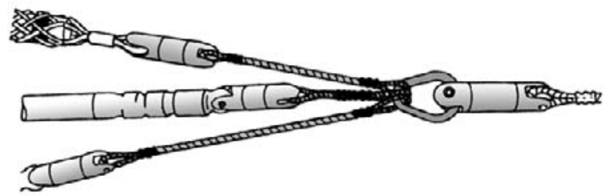
Breakaway swivel
Used to prevent excessive pulling tension. It is designed to break should it exceed a preset tension limit.



Multiple cable puller
Allows multiple cables to be pulled into place when lashing cables directly to strand. It's equipped with a strand brake to prevent sagging of cables as the pulling tension is released. Allows pulled cables to independently swivel.



Pulling sling
Used to prevent both excessive pulling tension and twisting of conduits in multiple-conduit installations. It is designed to break should it exceed a preset tension limit.



Packaging and shipping

ConQuest products can be packaged and shipped on either wooden reels (A), ReelSmart® composite reels (B), or lightweight steel reels (C).

Drop conduit products can be packaged on "reel-less" coils (D), making them light weight and easier to handle.

Lengths	½"	¾"	1"	1¼"	1½"	2"	3"	4"
500								102 x 74 x 43 217 lbs.
1000	35 x 16½ x 18 60 lbs.	42 x 24 x 24 130 lbs.	50 x 24 x 24 182 lbs.	54 x 28 x 43 106 lbs.			102 x 64 x 43 217 lbs.	
2500						90 x 43 x 43 195 lbs		
3000		54 x 28 x 43 106 lbs.	63 x 28 x 43 121 lbs.	68 x 43 x 43 132 lbs.	80 x 43 x 43 174 lbs.			
4000						102 x 43 x 43 217 lbs.		
5000		63 x 28 x 43 121 lbs.	68 x 28 x 43 121 lbs.	80 x 28 x 43 174 lbs.	102 x 43 x 43 217 lbs.			

ConQuest reel dimensions and weight chart (standards in bold)
(Flange x Drum x Traverse)
***Longer lengths may be available upon request.**

Toneable conduit specifications

Conduit size	CU-clad wire size AWG	Outside diameter (inches)	Wall thickness (inches)	Nominal inner diameter (inches)	Min. bend radius unsupported (inches)	Max. pulling tension (lbs)	Weight (lb/ft)
3/4" SDR 11	18	1.050 ± 0.005	0.095 ± 0.020	0.84	20	687	0.128
1.00" SDR 13.5	18	1.315 ± 0.007	0.097 ± 0.020	1.101	26	894	0.166
1.25" SDR 13.5	18	1.660 ± 0.008	0.123 ± 0.020	1.394	34	1,425	0.263
1.50" SDR 13.5	18	1.900 ± 0.010	0.141 ± 0.020	1.598	38	1,867	0.344
2.00" SDR 11	18	2.375 ± 0.012	0.216 ± 0.026	1.917	48	3,515	0.642
2.00" SDR 13.5	18	2.375 ± 0.012	0.176 ± 0.021	2.002	48	2,917	0.534
2.00" SCH 40	18	2.375 ± 0.012	0.154 ± 0.020	2.047	48	2,579	0.473

Conduit cable specifications

SDR 11

Nominal size	Nominal outside diameter (inches)	Minimum wall thickness (inches)	Nominal inner diameter (inches)	Min. bend badius unsupported (inches)	Max. pulling tension (lbs)	Weight (lb/ft)
½"	0.840	0.076	0.668	10	390	85
¾"	1.050	0.095	0.840	12	605	130
1¼"	1.660	0.151	1.338	18	1,520	320
1½"	1.900	0.173	1.533	20	1,760	416
2 "	2.375	0.216	1.917	26	3,105	640
3 "	3.500	0.318	2.826	48	6,740	1,386
4"	4.500	0.409	3.633	60	11,145	2,295

SDR 13.5

Nominal size	Nominal outside diameter (inches)	Minimum wall thickness (inches)	Nominal inner diameter (inches)	Min. bend badius unsupported (inches)	Max. pulling tension (lbs)	Weight (lb/ft)
½"	0.840	0.062	0.696	10	320	71
¾"	1.050	0.078	0.874	12	505	111
1"	1.315	0.097	1.101	14	790	169
1¼"	1.660	0.123	1.394	18	1,260	265
1½"	1.900	0.141	1.598	20	1,455	344
2"	2.375	0.176	2.002	26	2,580	532
3"	3.500	0.259	2.951	48	5,590	1,154
4"	4.500	0.333	3.794	60	9,250	1,905

Specifications are subject to change without notice.
*Weight does not include the reel.

Notes
Standard dimension ratio (SDR) is the ratio between the wall thickness and the outside diameter of a specific conduit. Schedule 40 and Schedule 80 dimensions are a specific wall thickness to each conduit diameter. Other wall thicknesses are available upon request.

Coaxial cable data conduit specifications

SCH 40

Nominal size	Nominal outside diameter (inches)	Minimum wall thickness (inches)	Nominal inner diameter (inches)	Min. bend badius unsupported (inches)	Max. pulling tension (lbs)	Weight (lb/ft)
1"	1.315	0.133	1.029	14	1,050	219
1¼"	1.660	0.140	1.360	18	1,420	295
2"	2.375	0.154	2.047	26	2,300	472

Notes
Standard dimension ratio (SDR) is the ratio between the wall thickness and the outside diameter of a specific conduit. Schedule 40 and Schedule 80 dimensions are a specific wall thickness to each conduit diameter.

Other wall thicknesses are available upon request.

Fill percentage

Coaxial data sheet

This data is provided as a means to determine the number of cables that will fit into a conduit.

Product	Diameter (DOJ) inches	Diameter (DOJ) mm	X-Sectional area inches	X-Sectional area mm	Pulling tension lbs	Pulling tension kgf
P3412	0.485	12.32	0.185	119.19	150	68
P3500	0.570	14.48	0.255	164.63	300	136
P3565	0.635	16.13	0.317	204.32	350	159
P3625	0.695	17.65	0.379	244.75	475	215
P3700	0.775	19.69	0.472	304.34	500	227
P3750	0.830	21.08	0.541	349.07	675	306
P3840	0.920	23.37	0.665	428.88	700	318
P3875	0.955	24.26	0.716	462.13	875	397
QR540	0.610	15.49	0.292	188.55	220	100
QR715	0.785	19.94	0.484	312.25	340	154
QR860	0.960	24.38	0.724	466.98	450	204
MC^2 500	0.605	15.37	0.287	185.47	300	136
MC^2 650	0.735	18.67	0.424	273.74	500	227
MC^2 750	0.855	21.72	0.574	370.42	700	318

Notes

All cables have standard jacket and flooding compound over the aluminum outer conductor. Specifications subject to change without notice.

Fill percentage calculation

The fill percentage can be calculated using this formula:

Single cable

Where:

ACa	Area of the cable
ACo	Area of the conduit
OD	Outer diameter of the cable
ID	Inner diameter of the conduit
FP	Fill percentage
ACa	π* (OD / 2) * (OD / 2)
ACo	π* (ID / 2) * (ID / 2)
FP	100 * (ACa / ACo)

Example: QR 715 in 1.5" schedule 40 conduit

ACa = π* (0.881 / 2) * (0.881 / 2) = .610

ACo = π* (1.580 / 2) * (1.580 / 2) = 1.960

FP = 100 * (.610 / 1.960) = 31.12%

Multiple cables

ACa1 = π* (OD / 2) * (OD / 2)

ACa2 = π* (OD / 2) * (OD / 2)

ACo = π* (ID / 2) * (ID / 2)

FP = 100 * ((ACa1 + ACa2) / ACo)

Calculated pulling tension

Maximum pulling length

The maximum pulling length is the longest distance a cable can be safely pulled through a straight and level conduit. This formula is used as an independent measure for route engineering purposes.

Lm = Tm / (W * f)

where:

Lm	maximum pulling length in feet
Tm	maximum pulling tension in pounds
W	weight of cable in pounds per foot
f	coefficient of friction (if unknown use 0.500)

Example: QR 715

Tm = 340

W = 0.144

f = 0.500

Lm = 340 / (0.144 * 0.500)

Lm = 340 / 0.072

Lm = 4722

Straight section of conduit (LSWP)

This formula is used to determine the amount of tension placed on a cable at the end of pull in a straight section of conduit. The formula is used in conjunction with the calculated pulling tension for a bend section of conduit to calculate an estimated pulling tension for an entire conduit run.

Ts = L * W * f

where:

Ts	pulling tension at end of straight section in pounds
L	length of straight section in feet
W	weight of cable in pounds per foot
f	coefficient of friction (if unknown use 0.500)

Example: QR 715

in a 500-foot straight section of conduit

L = 500

W = 0.144

f = 0.500

Ts = 500 * 0.144 * 0.500

Ts = 500 * 0.072

Lm = 36

Calculated pulling tension—bend section of conduit (HSWP)

This formula is used to determine the amount of tension placed on a cable at the end of pull in a bend section of conduit. The formula is used in conjunction with the calculated pulling tension for a straight section of conduit to calculate an estimated pulling tension for an entire conduit run. The tension through the straight section of conduit entering the bend must first be calculated as this formula uses that tension as part of the formula.

Tb = Ts * efa

where:

Tb	pulling tension at end of bend in pounds
Ts	pulling tension at end of straight section entering the bend in pounds
e	naperian log base (2.718)
f	coefficient of friction (if unknown use 0.500)
a	angle of bend (radians*)

*The bend angle in radians can be calculated by dividing the angle in degrees by 57.3 (57.30 = 1 radian)

Example: QR 715

after 500-foot straight section 90° bend

Ts = 36

e = 2.718

f = 0.500

a = 1.571

Tb = 36 * 2.718 0.500 * 1.571

Tb = 36 * 2.718 0.785

Tb = 36 * 2.192

Tb = 79

e^{fa} Values for common angles

Angle of bend in degrees	Coefficient of friction values					
	f=0.7	f=0.6	f=0.5	f=0.4	f=0.3	f=0.15
15	1.20	1.17	1.14	1.11	1.08	1.04
30	1.44	1.37	1.30	1.23	1.17	1.08
45	1.73	1.60	1.48	1.37	1.27	1.13
60	2.08	1.87	1.68	1.52	1.37	1.17
75	2.50	2.19	1.92	1.69	1.48	1.22
90	3.00	2.57	2.19	1.87	1.60	1.27

Calculated sidewall pressure

This formula is used to calculate the sidewall pressure in bends. The longer the bend is, the lower the sidewall pressure will be; this will also be true for smaller angles of bend.

P = Tb / I

where:

P	sidewall pressure
Ts	pulling tension at end of bend in pounds
I	length of bend radius

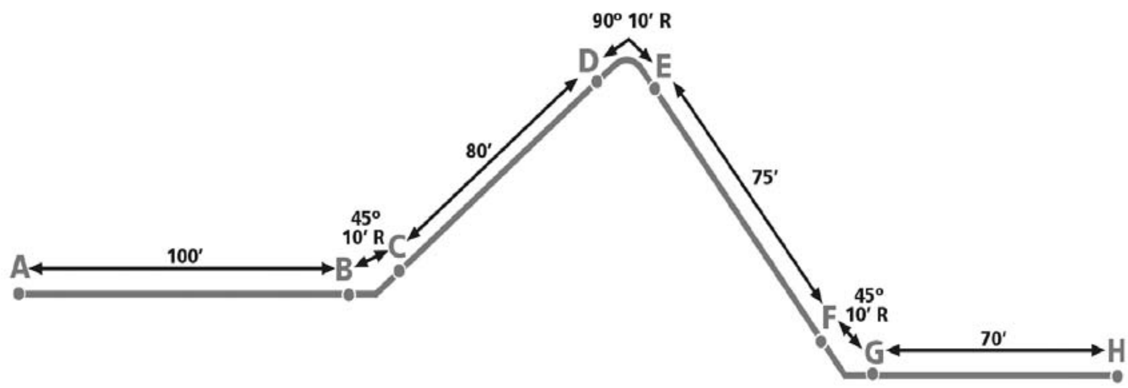
Example: QR 715

Tb = 79

I = 10

P = 79 / 10

P = 7.9



Calculating a complete run

An example provides a clear illustration of how to calculate a complete run and understand the effects of bends on pulling tensions and sidewall pressure. Calculations have been performed in both directions. In the first calculation, the run has the reel set up at point "A" with the cable being pulled from point "H". The second calculation is the opposite, with the reel set up at point "H" and the cable being pulled from point "A". The cable used is QR715.

Installation safety

Reel set up at "A", pulling from "H"

Pulling tension			
Tension @ A	= **0**	= **0**	**Sidewall pressure**
Tension @ B (Ts_1)	= 100 * 0.144 * 0.5	= 7	
Tension @ C (Tb_1)	= 7 * 1.48	= 10	P_{B-C} = 10 / 10 = 1.0 lbs/ft
Tension @ D (Ts_2)	= 10 + (80 * 0.144 * 0.5)	= 16	
Tension @ E (Tb_2)	= 16 * 2.19	= 35	P_{D-E} = 35 / 10 = 3.5 lbs/ft
Tension @ F (Ts_3)	= 35 + (75 * 0.144 * 0.5)	= 40	
Tension @ G (Tb_3)	= 40 * 1.48	= 59	P_{F-G} = 59 / 10 = 5.9 lbs/ft
Tension @ H (Ts_4)	= 59 + (70 * 0.144 * 0.5)	= **64**	

Reel set up at "H", pulling from "A"

Pulling tension			
Tension @ H	= **0**	= **0**	**Sidewall pressure**
Tension @ G (Ts_1)	= 70 * 0.144 * 0.5	= 5	
Tension @ F (Tb_1)	= 5 * 1.48	= 7	$P_{B\text{-}C}$ = 7 / 10 = 0.7 lbs/ft
Tension @ E (Ts_2)	= 7 + (75 * 0.144 * 0.5)	= 12	
Tension @ D (Tb_2)	= 12 * 2.19	= 26	$P_{D\text{-}E}$ = 26 / 10 = 2.6 lbs/ft
Tension @ C (Ts_3)	= 26 + (80 * 0.144 * 0.5)	= 32	
Tension @ B (Tb_3)	= 32 * 1.48	= 47	$P_{F\text{-}G}$ = 47 / 10 = 4.7 lbs/ft
Tension @ A (Ts_4)	= 47 + (100 * 0.144 * 0.5)	= **54**	

Installation safety
Construction of underground facilities requires a substantial amount of manpower, tools and equipment. Underground and aerial construction will expose the manpower, tools and equipment to hazards, dependent upon field conditions and circumstances.

The Occupational Safety and Health Administration (OSHA) defines a qualified employee as “any worker who, by reason of training and experience, has demonstrated his ability to safely perform his duties.” Only a qualified employee should be assigned duties that could cause harm or potential harm to the construction crew, general public, cable plant and other utilities. This manual cannot identify all the hazards that exist in the construction environment, nor can it dictate the caution required with all tools, equipment and field conditions. CommScope continues this manual with the assumption that the construction personnel performing the work are qualified employees.

Three sets of national codes and standards apply to the construction of underground facilities. The OSHA Safety and Health Standards applies to work in telecommunications and utility installations. The National Electric Code (NEC) applies to building utilization wiring, i.e. inside plant construction. The NEC applies specifically, but is not limited to, plant that is within or on public and private buildings or other structures. The National Electric Safety Code (NESC) generally applies to outside plant construction.

Municipal, state, county and local codes are often applied to the construction of telecommunication and utility systems or work that involves their respective properties and right-of-ways. Pole Lease Agreements often stipulate specific practices related to safety.

These codes, regulations and specified practices should be investigated, interpreted, communicated and observed.

Underground safety
Telecommunication construction is typically done within right-of-way dedicated for the routing of other underground systems**—**municipal and utility pipes, wires, cables, and conduits.

Damage to any one of these utilities could cause a disruption of services. At worst, it may cause catastrophic harm to personnel and surrounding property.

It is usually required by law that you contact all operators of these systems prior to the start of any excavation, including those that are out of the right-of-way (ROW). These system operators will indicate horizontal location of their plants with a flag or paint markings, called a locate mark or locate. Law usually requires that the subsurface plant owner perform this duty within a defined time period and ensure that the locate marks are correctly positioned. The primary intent of the locate mark is to PREVENT damage to conflicting ROW, not to define liability. However, the recovery of damages resulting from excavation work is generally decided with high consideration given to the locate marks.

Once the horizontal location of the conflicting ROW has been established, the depth, or "vertical" location of the ROW must be determined. This is usually done by potholing, or carefully digging a hole until the conflicting ROW (or its warning tape) is located.

The owner of the real estate should also be contacted prior to excavation. There may be a water sprinkler, closed circuit television or communication systems buried in or around the ROW. The excavating party should also make necessary locate marks on their existing plant.

Underground installations typically terminate in a pit or trench that is accessible to the public. **Pits and trenches MUST be guarded by barricades, warning devices and covers.**

Occupational Safety and Health Administration (OSHA) Standards
OSHA Standards were established in 1970 to help ensure workplace safety. The Standards are federal regulations that are intended to enable employees to recognize, understand and control hazards in the workplace. Standards have been established for general industry while some sections of the Standards are dedicated to specific industries such as telecommunications.

The general applicable OSHA Standards are found in:

Title 29 CFR Parts 1901.1 to 1910.399 General Industry, Part 1926 Safety and Health Regulations for Construction.

Most relevant is Title 29 CFR Part 1910 Occupational Safety and Health Standards.

Copies of OSHA Standards can be obtained from:

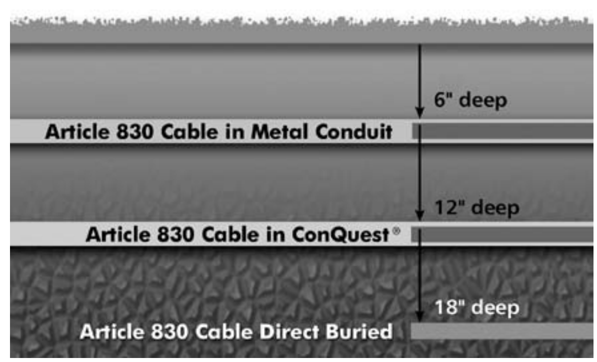
US Department of Labor
OSHA Publications
PO Box 37535
Washington, DC 20013-7535
(202) 693-1888
(202) 693-2S498 fax
website: www.osha.gov

National Electric Code (NEC) Standards
The NEC typically identifies the construction techniques and materials necessary in building wiring requirements, (e.g., inside plant construction, of fiber-optic, coaxial cable, or twisted-pair systems). The NEC has been developed by the National Fire Protection Association's (NFPA's) National Electric Code committee. Committee members are professionals from the electrical industry. The NEC addresses safety from fire and electrocution. The NEC has been adopted by the American National Standards Institute (ANSI).

Copies of NEC Standards can be obtained from:

National Fire Protection Association
1 Batterymarch Park/P.O. Box 9146
Quincy, MA 02269-3555
(800) 344-3555
website: www.nfpa.org

NEC article 830
Network-Powered Broadband Communication Systems have recently been added to the National Electric Code (NEC). Higher voltages will be used to power Network Interface Units (NIU) for Broadband systems, so it has become more important to safeguard the general public from the hazards posed. Drop cables pose the greatest hazard of exposure to the public in network-powered broadband systems.



As of January 1, 2000, all new installations of broadband cable carrying low and medium voltages must meet NEC Article 830. Low voltage is defined as 0 to 100 volts and medium voltage covers cables up to 150 volts.

Under Article 830, the depth of burial has been revised for direct buried cable, conduit or other raceways. The adjacent chart describes the minimum cover requirements prescribed by the NEC.

National Electric Safety Code (NESC) Standards
The NESC covers supply and communication cables and equipment in underground buried facilities. The rules also cover the associated structural arrangements and the extension of such facilities into buildings.

The NESC typically identifies the construction techniques and materials necessary in outside plant construction of electric supply or communication cable systems. The NESC is an American National Standard that has been written by a group of professionals that are concerned about the Standard's scope and provisions. The NESC has been adopted by the American National Standards Institute (ANSI). All references to the NESC in this manual are from the 1997 edition.

Special attention should be given to NESC Part 3 Safety Rules for the Installation and Maintenance of Underground Electric Supply and Communication Lines.

Copies of NESC Standards can be obtained from:

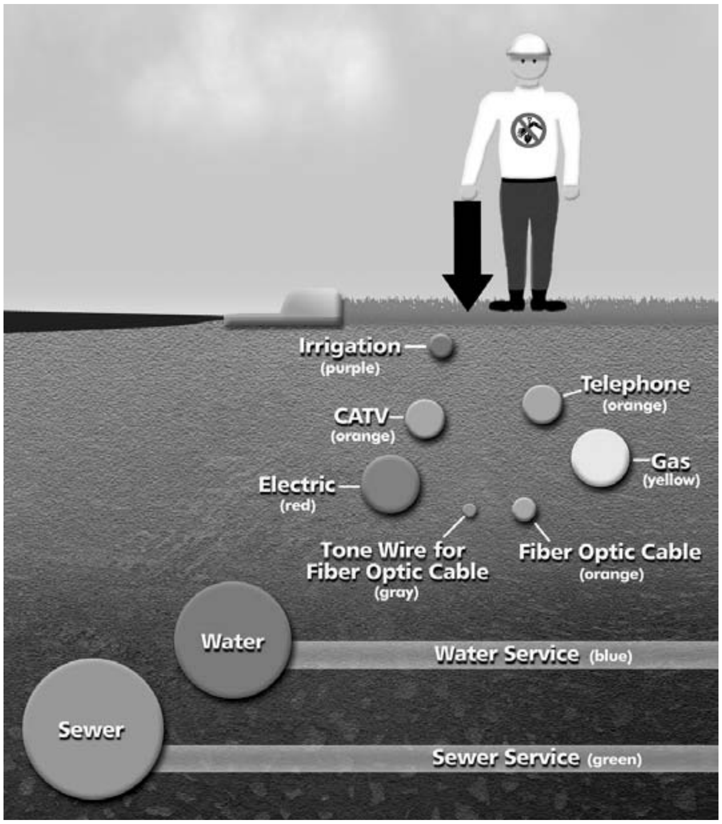
IEEE Service Center
445 Hoes Lane/P.O. Box 1331
Piscataway, NJ 08855-1331
(800) 678-4333
website: www.ieee.org

Conduit and tracer colors
CommScope manufactures conduit and tracers in a variety of colors to meet your specific requirements. However, please note that the most common colors are black, orange or terra cotta. Orange/terra cotta conduit is recommended for telecommunication conduit in buried applications. Black is recommend for applications where the conduit is exposed to direct sunlight. For other colors see the chart at right.

Note: Colors other than black do not tolerate direct sunlight for extended periods of time and are not recommended for aerial or above ground installations.

For more information on custom colors and tracers, please contact our Broadband Customer Service Center at 800-982-1708.

Typical colors used in underground applications



Legal disclaimer

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