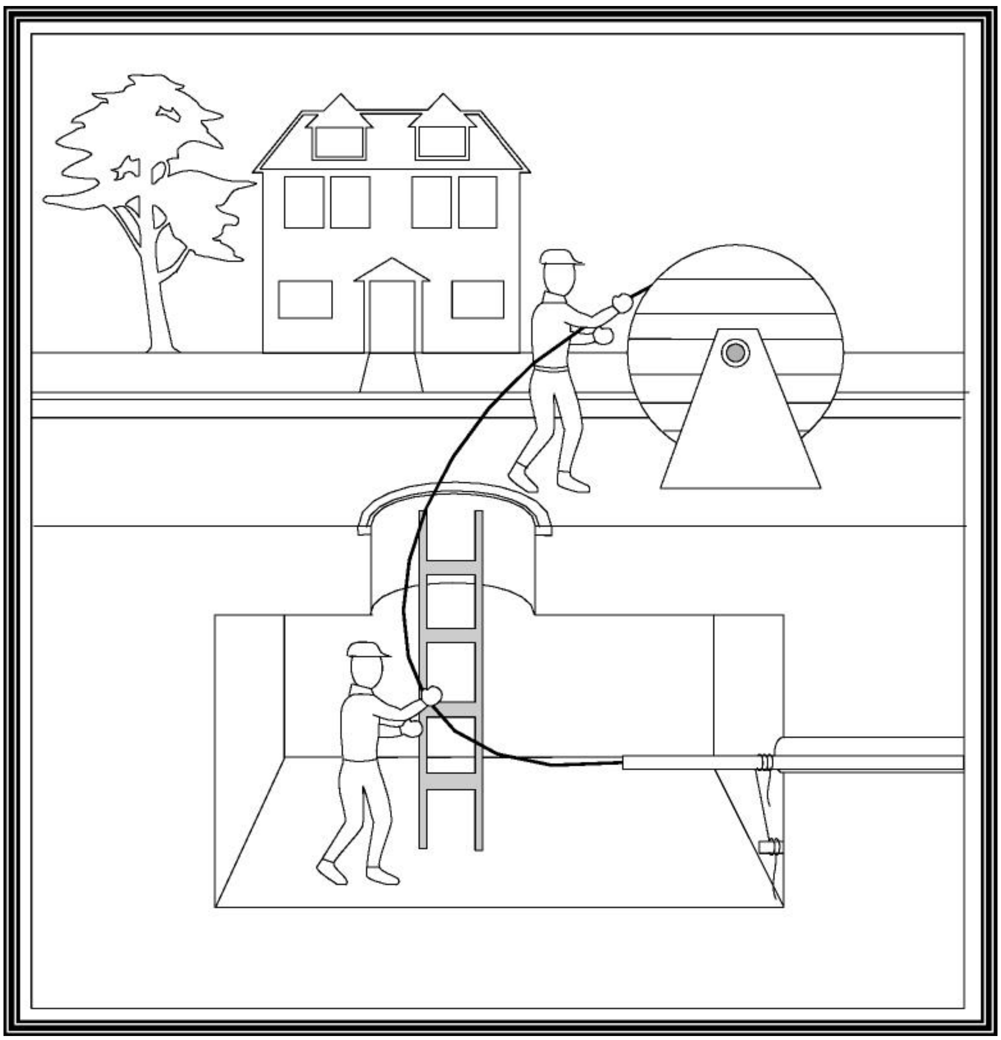
Duct Installation of 864 RILT™ (Multi-Tube) and RCLT™ (Central Tube) Ribbon Cable



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1.0 GENERAL

1.01 This document is not intended to provide basic safety or construction training. It is the responsibility of the installation company to properly train employees on safety and standard work practices.

1.02 The methods described in this document are intended to highlight considerations for specific cable designs. They are not intended to cover every aspect of installation or proper work practices. It is impossible to cover every situation that may arise during an installation. It is the responsibility of the installer to provide proper management and direction of the worksite.

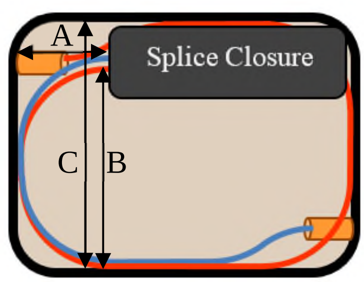
1.03 Fiber optic cable is easily damaged by excessive pulling force, sharp bends, and crushing forces. This damage may not be revealed until long after installation is complete. For these reasons extra care must be taken during the entire installation process.

2.0 CABLE SPECIFICATIONS

2.01 Specification Summary

Cable	Cable OD	Min Static BR / Diameter	Min Coil OD	Min Dynamic BR / Diameter	Max Short/Long Term Tension
864 Dry Central Tube Dielectric	0.97"	10.7" / 21.3"	30"	19.4" / 38.8"	600 / 180 lbs
864 Multi-Tube Dielectric	1.05"	11.6" / 23.1"	23.1"	21" / 42"	600 / 180 lbs

2.02 Minimum Static BR (Bend Radius) is the smallest allowable bend radius for a cable that is **not twisted** and **not under tension**. This number includes additional space for the thickness of the cable. In any vault, *Dimension A must never be smaller than the Minimum Static BR* (see diagram at right). Likewise, *Dimension B must never be smaller than the Minimum Static Bend Diameter*.



2.03 Minimum Coil OD (Outside Diameter) is the smallest space in which a single coil of cable can be placed. It includes space for a single layer of cable. In any vault, dimension C must never be smaller than the Minimum Coil OD (see diagram above). Additional space is needed if coils will have more than one layer.

When a straight section of cable is coiled, each coil normally adds one full (360-degree) twist. If this twist is not removed during the coiling process, it creates additional stresses. These stresses are worse for Central Tube Ribbon cables, because these cables have a preferred bending plane due to the rods embedded in their jackets. This is why the Min Coil OD is larger than the Min Static Diameter for Central Tube cables.

2.04 The Minimum Dynamic Bend Radius is the smallest allowable bend radius for a cable under tension. This number can be useful when checking 90-degree turns for temporary ducts that guide a cable out of a vault.

The Minimum Dynamic Diameter is the smallest wheel size that can be used for a cable under tension. This applies to both sheaves and bullwheels/capstans.

2.05 Maximum Short Term Tension is the tension limit for a cable while it is being pulled in.

Pulling a cable over a wheel creates compression forces on the cable where it contacts the wheel. These compression forces are increased if a smaller wheel is used, and decreased by larger wheels. **Pulling cables over wheels that are too small will crush the cable**—even if the Maximum short term tension is not exceeded.

2.06 Maximum Long Term Tension is the tension limit for a cable after installation. Care should be taken to minimize any residual tension.

Coils without closures can be stored in vaults with a minimum dimension equal to the Minimum Coil OD. But, *coils that end in closures may require larger vaults*. You can see an example of this in the vault diagram on the previous page. The cable coming out of the closure is offset from the vault wall (see dimension B versus C). Because Dimension A is already tight, the vault in the diagram must be wider than the Minimum Coil OD, or longer, so that the cable has space to transition (or “go wide”) to the vault wall before making the first turn.

3.0 TOOLS AND MATERIALS

3.01 This document highlights topics related to our cable. It does not cover all tools or materials needed for a safe and proper installation. It is the responsibility of the installer to have the knowledge and the approved tools needed to comply with company rules and good industry practices.

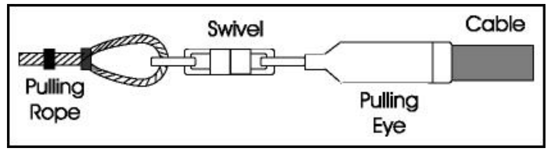
3.02 Innerduct size, type and condition will have a major impact on results.

Prysmian’s Dielectric 864 RILT™ (Multi-Tube) and RCLT™ (Central-Tube) ribbon cables can be installed in 1.25” or larger duct. Consult company guidelines, as larger sizes may be specified to allow future expansion.

Tight bends will significantly increase pulling tensions. Tight bends and/or crushing forces can ovalize a duct, which will reduce cable clearance. Dirt and debris will increase pulling tensions. If in doubt, a duct run should be blown out and checked with an appropriately sized duct proving mandrel prior to pulling.

3.03 Duct Lubricant should always be used when pulling cable. Be sure the lubricant is company-approved, and suitable for both polyethylene jackets and the duct. Also check to make sure it is rated for the temperatures expected during the pull.

3.04 A 600-pound breakaway swivel should be used to prevent twisting and protect the cable from excessive tension.



3.05 Wire mesh pulling grips can be used to pull the cable. Make sure the grip has a diameter range suitable for the cable OD, and a length suitable for the pulling tension. RILT™ (Multi-tube) cable can also be supplied with a factory-installed grip.

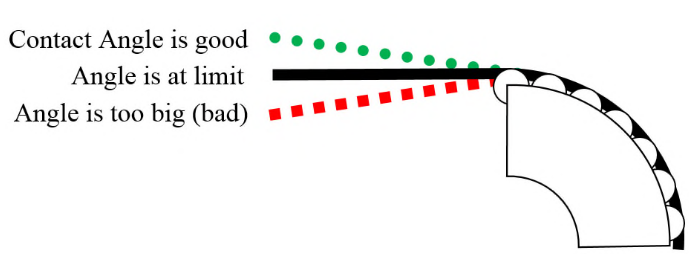
When pulling RILT cable with a mesh pulling grip into 1.25” duct, install the grip as follows. Remove a section of jacket equal to the length of the grip. Shift the fiberglass yarns to the side (do not cut the yarns), and cut out the exposed binders, tapes and buffer tubes. Distribute the fiberglass yarns evenly around the CSM (Central Strength Member). Apply friction tape over the fiberglass yarns and CSM. Place the grip over the friction tape and wrap the grip with tape to keep it in place.

A video of the grip installation process can also be seen on our website (na.prysmiangroup.com) or at www.tinyurl.com/864RILTgrip.

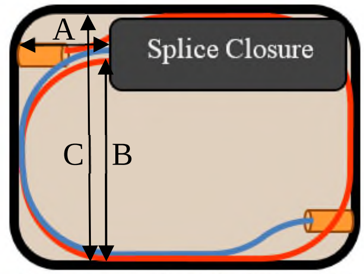
3.06 Sheave Wheels must have a diameter greater than or equal to the Minimum Dynamic Diameter (see Specification Summary on page 2).

Cables can be damaged if they run onto the shoulder or edge of a wheel. To prevent this, the angle of the wheel must match the intended cable path. This may require tying off the wheel with a support strap.

3.07 Quadrant Blocks can be used in place of Sheave Wheels if they meet the same bend radius requirements and have at least 6 rollers. **The cable will be crushed by the entry or exit roller of a Quadrant Block if the contact angle is too large.** The contact angle of the cable on the exit and entry rollers must never exceed the contact angle of the other rollers. If in doubt, tie off a piece of split conduit over the quadrant block for extra protection. Although this will increase friction, it will help provide a more gradual transition.



Single quadrant blocks must not be used for angles greater than 90 degrees. Angles of less than 90 degrees can damage cables if the quadrant block is not carefully positioned or adequately secured.



Recommended Vault Layout

Quadrant blocks can also be used to control the bend radius of a piece of conduit as it transitions out of a vault. This can be used instead of a bending shoe, which normally does not have a large enough bend radius for an 864 cable.

3.08 Capstans or Bull Wheels are used to apply tension during a pull. If pulling the cable over a capstan (for example, during a mid-assist), it must have a diameter greater than or equal to the Minimum Dynamic Diameter (see page 2). **An 864 cable must never be pulled over a 24" capstan**, because it is smaller than the Minimum Dynamic Diameter (see page 2).

3.09 Vaults must be large enough to meet the cable's minimum bend requirements (see the Specification Summary on page 2 for details). The dimensions required for this can vary a lot, depending on the location and/or presence of closures, slack cable and cable entrances. In general, a minimum 3' x 4' vault should be used for 864 fiber cable. Smaller vaults may be possible, but will require careful planning and execution.

3.10 Racking should be installed in any vault where 864 cable will be stored. Double racking should be used (two vertical racks on each major wall). A horizontal rack should be added on one side for securing the closure (if present).

3.11 Closure selection will affect vault requirements. If a closure it too long for a vault, there will not be enough room for the cable to exit the closure and make an acceptable 90 degree turn before contacting the vault wall.

In general, only butt closures should be used in vaults. If an in-line closure is required, a longer vault will be needed in order to make room for cable exiting from both ends. It is also more difficult to store cable slack when attached to an in-line closure.

4.0 PREPARATION

4.01 A pre-survey of the fiber cable route is an integral part of the total project. Engineering and Construction should jointly pre-survey the job site and cable route to ensure all problem areas are identified and addressed before pulling begins.

4.02 Vaults in which splicing will take place should be inspected and plans made for closure and cable slack racking. **Dimension "A" must not be less than the Minimum Static Bend Radius of the cable. Dimension "B" must not be less than the Minimum Static Bend Diameter. Dimension "C" must not be less than the Minimum Coil**

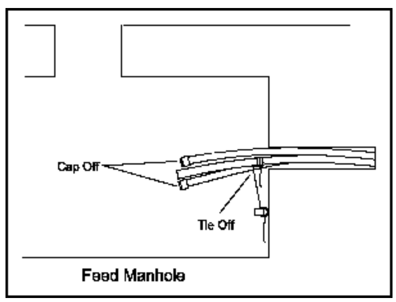
Diameter (see page 2 for these numbers).

In general, vaults for 864 count cables should be at least 3' x 4'. Smaller vaults may be possible, but will require extra care and must meet all minimum dimensions. Cable/Duct entrances should be on opposite sides of the vault, to simplify coiling. Only butt-splices should be stored in vaults. Racking should allow closures to be stored horizontally along the wall with the top of the dome at one end, so that the cable has plenty of room when exiting the closure. Both cable and closure should be well supported by racking in storage to prevent sharp bends in the cable.

5.0 CABLE PLACEMENT

5.01 Tie off the innerduct to keep it from "creeping" as the cable is being pulled into it. Any spare ducts should be capped off so that they do not interfere with the cable pulling operation.

Cable Tie-off in Manhole



5.02 Prepare the pull-through manholes. This includes un-racking the innerduct and removing slack caused by the racking, placing lubricant where appropriate, preparing the pulling line and usually re-coupling the innerduct to provide a continuous path for the cable to follow. The amount of lubricant used in intermediate manholes will depend on the length between manholes, type of innerduct, etc.

A general rule of thumb is to apply a minimum of one gallon of lubricant for every 1000 feet of the pull.

5.03 Position the pulling equipment (winch or capstan) at the pulling manhole. The pulling equipment should be fitted with a tension monitor. Never exceed the 600 pound pulling limit of the cable.

5.04 At the pull end manhole, install the proper guides specified by your company's practices. These guides are to ensure that the pull line and fiber optic cable enter and exit the innerduct in a straight path.

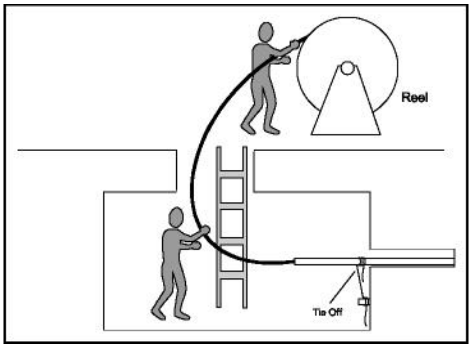
5.05 The intermediate manholes should be prepared for the cable pull by having any problems that were observed during the pre-pull survey already sorted out. The following is a list of some but not all possible issues that should be addressed:

a) If the innerduct is continuous, and has been racked, work the excess slack towards adjacent manholes. If necessary, slack can be removed using an innerduct slitter and cutter. Temporarily tie the innerduct to keep it from creeping into the main duct and to keep the innerduct ends in alignment during the cable pulling operation.

b) If the innerduct is not continuous, and the exit and entry ducts are aligned, the inner duct ends may be joined with a coupler. If the innerducts are not long enough to join, a short section may be added.

c) If the entry and exit ducts are offset (not directly in-line) by more than a 3:10 ratio (3 foot lateral offset in a 10-foot long manhole), properly sized sheaves should be used to make the transition. Innerduct can also be used to form a gradual sweep, but will increase tension.

5.06 Position the cable reel adjacent to the feed manhole so that the cable can be hand-fed in the manhole. The cable should be pulled off the top of the reel by hand and manually fed into the manhole to reduce pulling tensions.



5.07 Connect the pulling line to the pulling eye/grip installed on the fiber optic cable with a 600 pound breakaway swivel.

5.08 An approved cable lubricant should be used to lubricate the entire duct run being used in order to reduce pulling tension.

5.09 Before pulling operations begin, a communications link must be established between the feed and pull manholes (and any intermediate manholes through which the cable passes).

5.10 Start the pull by engaging the winch/capstan at a slow speed. Hand turn the reel as the pull begins to decrease start-up tension. After the pulling eye/grip has entered the duct at the feed manhole, the speed of pull may be increased. The speed should be increased slowly, and never exceed approximately 100 feet per minute (30 meters per minute).

5.11 The cable must be kept thoroughly lubricated, even if the pulling tension is very low. Surges and stops during the pull should be kept to a minimum and, if possible, avoided altogether. The maximum pulling tension is 600 pounds. If the pulling tension approaches the limit, the pulling operation must be stopped so that the pulling tension can be reduced by intermediate assists, or by changing the pulling operation to a back-feed method.

5.12 The winch/capstan operator at the pull manhole controls the speed of the cable pull. He or she must be kept informed of the cable's progress as it passes through each intermediate manhole. A constant pull rate is the desired method of placing cable in innerduct. Variations in pulling speeds, starts and stops are to be avoided. If it is necessary to stop the pull at any point, the winch/capstan operator should stop the pull but not release the tension on the cable. Pulls are more easily resumed if tension is maintained on the pull-line and cable.

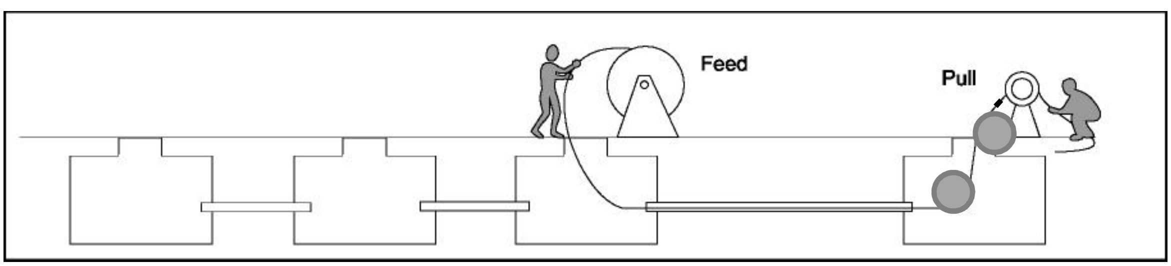
5.13 Once the cable appears in the pull manhole it may be pulled over a sheave or quadrant block as long as the diameter of the sheave or block meets the cable's minimum dynamic bend diameter/radius. Do not pull the cable over the capstan, unless it is large enough to meet the Minimum Dynamic Diameter (see page 2).

No attempt should be made to inch the cable to its final manhole length. This may cause undesirable surges to the end portion of the cable.

6.0 BACK-FEEDING

6.01 When pulling problems are expected due to long duct lengths, excessive curvatures in the duct or for other reasons, the cable can be pulled in from two directions.

6.02 Place the fiber optic cable reel at the mid-feed manhole. Attach the pulling line to the fiber optic cable and position the reel in the same manner as for an end pull. The pull manhole setup and the feed manhole setup are the same as they were for an end pull. Communication, lubrication and cable pulling are all conducted as for an end pull.



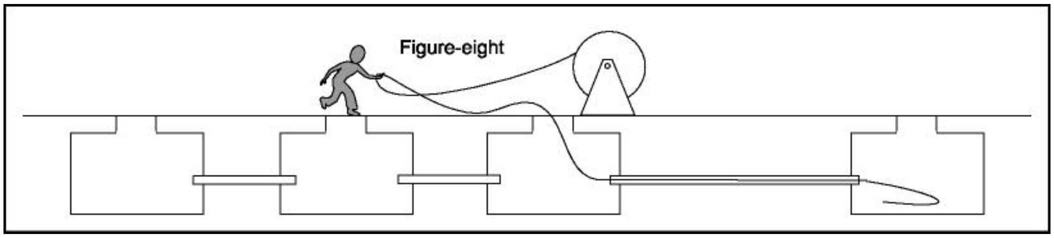
Bi-directional Pull Start

6.03 When the cable reaches the pulling manhole and sufficient slack has been acquired, stop the pull and move the pulling equipment to the opposite end of the run.

6.04 At the mid-feed manhole, remove the remaining fiber optic cable from the reel. **The cable must be laid out in a large figure-eight configuration close to the manhole opening.**

The minimum size for the "figure-eight" is 15 feet (about 4.5m) in length with loops of at least 5 feet (2.4m) in diameter. A larger figure-eight will allow longer lengths to be handled more easily and is highly recommended. Don't pile a figure-eight too high. The cable can be damaged at the crossover, or become tangled if the stack collapses.

Keep the cable as clean of debris as possible during the figure-eight operation. Sand or dirt clinging to the cable will cause increased pulling tensions. Spreading out a sheet of polyethylene before beginning to figure-eight is one method that will help keep the cable reasonably clean. Figure-eighting onto clean pavement or grass will also help lower the possibility of a dirty cable.



Bi-directional Pull Figure-eight

6.05 With all the cable off the reel and laying on the ground in a figure-eight, attach the pulling line to the end of the cable. Begin the pull just as before by hand pulling the cable out of the figure-eight and into the manhole.

The cable must be carefully guided from the figure-eight by hand at all times. Radio communications must be maintained to ensure the pull can be quickly stopped if trouble develops with feeding the cable from the figure-eight.

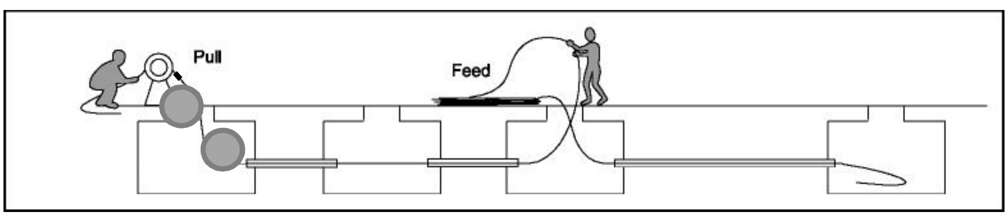
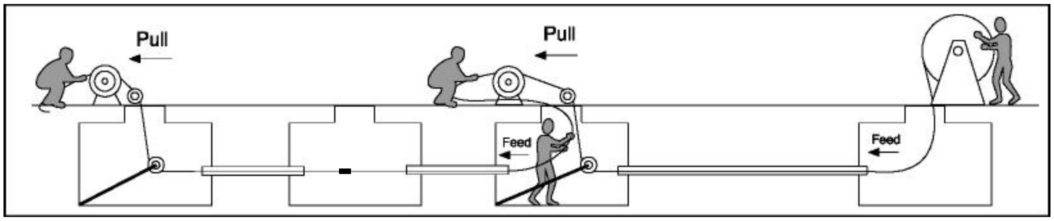


Figure 7 - Bi-directional Pull Completion

6.06 An installer must hand feed cable from the figure-eight. **While feeding the cable, be very careful to avoid kinks**. Kinks during figure-eight pay-out are a common cause of cable damage.

7.0 MID-PULL ASSIST

7.01 For pulling cable into a duct that may be very long, have an uphill slope, or have some severe curves in it, a middle manhole capstan pulling assist may be the solution. But, since the cable will pass over the capstan, **it is critical to make sure your capstan is large enough** (see Minimum Dynamic Diameter on page 2). The figure below illustrates a middle manhole capstan setup.



Mid-pull Assist Setup (Note: wheels are not to scale—use larger wheels)

7.02 At a midpoint in the duct run, a second pull capstan is positioned near the manhole. The cable exits the manhole, wraps around the capstan, returning into the manhole to be pulled onward by the far-end winch or capstan. The diameter of the mid-pull capstan and associated sheaves or quadrant blocks must not be smaller than the minimum dynamic bend diameter of the cable. See page 2 for details.

7.03 Using the setup illustrated above, it is important that good communications be established and maintained between all workers involved in the pull. The mid-pull capstan will first begin pulling followed by the far-end winch or capstan. To stop, the order should be reversed with the far-end winch or capstan stopping before the mid-pull capstan stops.

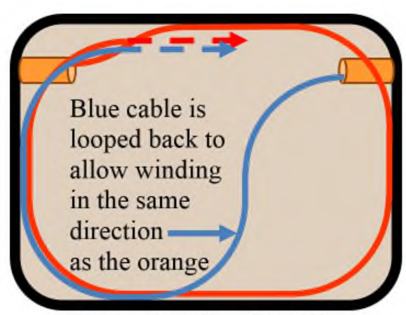
7.04 The mid-pull capstan must maintain a steady pulling rate that will enable it to feed cable that is not under tension back down into the manhole for the far-end winch or capstan to pull.

8.0 STORAGE OF CABLE IN VAULTS

8.01 It is preferable to have ducts and cables enter a vault on opposite sides. This naturally sets the cables up for storage winding in the same direction.

8.02 If the ducts are already placed on the same side of the vault, one (or more) cables may have to be looped back in order to change direction (for example, if the cables will be going to the same splice closure).

If you need to loop cables back, take a minute to plan out the easiest option. Smaller cables are easier to loop than larger ones. Multi-tube ribbon cables are easier to loop than central-tube ribbon cables.



Loop-Back of Cable

8.03 Central Tube cables typically have strength rods embedded in their jackets. This construction has a preferred bending plane. **Forcing a central tube cable to bend against its preference can cause stress or permanent damage.**

Directly coiling a cable will induce 1 twist per loop. As a result, each coil will have two places where the cable must bend against its' preference. For this reason, **direct coiling is not recommended for central tube cables or long lengths of any design.**

If direct coiling is unavoidable, it must be done carefully. The coils must be at least as large as the Minimum Coil OD (see page 2), and should be much larger if at all possible. Rough handling of the cable may cause kinks and permanent damage.

8.04 Cable Winding is a safer, neater and easier way to store slack. Winding is similar to placing cable on a reel that is lying on its side. Imagine walking the free end around the drum until it's all on the drum. The same approach can be used for storing cable in vaults.

A video of this process can be found at: https://tinyurl.com/VaultWinding

The process is also explained below:

Find the mid-point of the slack. Make a loop at the mid-point. Handle the loop carefully. The loop must never be smaller than the Minimum Static Bend Diameter (see page 2). The loop will kink if handled roughly. (The loop can be stored on a snowshoe, for added protection.)

Tape the loop together approximately 5' from the mid-point.

Tape the cable together at roughly 3' intervals, all the way back to the vault.

Pick up the loop and walk in a circle around the vault. Walk in whichever direction suits the orientation of the cable in the vault. (A shallow box is used in the demo, so that it's easier to see the cable in the stored position.)



Have a helper place the cable against the interior wall of the vault. Or, stop occasionally and place the cable yourself.

As you continue walking and placing the slack, you will be walking in a spiral. Continue walking and storing the cable until only the loop remains.

Carefully store the loop, being careful not to make it any smaller than the Minimum Static Bend Diameter. The loop does not have to be stored horizontally. It is sometimes easier to store loop diagonally in the vault, at an angle.

DISCLAIMER OF WARRANTIES AND LIMITATIONS OF LIABILITIES

The practices contained herein are designed as a guide. Since there are numerous practices which may be utilized, Prysmian has tested and determined that the practices described herein are effective and efficient. The recommended practices are based on average conditions.

In addition, the materials and hardware referenced herein appear as examples, but in no way reflect the only tools and materials available to perform these evaluations.

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For further information or assistance, contact:

Prysmian
700 Industrial Drive
Lexington, SC 29072-3799
800-669-0808 or 800-879-9862