Wireways—sometimes known as "troughs" or "gutters" within the electrical contracting field—are used to control wiring in environments where contaminants may cause problems.

A cable wireway is designed to protect **electrical** wiring from dust, dirt, oil, and water. It carries **electrical** feeders, branch circuits, and other groups of conductors. Most sections and fittings are completely open on one side like the letter “U” so wires and cables can be laid in along an entire **wireway** run.

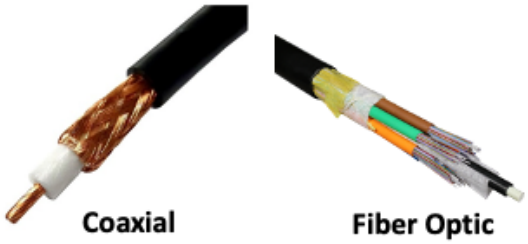
Training Objectives

- Distinguish between basic cable types
- Know the importance of following cable installation minimum bend radius (MBR) requirements
- Understand the impact of failure to follow MBR
- Know the importance of proper cable installation

- In this lesson, we will learn to distinguish between basic cable types, understand the importance of following minimum bend radius requirements, and learn the importance of proper cable installation.

Types of Cable

- Copper
- Coaxial
- Fiber Optic



Coaxial

Fiber Optic

Copper

Cable is most often provided in a single solid strand or in multiple smaller strands wound together to form a single line. Using many smaller strands to create a single line provides greater flexibility and resistance due to vibration-caused damage, while also making the cable easier to handle.

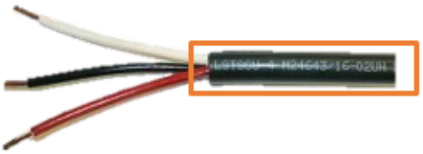
Copper is the most commonly used cable material. Copper is an excellent conductor of both thermal energy and electrical charges. It is soft and malleable – meaning it can be easily and permanently reformed into different shapes. Copper cables are used to transfer electrical power for equipment and lighting, in electrical and electronic control circuits, and for communications such as telephone signals.

Fiber Optic cable is created by making one cable from many smaller glass threads, each of which can be used to transmit information. Because glass is a poor conductor, fiber optic cable is not used to transmit electrical power. A break in a glass strand makes the strand unusable. When used to transmit digital information, fiber optic cable has much greater bandwidth than copper cable.

Coaxial cable is constructed of a single internal conductor, usually either a solid copper wire or single cable constructed of multiple copper strands, surrounded by an insulating layer and then a shield layer of woven metallic braid or metallic tape or a combination of the two.

Cable Identification

- Cables are identified by purpose, characteristics, and size using a code printed on the cable



- A cable marked LSTSGU-3 means
  - LS – Light smoke cable
  - T – three conductors
  - SG – Silicone rubber and glass tape insulation
  - U – unarmored cable
  - 3 – the cross-sectional area of the cable in ”Circular mils”
    - One circular mil is the area of a circle with a diameter of one mil – one thousandth of an inch

Cables are identified by labels printed intermittently along the insulation. The labels use an identification code composed of sixth numbers and letters followed by a seventh number. In the next two slides, we'll discuss the code used in detail.

In this example, the cable is marked LSTSGU-3. The six letters reveal that this is a low smoke cable which includes three conductors, has silicone and glass insulation, and is unarmored.

The final number, 3, indicates that the cross section of the cable has an area of 3000 circular mils where one circular mil is the area of a circle with a diameter of one thousandth of an inch. We'll learn in the next slide that if the third letter were an “M” meaning multiple conductors, the number at the end would indicate the number of conductors instead of the cable's cross-sectional area.

Conductor Identification Guide

Number of Conductors	
The third letter (or pair) in each conductor name lets the electrician know the number of conductors in the cable.	
Type	**Description**
LSSSGU S = Single conductor	Low smoke, single-conductor, silicone rubber, and glass tape insulation, unarmored
LS7SGU 7 = Seven conductors	Low smoke, seven conductors, silicone rubber, and glass tape insulation, unarmored
LSMSCU-91 M = Multiple conductors; 91 in this example-the number given is the number of conductors	Low smoke, multiple conductors, silicone rubber, glass braided conductors, cross-linked polyolefin jacket, unarmored
LSTTSU-20 TT = Twisted pairs; 20 in this example for a total of 40 conductors	Low smoke, twisted pairs, extruded silicone rubber and polymide special purpose, cross-linked polyolefin jacket, unarmored
Common Abbreviations	
S - single conductor D - Two conductors T - Three conductors F - Four conductors	6 - Six conductors 7 - Seven conductors M - multiple conductors TT - Twisted pair

As an electrician, you must ensure that the correct cable is being installed or connected. This requires that you understand cable markings as described in this table.

Low smoke means that the cable insulation would give off only low amounts of smoke and toxic gases during combustion.

Armored cable has a layer of very thin, braided wire outside of the insulating material to provide additional strength, flexibility, and protection.

It is important to understand that letters may have different meanings depending on the type of cable and its use and unfortunately, this means that you'll need to become familiar with a few different systems. You will see examples of this in later slides.

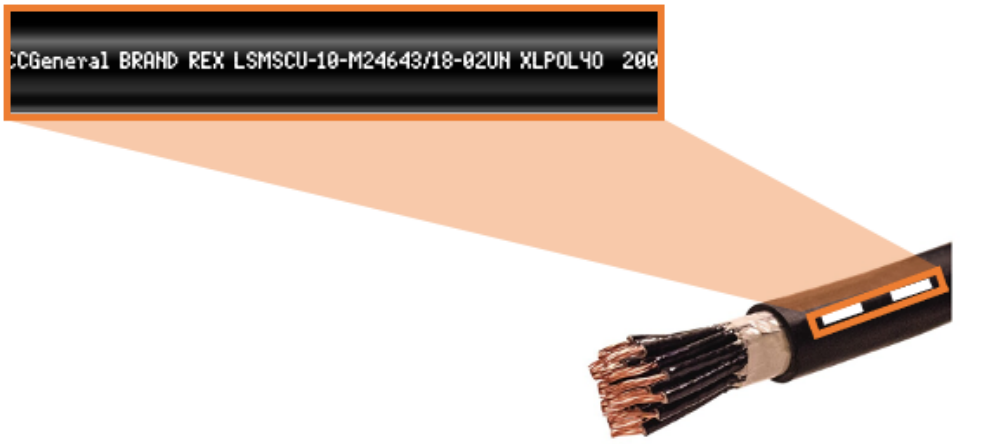
Conductor Abbreviations

Cable Designations & Common Abbreviations	
Type	**Abbreviation**
LSSSGU-50 to LSSSGU-2000	S-50 to S-2000
LSDSGU-3 to LSDSGU-400	D-3 to D-400
LSTSGU-3 to LSTSGU-400	T-3 to T-400
LSFSGU-3 to LSFSGU-200	F-3 to F-200
LSMSCU-7 to LSMSCU-91	M-7 to M-91
LSTTSU-1½ to LSTTSU-60	TT-1½ to TT-60
LS5KVTSGU-100 to LS5KVTSGU-400	5KVT-100 to 5KVT-400

This table provides a listing of some of the more common types of cable you are likely to use as a marine electrician and shows the short-hand version you might also see so that you can recognize them in all their potential forms. These abbreviations might be used when the primary cable types used in a work package or diagram are already known and where confusion is unlikely. The extended versions on the left side are the proper designations.

Cable Identification

- LSMSCU-10 – Low Smoke, Multiple Conductor, Silicone Rubber insulated, glass braided conductors, cross linked polyolefin jacket, unarmored



LSMSCU-10 has 10 conductors

Here you see a cable label. The cable is identified as “L-S-M-S-C-U-10”.

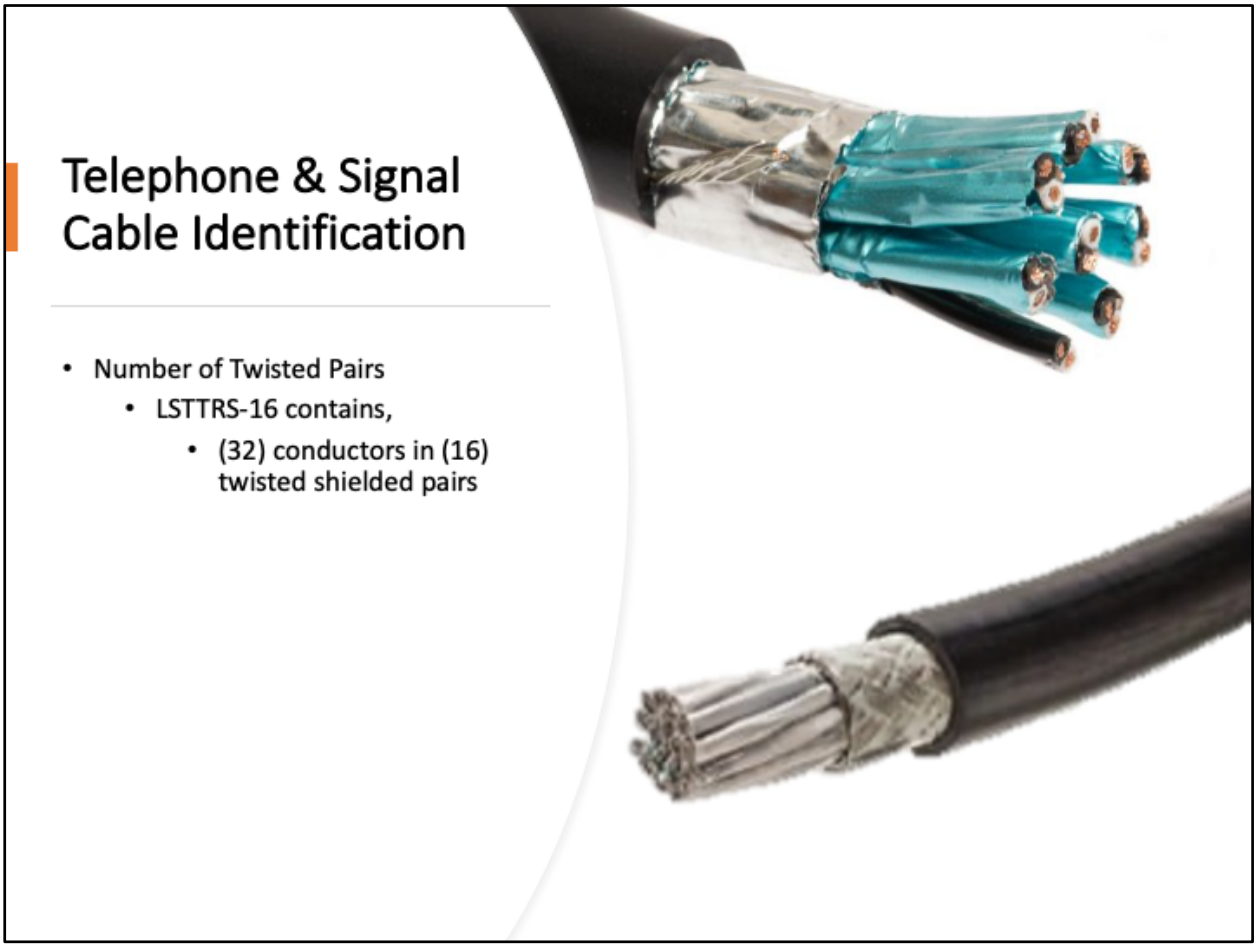
The code starts with “LS,” which means that it is “low smoke” and will only give off small amounts of smoke or toxic gas when overheated or in a fire. The next “M,” tells us that it is carrying multiple connectors. This goes with the “10” at the end, which says the cable is carrying 10 conductors.

“SC” tells us that the cable uses silicone rubber and glass braided insulation.

The “U” before the dash indicates that the cable is “unarmored.” Armored cable has a layer of very thin, braided wire outside of the insulating material to provide additional strength, flexibility, and protection. Though not previously discussed, to the right of this portion of the marking, the XLPO indicates that the cable has a cross-linked polyolefin jacket which might be required in some applications.

You should understand that this means a low smoke cable designated by the “LS” carrying multiple connectors as shown by the “M”.

The ”S” and “C” tell us that the cable uses silicone rubber and glass braided insulation. The ”10” at the end relates to the “M” and means the cable carries 10 conductors.

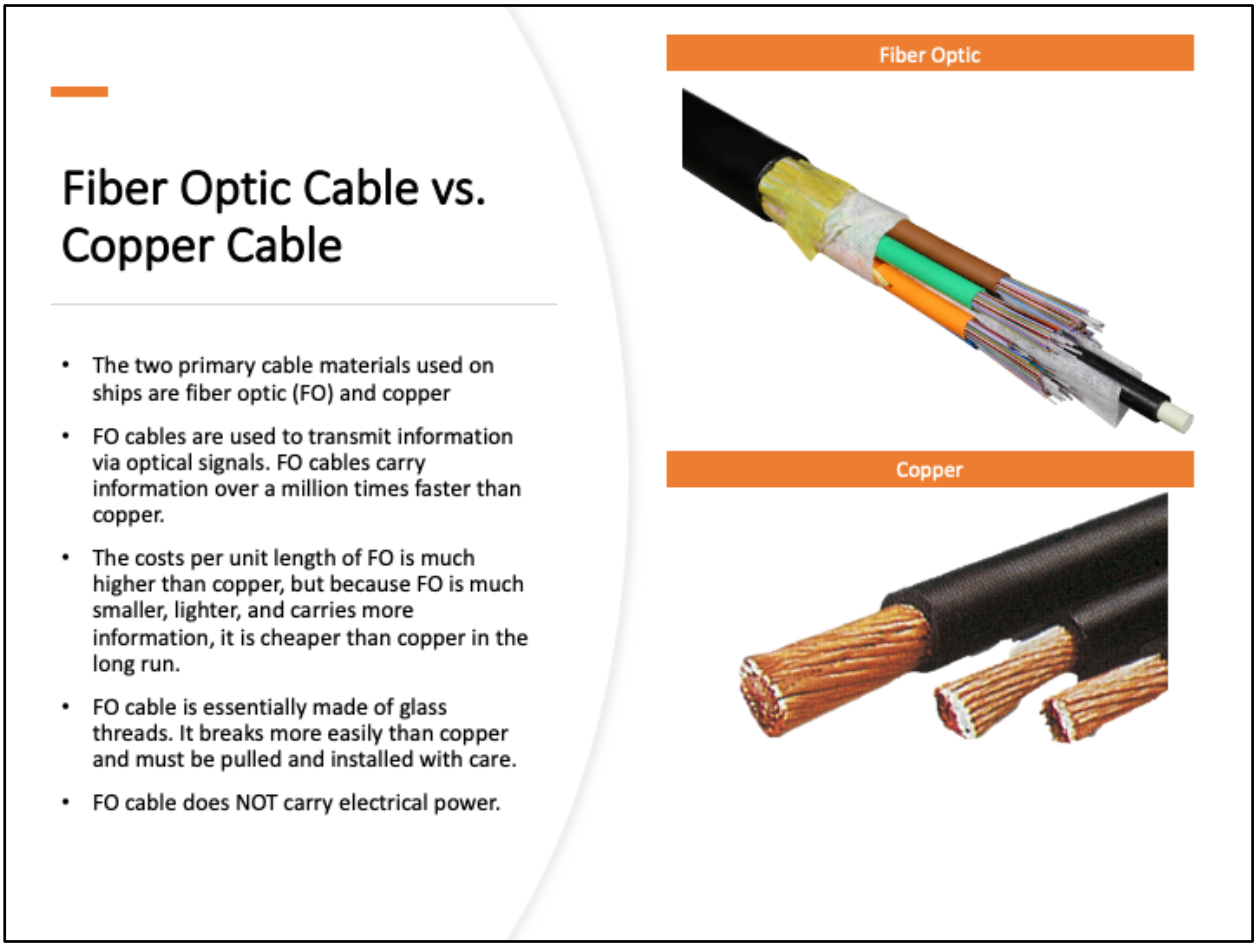


This is a picture of a typical telephone cable. The cable markings identify this as LSTTRS-16.

LS means that this cable is Low Smoke producing.

The TTRS tells us that the cable carries 16 Twisted Pairs of conductors – 32 conductors in all – and is shielded

The letters and numbers on cables may have different meanings depending on the cable type. –



Cables used on ships are usually fiber optic or copper.

Copper has been used for more than a century. Fiber Optic use did not become common until the 1990s. It carries digital information using optical signals and can carry information much faster than copper cables. Fiber Optical cable does not carry electrical power.

The initial cost of FO cable is higher than that of copper but because it is much smaller, lighter, and has greater capacity, the lifetime cost is actually cheaper than the cost of copper.

Fiber optic cable is essentially made of glass threads. It can be easily broken during installation and must be pulled carefully.

Cable Types: Fiber

- Two kinds of Fiber Cables:
  - Blown Optical Fiber (BOF) Tube
  - Hybrid Fiber Copper Cable (HFC)
- These are used for:
  - Control
  - Telephone & Signal
  - Computers
  - Data Transmission

Blown Optical Fiber tubes contain one or more microducts with fiber optic cables. Compressed air is used to insert the fiber optic cable into the microducts.

Remember that FO cable is very fragile. The air does not really blow the fiber optic in, but provides a layer of air between the fiber optic and microduct surface that serves as a lubricant and aids insertion.

Hybrid Fiber Copper Cable includes both fiber optic cables and a copper conductor. Hybrid Fiber Copper Cable keeps the high bandwidth and low noise/low interference susceptibility of fiber optic cable and can be brought close to the user without having to replace all of the existing copper cable.

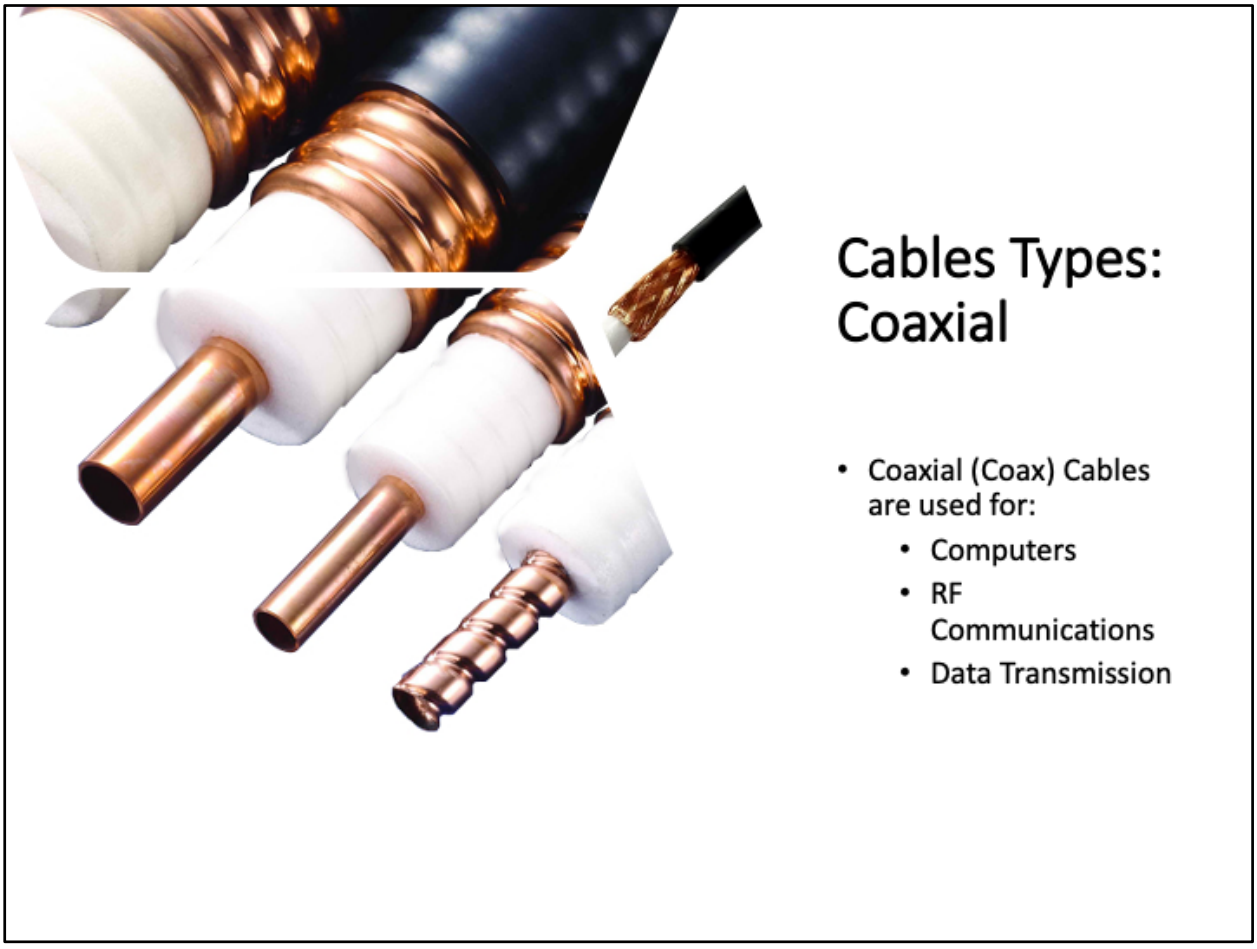
Hybrid Fiber Copper Cable is used for relay control of fiber optic data.

Fiber optic cable is generally installed in separate wireways from heavier copper cable.

Because of its sensitivity and susceptibility to physical damage, there are special rules for stacking fiber optic cable depending on the cable's type and purpose. You will need to learn and be familiar with the stacking rules.

Be very careful not to stack heavier copper cable on top of fiber optic cable. Do not lay other equipment or tools on the cable. And do not step on the cable.

Cable saddles are required on all blown optic fiber cable. These are contoured hangers that protect the cable at the support points.



You are probably familiar with coaxial or “co – ax” cable as a type used to connect cable tv.

It is made of a center conductor material, usually copper, surrounded by a non-conducting dielectric material that looks like plastic. Dielectric materials are a special type of insulator that reduce the impact of electrical interference or static.

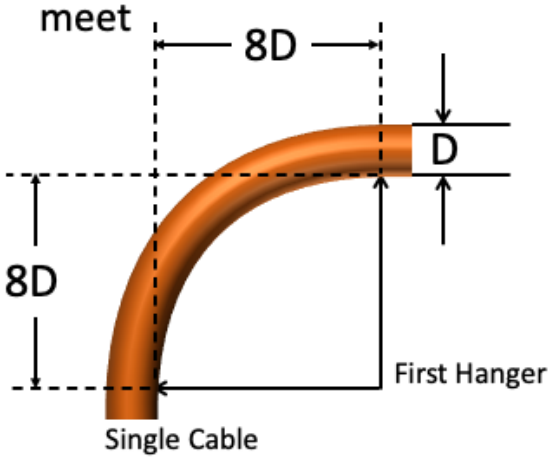
The dielectric is itself surrounded by a conducting layer of copper sheet or copper braid cable. The outside layer of coax is an insulator.

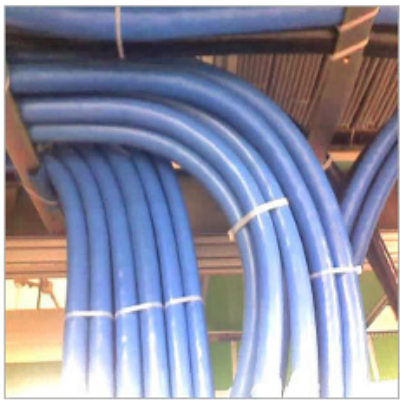
Coax is used to connect computers, radio frequency (RF) communications systems, and data transmission systems.

Like blown optic fiber cables, coax always uses cable saddles.

Minimum Bend Radius (MBR)

- To prevent damage caused by bending cables to sharply, the cable turns are limited by the Minimum Bend Radius
- In general, the MBR is equal to 8 times the diameter of the largest cable in the run (10 times for coaxial cable)
- The MBR is measured at the point where lines perpendicular to the cable at the two hangers involved meet



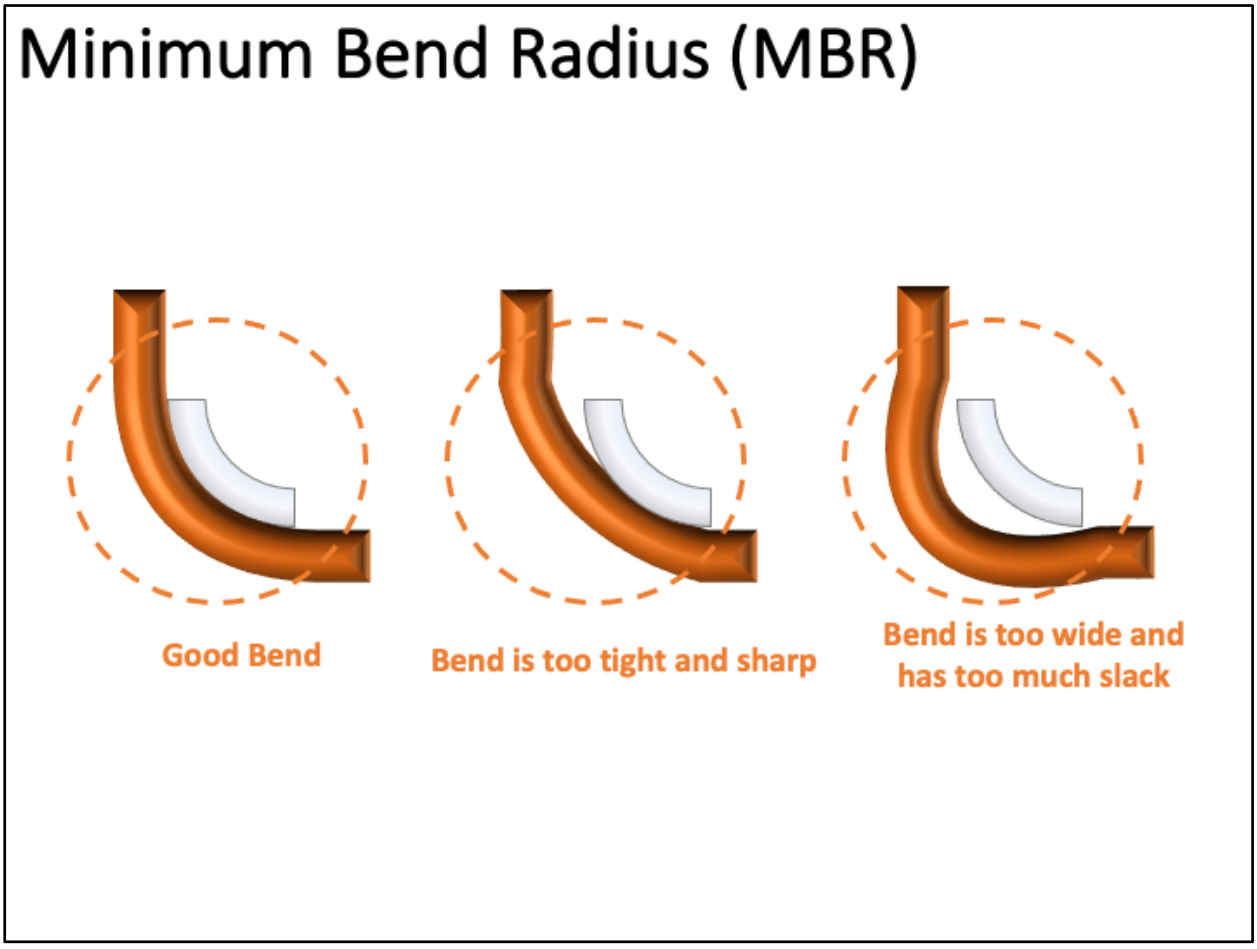


When cable is installed, we must be careful not to cause it to bend too tightly. This can weaken or crack the cable jacket and lead to potential cable failure over time.

We must also not have too much slack in a cable. Too much slack could allow equipment or tools in a future action to catch on the cable. This would create a bend or kink that violates minimum bend radius limits.

In general, the minimum bend radius or MBR of a cable bundle must be greater than 8 times the diameter of the largest cable in a run. To provide sufficient protection for coax, the minimum bend radius is 10 times the largest cable in the bundle.

Once you have identified the value of the MBR, identify the point from which it is measured. In the diagram provided, this would be the point at the bottom right where lines perpendicular to the cable at the two hanger points meet.



These graphics show examples of cables with correct minimum bend radius, too tight a bend radius, and too much slack in a bend.

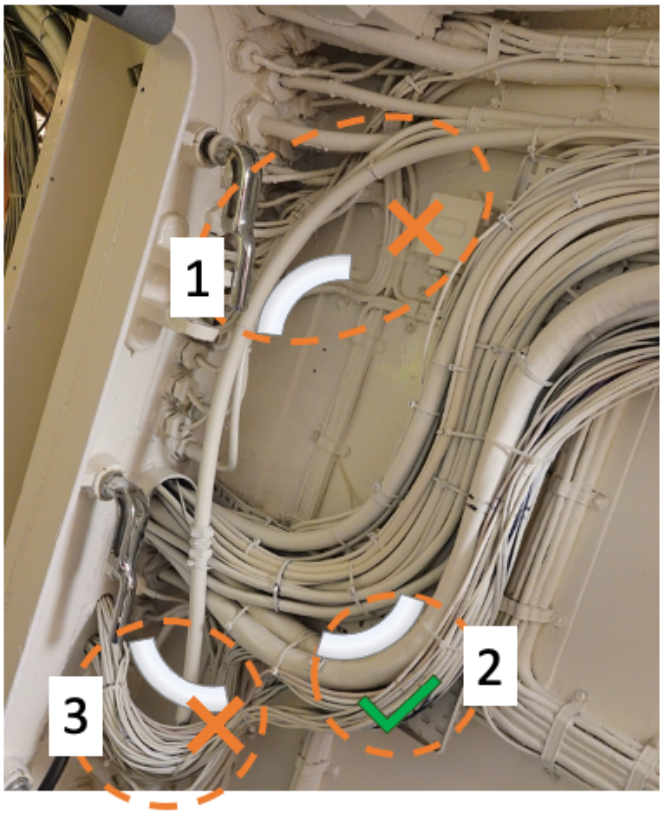
Notice how, when the bend is too tight, the cable enters the hanger at an angle and does not come straight through. This can cause stress and lead to future cable failure. Cables should always enter and exit perpendicular to the hanger.

You can also see that when a bend is too wide and there is slack in the cable, portions of the cable within the bend may curve too tightly.

Tools like the ones shown in these graphics are used to make it easier to check MBR for common cable sizes.

Correct Bend Install

Good Bend



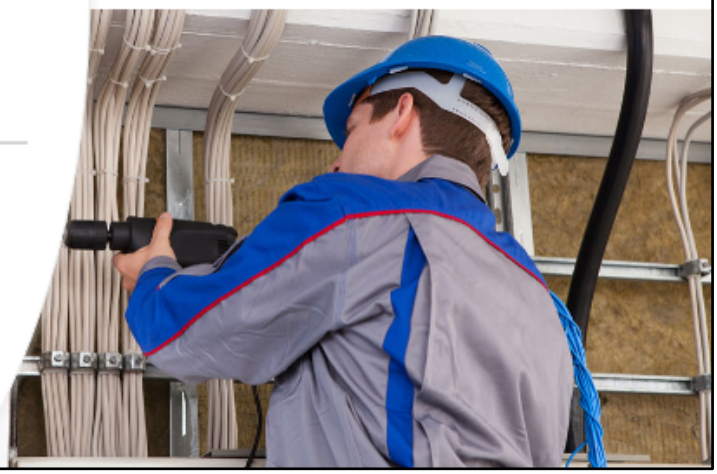
In the graphic on the left, a simple tool used to check cable bend is shown with the cable. This tool makes it easy to see proper bend.

In the picture on the right, in area 1 some of the cables have too little bend radius and some have too much. Also, some cables cross over one another,

Area 2 shows a correctly installed bundle.

In area 3 on the right, the bend appears to be too tight but may be acceptable. It's a good example of why checking the bend instead of relying on appearance alone is important.

Cable Storage, Handling, and Installation



Let’s talk now about general cable storage and handling

Cable Storage & Handling

- Cables are fragile and should not have weight put on them
  - Store them off deck
  - Don't let them get stepped on
  - Don't stack anything on them, like equipment, material, or pallets
- Handling cables can cause damage
  - When preparing to install cable, lay it out in a large "figure 8" but don't make large stacks.
  - Never hang a cable where a single support is holding all the cable weight. Avoid using excessive force when pulling.
- Inspect cables for damage before, during and after installation.

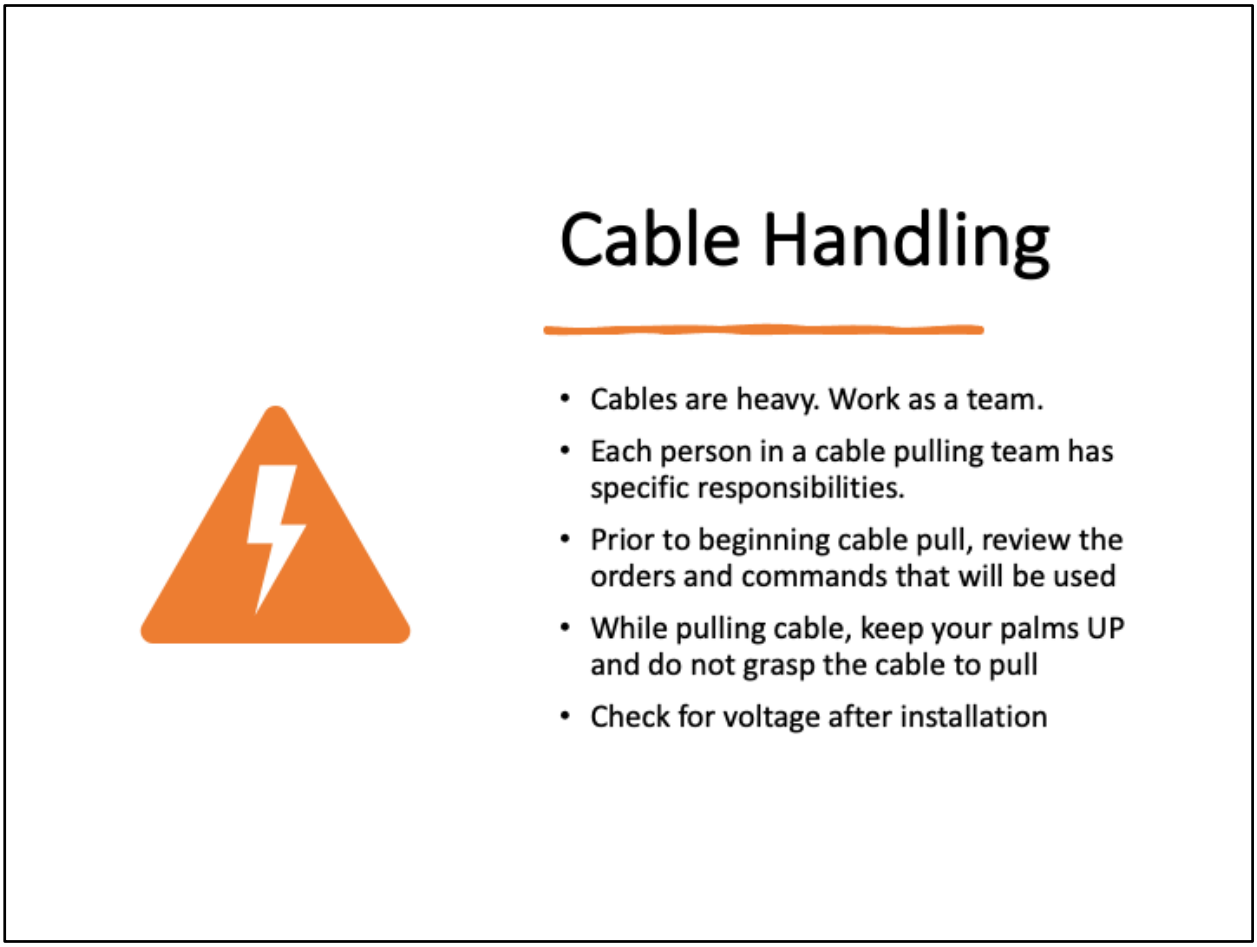
As you've learned, cables are very fragile, especially when bent or crushed under weight. That weight can come from the cable itself, when it is stacked too high, or from putting stuff on top of it.

Prior to installation, store cables off the deck in a way that minimizes the chance that they could be walked on. Do not stack equipment, material, or pallets on cables as these might cause damage. Just prior to installation, cable may be laid out in large figure 8s but these, too, should not be stacked deep. The cable's own weight can cause damage if you make the figure-8 stacks too large. Cables can also be damaged while you're handling them.

While pulling cable, use steady pulling force and avoid sudden jerks or excessive pulling force that could cause damage. When you feel like you need to use a great deal of force, walk the cable to identify where it is being hung up.

Cables should never be hung with a support holding the full weight of the cable. This leads to excessive cable bend and can overstress the support.

Because there are so many ways in which cables can be damaged, it is important to inspect cables prior to, during, and after installation to ensure that there is no damage.



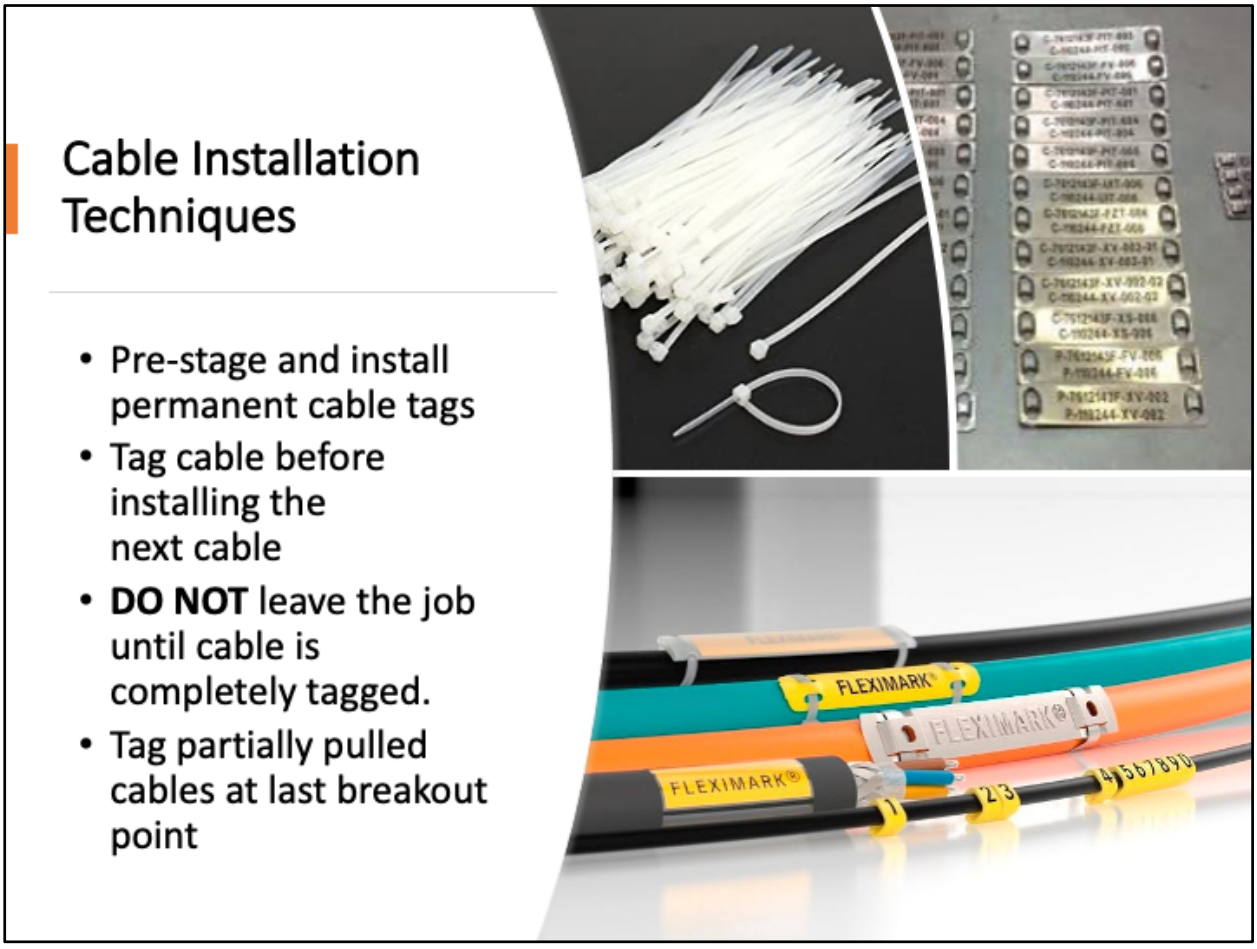
Cables, especially power cables, are very heavy. Work as a team to share the load and reduce the need or temptation to jerk on the cable to start it moving.

All workers involved should gather as a team before beginning a pull to reinforce individual responsibilities and review the orders and commands that will be used.

Be alert to those who may be participating in a cable pulling evolution for the first time and ensure they fully understand what is expected. Damage caused to cables may not be immediately obvious but is always expensive. It is important to ensure new team members understand what to expect.

While feeding the cable, keep your palms up. This helps you remember to support and pass the cable down the line. Avoid grasping the cable with your hands. This naturally lends itself to pulling.

Once the cable is installed, a qualified individual must check to ensure voltage is present and correct.



Cable tags are ALWAYS required. Work is not fully complete until permanent tags are installed.

Always tag one cable before beginning the next installation and never leave the job site unless cables are tagged. With the large number of cables that may be worked at a time, it is very easy to confuse cables that are not properly marked.

If work must stop before a cable pull is complete, tag the partially pulled cable at the last breakout point to reduce confusion when work resumes.

Cable Installation (1)

- Prior to beginning the cable pull
  - Lay cable out in a figure 8 pattern or remove it from the spool or turntable
  - Walk and inspect the full cable run
  - Move existing cables so as not to cause damage when pulling in new cable
  - Minimize breakout points
  - Station a puller at breakout points to help guide cable
- Cable run – Pulling the cable
  - Install the cable with the largest cable in the middle of the hanger and smaller cables on either side
  - Do not stress Coaxial or Fiber Optic cables
  - Use Cable Lube or cable rollers if authorized

Prior to starting a cable pull, pre-stage the cable by laying it out in a figure 8 pattern or remove it from the spool or turntable. Prestaging the cable eases loading by reducing cable-on-cable friction. It also helps to reduce cable twisting. Remember not to let the stacks get too high when working with certain types of cables or they will damage the cables.

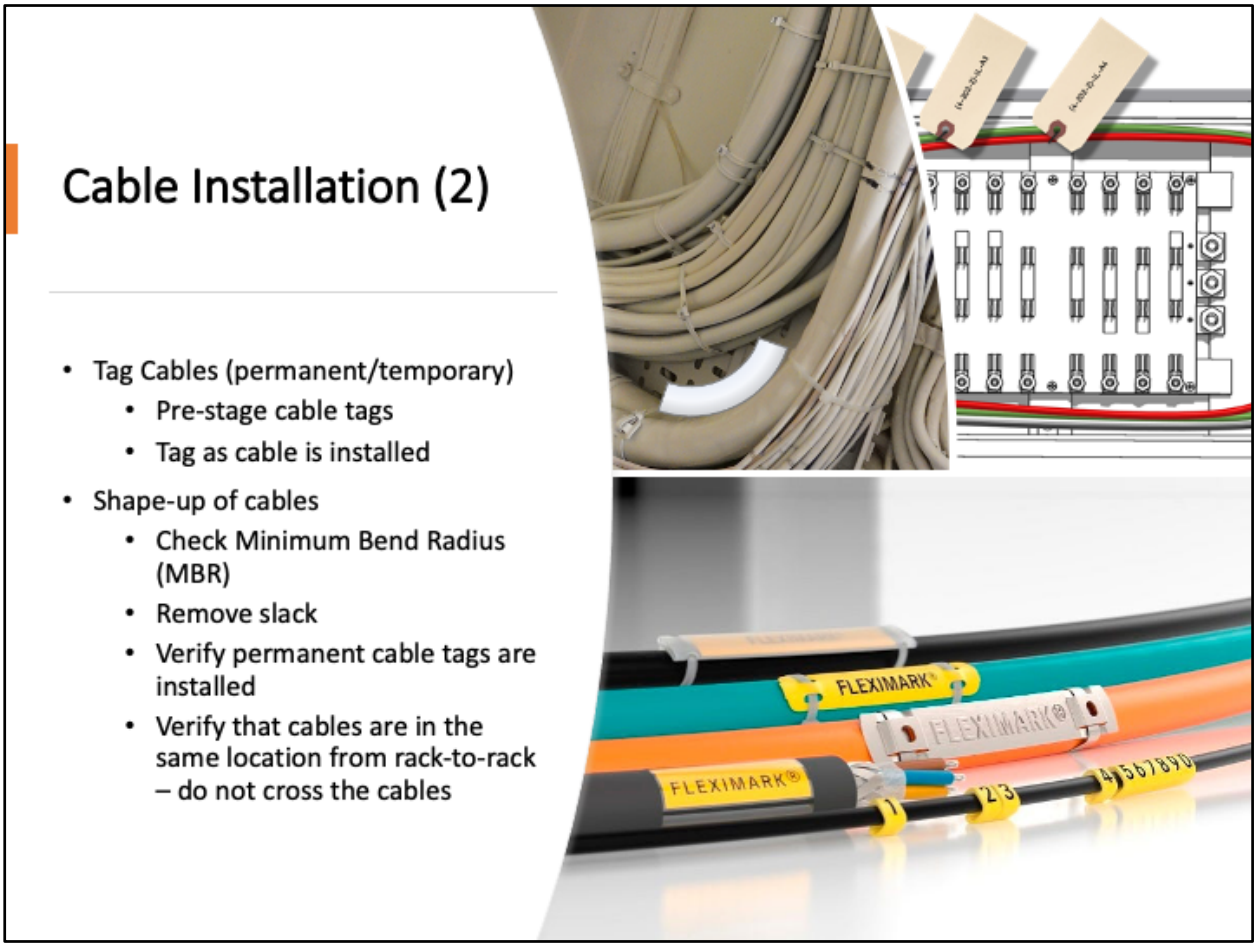
Walk the full length of the planned cable to check for potential problems before beginning. Existing cables should be moved as necessary to ensure space is available for the new installation.

Minimize the number of breakout points where the cable leaves or enters a confined, dedicated space. These are points where friction is likely to increase and where the cable may tend to droop under its own weight. If necessary, stage extra workers here. Ensure at least one member of the assigned pull-team is at all breakout points to guide the cable.

Install cable with the largest cable in the middle of the hanger and smaller cables on either side. This balances weight and reduces the difficulty of future cable movements if required.

Be especially careful with coax and fiber optic cables which are easily damaged.

Some installations can be made easier by using Cable Lube or cable rollers. However, verify that these are allowed. If cable lube is used, it must be COMPLETELY removed after the cable is in place.



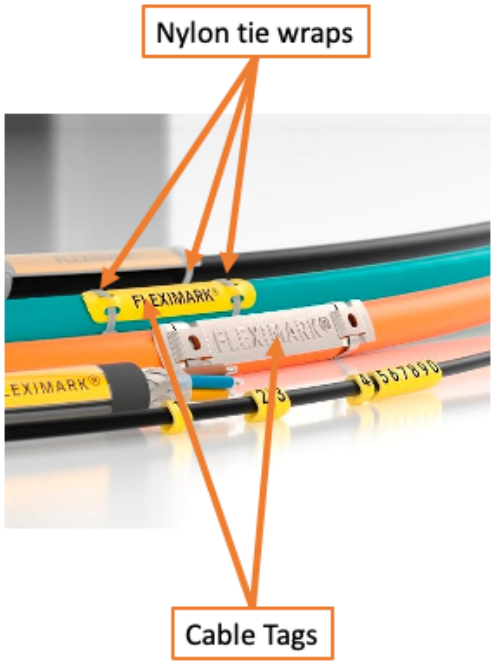
Cables must be tagged immediately after installation to prevent confusing cables in the future. Temporary tags can be used if permanent tags are not yet available. To make this easier, pre-stage the cables with labels where they will be used.

Work is not complete until final inspections are satisfactory. This requires walking and inspecting the full length of the installation. Ensure that all cable turns comply with minimum bend radius requirements and that all slack has been removed. Permanent cable tags must be installed. Check to make sure that cables are in the same relative position from rack-to-rack or hangar-to-hangar and that no cables are crossed

Cable Tags

- Permanent cable tags are strips of metal with the cable identification stamped in
- Tags are attached to the cable with nylon tie wraps
- Orient the tags so that they face out and are easily read from left to right
- Install tags a uniform distance from all penetrations

ALWAYS TAG THE CABLE!



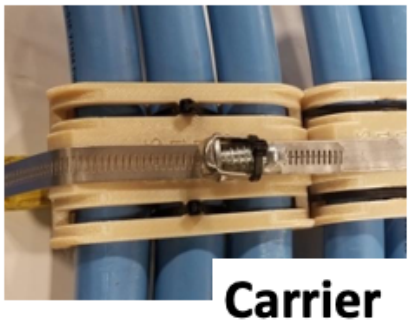
Permanent cable tags are metal strips with the cable identification stamped into the tag. The tags are tie wrapped to the cable. Be careful to ensure that the tags are installed ”right-side-out” so that they can be read from left to right.

The sharp edges of the cable tags should be pointed toward the cable and not away from the cable where they might cause injury. The raised buckle on the cable should also be toward the cable.

Install tags a consistent distance and as close as practicable to each point of connection and on both sides of decks or bulkheads.

Banding

- Cables in a bundle are banded together
- Cable bands are metal bands that form a loop when joined. Bands are tightened by rotating a bolt that draws the free end of the band through the housing.
- Banding restricts the movement of cables within a cable run, reducing the the chance of chafing, vibrations, or slapping against fixed objects
- Cable movements may lead to damage or cause sound shorts
  - Internal - electrical
  - External - sound shorts



Carrier

Submarine and Carrier

After cables are installed, bundles of cables are banded together using a metal loop much like a hose clamp used on automobiles or some plumbing applications.

The banding is wrapped around the cable and the free end of the band is inserted into the housing. Threads in the bolt in the housing engage the slots in the band and when the bolt is rotated, pull the free end through the housing tightening the band.

Banding the cables prevents relative movement of the cable which could lead to chafing and cable damage. It also reduces cable vibrations or movement that could cause damage or noise such as slapping against a bulkhead.

Sound shorts are caused when sound vibrations are transmitted into the water. These make a vessel more detectable to sonar equipment.