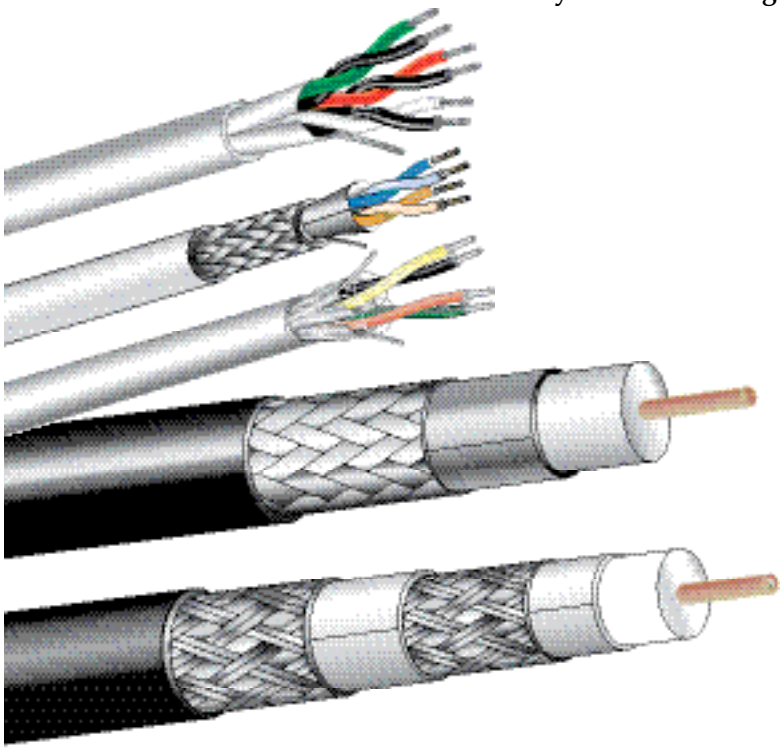
Technical Reference

This Technical Reference Section was developed as an aid to better understanding, specifying and installing electronic wire. The information contained in this section is written for the novice while still providing a quick reference of commonly used parameters for the experienced designer, engineer, consultant or installer.

This information should only be used as a general guideline. Various parameters such as the system type, electrical and mechanical characteristics, and environmental locations will determine your exact cabling needs.



Mini Index

Technical Reference Section

Basic Cable Construction

A cable type is determined by the specifications of the system installed, basic electronic principles, and environment and regulatory agencies. These various criteria dictate the type of conductor(s), gauge of wire, type of insulation, twisted or cabled construction, type of jacket and if any shielding is required. A basic understanding of cable construction should be helpful in selecting and installing the proper cable for a particular system.

Conductors

Conductors for electronic cables can vary greatly from stranded conductors for maximum flexibility to copper covered steel which provides a stronger cable that will withstand a greater physical strain than copper. The American Society For Testing and Materials (ASTM) standards are followed for all of West Penn Wire conductor material. The ASTM standard defines standard requirements such as tensile strength, elongation, resistivity, dimensions, permissible variations, finish, inspection, and testing.

Conductor Material

There are several types of material that conduct electricity well (aluminum, nickel, gold, silver). However, copper is the most popular due to its excellent conductivity compared to other material cost. West Penn Wire uses a variety of conductors in our cable. Material used can be bare copper, tinned copper, and copper covered steel. The conductor can consist of solid or stranded construction. The type of conductor selected is determined by the application the cable will be used for.

Solid Conductors

A copper rod provides a solid conductor for a wire. A solid conductor offers lower cost and is easily formed to any shape desired. A solid conductor does not have much flexibility and may break if flexed too much in one place. For these reasons, a solid conductor is best suited for use in a fixed or permanent installation.

Stranded Conductors

By combining several strands together a stranded conductor can be formed. A stranded conductor is easy to pull, flexible, and is less likely to break if subjected to frequent bending. The finer the strands and the more strands used to assemble a conductor, the more flexible the conductor becomes. Therefore, stranded cable is ideal for installations where frequent movement of the cable is required.

Bare and Tinned Conductors

Conductors can be either tinned or plain bare copper. Most electronic connectors today are designed to be used with bare copper. In cables that are terminated with soldered connectors, tinned plated conductors can help in soldering the wire to the connector.

Copper-Covered Steel

This type of conductor uses a steel conductor covered with copper. This type of conductor make-up is used for RF applications that require a cable to withstand added tension. The steel provides added strength, and the copper provides good conductivity for higher RF signals. This type of conductor is not good for low frequency transmission.

Conductor Size (AWG)

Conductors are measured in size/diameter through a gauging system. There is no industry standard. However, the American Wire Gauge (AWG) system has been generally accepted as the standard in the wire and cable industry. The sizes are derived through a logical, geometric progression. The smaller the number, the larger the wire, and likewise, the larger the number the smaller the wire. The AWG system is important because it provides a standard reference for comparison of various conductor materials based technically on the cross-sectional area of the wire.

Example: A #22 AWG wire is smaller than a #18 AWG wire.
A #14 AWG wire is larger than a #24 AWG wire.

Dielectric

Insulation is a highly resistive material that is applied to the conductor to resist the flow of electric current to other conductors and provide protection to the conductor. There are many types of insulation materials used and each has its advantages and limitations. The type of insulation selected is based upon the application of the cable. Insulation is also referred to as the dielectric of a cable.

Dielectric Strength

This is the amount of voltage that insulation can withstand before it "breaks down". The material type and thickness determines the insulation's dielectric strength. The application and environment the cable will be used will determine the dielectric strength required.

Protection

Insulation also must provide flame retardancy in case of fire, provide resistance to abrasion and provide protection from electrical shock.

Dielectric Categories

Electrical insulations can be divided into four categories.: Thermoplastics, Thermosets, Fluoropolymers, and Elastomers. Insulations are normally applied by an extrusion process. The extrusion process forces pre-heated plastic through dyes which forms a continuous covering over the conductor. This is usually called the primary insulation.

Thermoplastics

Thermoplastic compounds are compounds that are softened by mechanical pressure and applied heat, and maintain their altered shape when cooled and/or the mechanical force is removed.

Polyvinylchloride (PVC)

This is probably the most widely used insulation for low voltage insulation. This compound is offered in a variety of formulations. Through different manufacturing processes, PVC can be made to resist sunlight, ozone, flames, oil, and most solvents. PVC insulation is fairly consistent, allowing for bright colors, and is very flexible and easy to strip.

Polyethylene

This compound offers excellent electrical properties such as low capacitance and low loss of a signal. Polyethylene is lightweight, water-resistant, and fairly chemical resistant. Polyethylene offers good abrasion resistance and is somewhat harder to strip than PVC.

Polypropylene

This material is similar to polyethylene as to electrical properties providing low loss properties with less material. Polypropylene also provides excellent mechanical properties and is very abrasion resistance although stiffer than Polyethylene. Of the four compounds listed in this category, polypropylene is the most difficult to strip.

Copolene

Copolene is a West Penn Wire Trademark. This insulation offers a low dielectric constant enabling low capacitance. Excellent electrical properties allow high speed, low distortion signal transmission.

Basic Cable Construction

Fluoropolymers
These compounds are commonly used for high temperature applications and areas such as plenums that require flame retardancy and low smoke characteristics. The NEC mandates the use of these types of materials in ducts, plenums, and other space used for environmental air. Using these types of compounds will allow for reduced cost in installation because there is no need to install conduit.

Halar®
A premium insulation with excellent electrical and mechanical properties. This compound offers a stable low dielectric constant over a wide range of frequencies. It is also chemical resistant, abrasion and impact resistant, and can withstand high temperatures.

Teflon®
A premium insulation with excellent electrical and mechanical properties. This compound is widely used as a solid or foamed dielectric, allowing for an extremely low loss cable. This compound can withstand high temperatures and has low flame and smoke characteristics.

Copolymer
Polyvinylidene Fluoride (PVDF). This compound has rather poor electrical properties. However, this compound has a very high temperature rating and excellent mechanical properties such as cut-through resistance, corrosion resistance, abrasion resistance, and high tensile strength.

Elastomers
This is a group of compounds that are "rubber-like" in appearance. They can be compressed or even stressed and will snap back to their original shape with the release of tension.

TPE - Thermo-Plastic Elastomer

Shielding
There are basically three types of shielding techniques: foil shielding, braid shielding, and combination shielding. Shielding is utilized to prevent radiation and signal loss of high frequencies used in electronic circuits and to reduce EMI/RFI interference. However, shielding tends to increase the overall capacitance of the cable.

Foil Shield
Foil shields are usually made of a thin layer of aluminum bonded to a polyester film. A foil shield allows for 100% coverage if applied with an appropriate overlap construction. A drain wire is used in conjunction with the foil shield to connect the shield to ground. This permits extraneous signals to be “drained off” to ground. It is very good in reducing Radio Frequency (RF) interference, but does not perform as well in blocking Electro Magnetic Interference (EMI). Foil shields do provide easy termination and low cost protection, although fragile (low tensile strength and impact resistance).

BiFoil
This type of foil shield allows for added protection by increasing the metallic coverage without adding increased thickness to the diameter of the cable. Mainly used in coaxial cable, the BiFoil shield is an aluminum-polyester-aluminum tape with 100% coverage.

Bonded BiFoil
This type of foil shield has the same aluminum-polyester-aluminum construction as the BiFoil shield, but is also bonded to the dielectric with adhesive. This allows for better shielding capabilities as well as providing excellent ease of stripping because the foil does not pull away from the dielectric.

Braid Shield
Braided shields can be constructed in various coverages, 95–98% being about the highest coverage available with this type of shielding. The material can be bare copper, tinned copper, or aluminum. Depending on the amount of coverage, braid shields reduce EMI interference well, but are not as reliable in the RF range. Braid shields also allow for a much lower shield D.C. resistance than foil

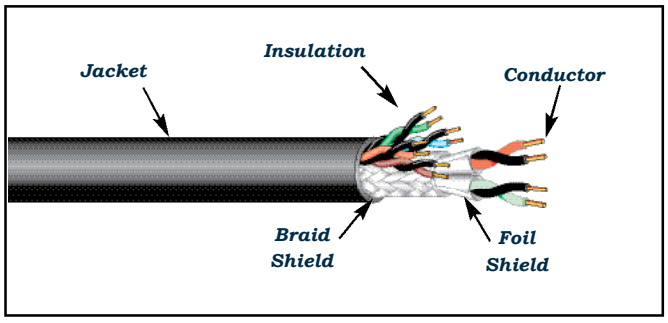
Combination Shielding
This technique offers the best of both types of shielding. First, a foil shield is applied around the primary conductors and then a braided shield is placed on top of the foil shield. This allows for greater coverage in blocking both EMI and RFI signals while allowing for a low D.C. resistance in the shield. There are also various versions of this basic technique such as triaxial and quad shielding.

Foil/Braid
This is the most common type of combination shielding. The aluminum foil is wrapped around the cabled or twisted primaries and then a braided shield is applied over top
of the aluminum foil. The metallic side of the foil shield is usually in contact with the braid. The braid is then used for shielding as well as ground termination eliminating
the need for a drain wire.

Triaxial - A Braid-Separator-Braid combination shield construction.

Quad - A Foil-Braid-Foil-Braid combination shield construction. This provides for maximum shielding against EMI/RFI interference.

Jackets
The cable jacket is for strength, integrity, and overall protection of the primaries and/or shield inside the jacket. There are a variety of jacketing materials that are used in cable construction. Standard compounds and special variations of these compounds can be used in making the jacket. Selecting a cable with the proper jacket for the environment it will be installed in is an important consideration. Environmental parameters that should be considered include temperature variations, chemical reactance, sunlight resistance, mechanical and abrasion impact. Jackets are usually made up of the same material as insulation used on primaries. To learn more about the various compound properties, please refer to the Insulation Section.



Coaxial Cable Construction

This section provides an introduction to understanding coaxial cable construction. These fundamentals will allow you to understand the basic materials that are used in the construction of a coaxial cable. A coax cable type is determined by the specifications of the system installed, basic electronic principles, environment, and regulatory agencies. These various criteria dictate the type of conductor, gauge of wire, type of insulation, shielding, and type of jacket. A basic understanding of coaxial cable construction should be helpful in selecting and installing the proper cable for a particular system.

Conductors

Conductors for coaxial cables can vary greatly from stranded conductors for maximum flexibility to copper covered steel which provides a stronger cable that will withstand a greater physical strain than copper. The American Society For Testing and Materials (ASTM) standards are followed for all of West Penn Wire conductor materials. The ASTM Standard defines standard requirements such as tensile strength, elongation, resistivity, dimensions, permissible variations, finish, inspection and testing.

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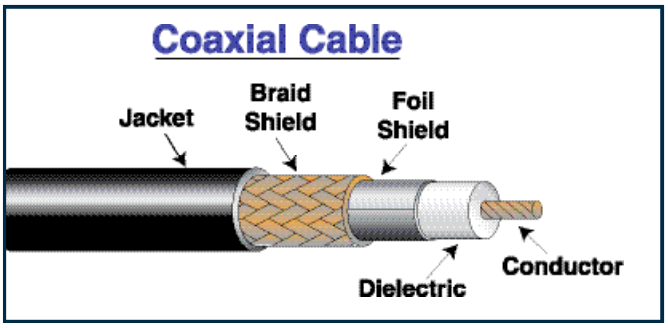
Bare and Tinned Conductors

Conductors can be either tinned or plain bare copper. Most electronic connectors today are designed to be used with bare copper. In cables that are terminated with soldered connectors, tinned plated conductors can help in soldering the wire to the connector.

Copper-Covered Steel

This type of conductor uses a steel conductor covered with copper. This type of conductor make-up is used for RF applications that require a cable to withstand added tension. The steel provides added strength and the copper provides good conductivity for higher RF signals such as CATV. This type of conductor is not good for low frequency transmission, such as CCTV.



Dielectric

A coaxial cables dielectric is a highly resistive material that is applied to the conductor to resist the flow of electric current to the shield. It also sets up a cables electrical characteristics. There are several types of insulation materials and constructions used and each has its advantages and limitations. The type of insulation selected is based upon the application of the cable. Insulation is also referred to as the dielectric of a cable.

Solid Dielectric Construction

A solid dielectric construction uses a process of extruding a solid material over the center conductor of a coaxial cable. It provides good electricals, added cable strength and uniformity of termination. However, a solid dielectric provides poorer electricals and less velocity of propagation than cellular designs.

Foamed (Cellular) Dielectric Construction

A cellular dielectric construction uses a process of extruding a cellular material over the center conductor of a coaxial cable. This improves the dielectric constant of the dielectric material which improves the electricals of a coaxial cable. The dielectric material exhibits a lower capacitance, which in turn provides lower loss. This dielectric material also provides a higher velocity of propagation. With the advent of the "Gas Injection" process, cable manufacturers are able to improve their cellular design and provide a lower loss cable with higher velocity of propagation values.

Dielectric Materials

Polyethylene

This compound offers excellent electrical properties providing for low loss of a signal. However, it can only be used on a non-plenum rated cable because the compound has a poor flame and smoke retardancy.

Teflon® (FEP)

A premium insulation that provides excellent electrical and mechanical properties. This compound is widely used as a dielectric for coaxial cables providing low loss and the ability to withstand high temperatures and also having low flame and smoke characteristics.

Coaxial Cable Construction

Shielding
There are basically three types of shielding techniques:

1. Foil Shielding, 2. Braid Shielding, 3. Combination Shielding

Shielding is utilized to prevent radiation and signal loss of high frequencies used in electronic circuits and to reduce EMI/RFI interference. However, shielding tends to increase the overall capacitance of the cable.

Foil Shield
Foil shields are usually made of a thin layer of aluminum bonded to a polyester film. A foil shield allows for 100% coverage if applied with an appropriate overlap construction. It is very good in reducing Radio Frequency (RF) interference, but does not perform as well in blocking Electro Magnetic Interference (EMI). Foil shields do provide easy termination and low cost protection, although they are fragile (low tensile strength and impact resistance).

BiFoil
This type of foil shield allows for added protection by increasing the metallic coverage without adding increased thickness to the diameter of the cable. Mainly used in coaxial cables, the BiFoil shield is an aluminum-polyester-aluminum tape with 100% coverage.

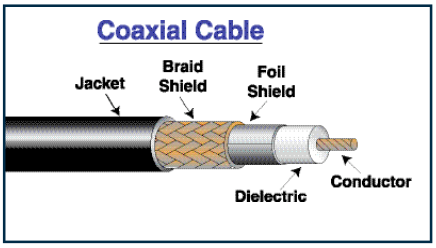
Bonded BiFoil
This type of foil shield has the same aluminum-polyester-aluminum construction as the BiFoil shield, but is also bonded to the dielectric with adhesive. This allows for better shielding capabilities and also provides excellent ease of stripping and termination because the foil does not pull away from the dielectric.

Braid Shield
Braided shields can be constructed in various coverages (95% - 98% being about the highest coverage available with this type of shielding). The material can be bare copper, tinned copper, or aluminum. Depending on the amount of coverage, braid shields reduce EMI interference well, but are not as effective in the RF range. Copper braided shields also allow for a much lower shield D.C. resistance than foil shields.

Combination Shielding
This technique offers the best of both types of shielding. First a foil shield is applied around the dielectric and then a braided shield is placed on top of the foil shield. This allows for greater coverage in blocking both EMI and RFI signals. There are also several versions of this basic technique such as triaxial, tri-shielding and qua shielding.

Foil/Braid
This is the most common type of combination shielding. The aluminum foil is placed around the dielectric and then a braided shield is applied over top the aluminum foil. The metallic side of the foil shield is usually in contact with the braid. The braid is then used for shielding as well as ground termination eliminating the need for a drain wire. There are various types of shieldings offered on West Penn Wire coaxial cable:

1. Quad Shield - A Foil-Braid-Foil-Braid combination shield construction. This provides maximum shielding against EMI/RFI interference.
2. Tri-Shield - A Foil-Braid-Foil combination
3. Triaxial - A Braid-Separator-Braid combination shield construction.



Jackets
The cable jacket is for strength, integrity, and overall protection of the other components inside the jacket. There are a variety of jacketing materials that are used in cable construction. Standard compounds and special variations of these compounds can be used in making the jacket. The selection of cable with the proper jacket and conditions of the environment the cable will be installed in are important considerations. Environmental parameters that should be considered include temperature variations, chemical reactance, sunlight resistance, mechanical and abrasion impact. Jackets are sometimes made up of the same material as insulation used on a dielectric. To learn more about various compound properties, please refer to the Dielectric Section.

Fiber Optic Cable Construction

Fiber Elements

Fiber optic cable provides the most advanced communication media available today. An increasing amount of fiber will be installed in the future as we find more and more uses for this technology. Fiber optic cable can support voice, data, video, and other types of transmission, and offers many advantages over standard copper circuits which we will discuss later in this section.

Core

This is the very center of the cable and is the light guiding area used for light transmission. The size of the core will determine the amount of light to be transmitted into the fiber. The larger the core, the greater the amount of light will that will be transmitted.

Cladding

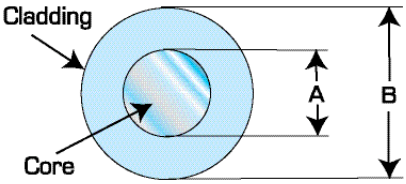
The cladding surrounds the core glass and serves to refract the light back into the core. The cladding has a different index of refraction than the core so that the lightwaves are re-directed back into the core allowing continued light transmission through the fiber.

Coating

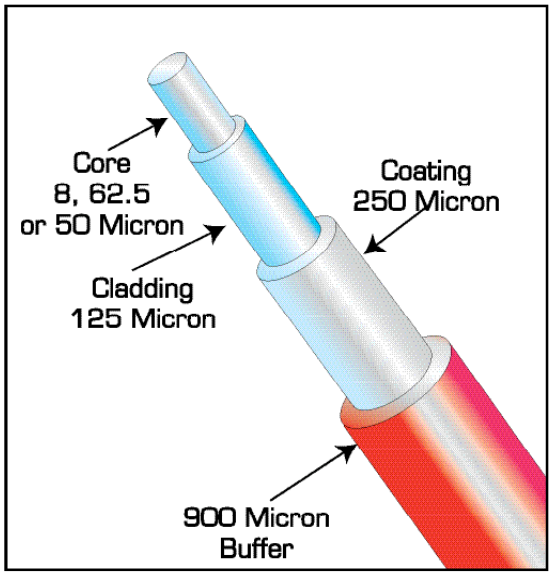
Several coatings of acrylate are usually applied to the fiber to provide tensile strength and protection to the glass fiber core.

Jacket

The cable jacket works along with the aramid fibers to provide strength, integrity, and overall protection of the fiber member. There are a variety of jacketing materials that are used in fiber optic cable construction. Standard compounds and special variations of these compounds can be used in making the jacket. The jacket should be appropriate for the environmental conditions that the fiber optic cable will be subjected to. Environmental parameters that should be considered include temperature variations, chemical reactance, sunlight resistance, mechanical and abrasion resistance.



Buffered Fiber



Fiber Optic Cable Types

Fiber Optic Size - This is measured by comparing the core size to the cladding size. This is expressed by the core diameter and then the cladding with coating diameter.

Example: 62.5/125., 62.5 being the core diameter and 125 being the cladding with coating diameter.

Fiber Optic Modes - There are basically two types or modes of fiber optic cable, single-mode and multimode.

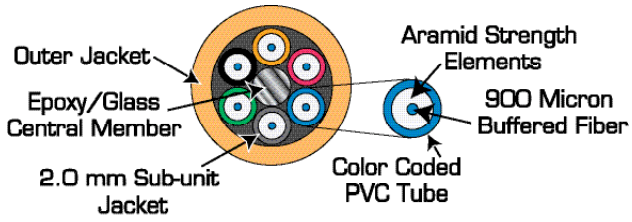
Single-Mode - The core on single-mode is about 8-10 micron. This small core size allows only one mode of light to travel within the core at a time. The higher the bandwidth, the more information carrying capacity the cable has. This type of cable is good for long distances, and is often used by telephone companies for long transmissions.

Multimode - The core on multimode is about 50 - 100 micron. A larger core allows many light pulses or modes to travel through the core simultaneously. Mode overlap can occur over extremely longer distances and may cause bit errors. Multimode is best used for lengths up to 2 kilometers.

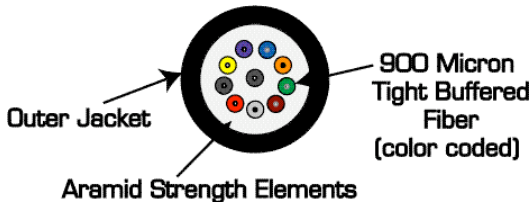
Fiber Optic Cable Construction

Fiber Optic Cable Used for Indoor Installations

Breakout Cable

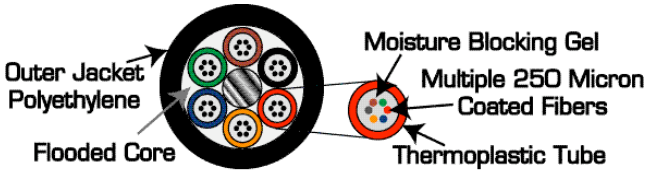


Distribution Cable

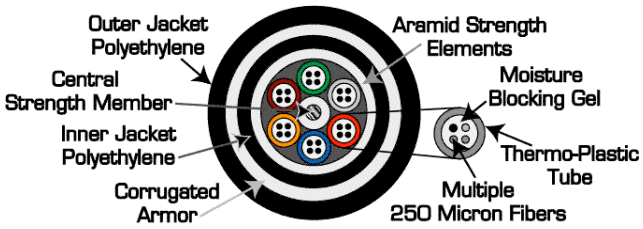


Fiber Optic Cable Used for Outdoor Installations

Loose-Tube Cable



Armored Loose-Tube Cable



Fiber Optic Cable Benefits

High Bandwidth - The higher the bandwidth, the greater the information carrying capacity. A higher bandwidth allows for higher data rates, more users and longer distances.

Easy Upgrades - Fiber optic cable allows for easy future upgrades. Because a variety of transmissions can use fiber optics, it is only necessary to change the electronics. The cable can stay in place. No need to pull new cable in the future.

Low Attenuation - This is a reduction of signal strength or loss of light power over the length of the fiber. Fiber optic cable usually has low attenuation characteristics which allow signals to travel over longer distances without reamplification. However, attenuation can be affected by extrinsic (environmental and physical bends), intrinsic (absorption and scattering) and wavelength. The longer the wavelength, the lower the attenuation.

EMI/RFI Immunity - Since fiber optic cable transmits light instead of electrical current, immunity to electromagnetic and radio frequency interference provides better signal quality, ensuring low bit error rates and/or low noise on the system.

Security - Again, since there is no electrical signal, fiber optic transmission is almost impossible to tap into without being detected.

Lightweight - Fiber optic cable is smaller and lighter than copper cable allowing for easier installation, especially when conduit and/or raceway space is at a premium.

Understanding the National Electrical Code

The National Electrical Code (NEC) is a set of guidelines written to govern the installation of wiring and equipment in commercial buildings and residential areas. These guidelines were developed to ensure the safety of humans as well as property against fires and electrical hazards. Understanding the National Electrical Code is important from the cable manufacture engineer and distributor, to the designer and installer. Anyone involved in specifying cable to installation of cable should be aware of the basics of the code.

In 1987, the National Electrical Code introduced some major changes that had a major impact on the wire and cable industry. The code now has listing requirements for communication and power-limited circuit cable. These requirements developed fire resistance levels for cable. The code covers initiation of fire by electronic cable as well as flame spread characteristics of the cable.

Code Organization

The NEC code book is made up of nine chapters, with each chapter divided into separate articles pertaining to specific subjects. There are about five articles that pertain to communication and power-limited cable. Each article describes wire and cable construction, material use, cable markings, installation environments and applications.

Article Categories

There are four articles that cover communication, power-limited and CATV wiring. There is another category that deals strictly with optical fiber. The following is a list of those articles and the applications or systems they cover:

Article 725 - Class 1, Class 2, Class 3, Remote-control, Signaling and Power-Limited circuits

Article 760 - Fire Protective Signaling Systems

Article 770 - Fiber Optic Systems

Article 800 - Communication Circuits

Article 820 - Community Antenna Television

Article Overviews

The NEC code can be somewhat confusing to the novice who has not studied the code in depth. In most cases, within an article, a listing will allow for a higher listed cable to be substituted for lower listed cable. And some listings from one article may be substituted for another article listing with possible restrictions. This section will briefly cover the basis of the code to try to make things clearer for you. However, you should consult the NEC book for exact specifications, wording, and accuracy of the code. This is not in any way an exact excerpt from the code.

Article 725

Article 725 covers Class 1, Class 2, and Class 3 remote control and signaling cables as well as power-limited tray cable. Power-limited tray cable can be used as a Class 3 or Class 2 cable. Cable listed multi-purpose, communications, or power-limited fire protective can be used for Class 2 and Class 3 applications. A Class 3 listed cable can be used as a Class 2 cable.

Article 760

Article 760 covers power-limited fire protective cable. Cable listed as power-limited fire protective cable can also be used as Class 2 and Class 3 cable. Cable listed as communications and Class 3 can be used as power-limited fire protective cable with restrictions to conductor material and type, gauge size and number of conductors.

Article 770

Article 770 covers fiber optic cable. This article covers three general types: non-conductive, conductive, and composite. Non-conductive type refers to cable containing no metallic members and no other electrically conductive materials. Conductive type refers to cable containing non-current carrying conductive members such as metallic strength members, etc. Composite type refers to cable containing optical fibers and current carrying electrical conductors. Composite types are classified according to the type of electrical circuit that the metallic conductor is designed for.

Article 800

Article 800 covers multi-purpose and communication cable. Multi-purpose cable is the highest listing for a cable and can be used for communication, Class 2, Class 3, and power-limited fire protective cable. Communication cable can be used for Class 2 and Class 3 cable and also as a power-limited fire protective cable with restrictions.

Article 820

Article 820 covers community antenna television and RF cable. CATV cable may be substituted with multi-purpose or communication listed coaxial cable.

Designation and Environmental Areas

Not only does listing by circuit types have to be adhered to, but installation in various environments have to also be considered. The NEC has designated four categories for various environments. These will be listed from the highest to the lowest listing. A higher listing can be used as a substitute for a lower listing.

Plenum - This listing is suitable for use in ducts, plenums, and other space used for environmental air without conduit and has adequate fire-resistant and low-smoke producing characteristics. It can also be used for applications below.

Riser - This listing is suitable for use in a vertical run, in a shaft or from floor to floor, and has fire-resistant characteristics capable of preventing the carrying of fire from floor to floor. It can also be used for applications below.

General Purpose - This listing is suitable for general-purpose use, with the exception of risers, ducts, plenums, and other space used for environmental air, and is resistant to the spread of fire. It can also be used for all applications below.

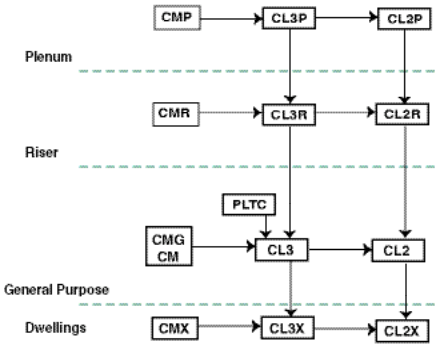
Restricted Applications - This listing is for limited use and is suitable for use in dwellings and for use in raceways and is flame retardant. Restricted use is limited to non-concealed spaces of 10 feet or less, fully enclosed in conduit or raceway, or cable with diameters less than .25" for a residential dwelling.

Understanding the National Electrical Code

National Electrical Code Substitution Chart

The following chart explains the NEC cable hierarchy and will give you a "picture" view of how this all fits together. The chart starts with the higher listed cable at the top descending to the lower listed cable. Following the arrows will allow you to find what listing can be substituted for others. Also note restrictions in which case you will have to review the NEC code in order to see if your cable is applicable.

Article 725



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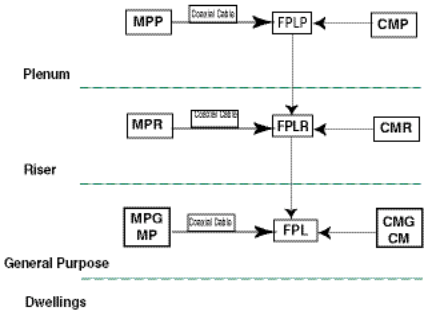

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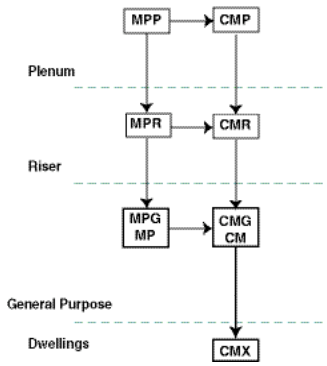
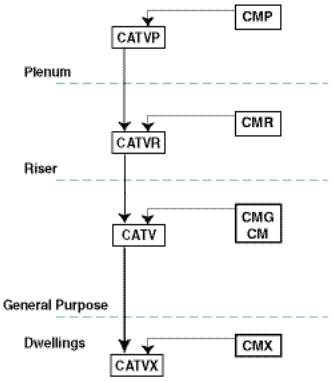


Article 820



Final Considerations

The National Electrical Code is widely accepted as the suggested regulations governing the proper installation of wire and cable in the United States. The code is revised every three years to keep safety in the forefront in wire and cable manufacturing and installation. Even though the code is generally accepted, each state, county, city and municipality has the option to adopt all of the code, part of the code, or develop one of its own. The local inspectors have final authority of your installation. Therefore, the NEC is a good reference when questions arise about the proper techniques for a particular installation, but local authorities should be contacted for verification.

When choosing cable for your installation there are four guidelines to follow to keep problems to a minimum:

1. The application and environment determines which type of cable you can use and what rating it should have. Make sure the cable you're installing meets the proper ratings for your application.

2. If you will be substituting a cable with another, you must have a cable that is rated higher than what the code calls for. Check with your local inspector as to what is allowed in your local area.

3. The NEC code is a general guideline that can be adopted in whole or in part. Your local state, county, city, or municipal approved code is what you must fol low. Contact your local authorities for verification of the code in your area.

4. The local inspector or fire marshal has the final authority to approve or disapprove any installation of cable based on the National Electric Code or on the local code.

If you remember these four guidelines, you should have fewer complications and headaches when installing cable in your area. Remember to always work closely with your local authorities.

Calculating Conduit Capacity

One Cable Type in Conduit

The following information is to provide you with a quick and easy reference for conduit fill requirements. This information is to be used as a general guideline. Each installation has different restrictions for installation environments and/or local codes to follow.

The Conduit Capacity Chart provided on the following page is for applications when only one type of cable is to be used in a conduit. For example, if you know the diameter of the cable you will be installing, use the cable O.D. column, and find the exact or next largest diameter cable O.D.. Next, follow this row over to the number of cables you need to install in a conduit. Then follow this column to the top of the chart and read the conduit size required for the number of cables you need to install.

Multiple Types of Cable in One Conduit

If you will be mixing various cable diameters in a conduit, then this overall chart does not apply. You will have to use the following guidelines to calculate the conduit fill requirements.

To determine the conduit size required for a particular installation of cable follow these steps:

1. Square the O.D. of each cable and total the results.
2. Multiply the total by .7854*. This is the total area of the cables in square inches.
3. From the Permissible Area row on the Conduit Capacity Chart shown on the following page, select the conduit size with an area equal to or greater than the total area you calculated.

* See Important Notes and Installation Suggestions

** Permissible Area to be occupied (sq. in.) is based on the NEC standard of 40% fill, which applies to three or more non-lead covered cable installed in the same conduit.

Important Notes and Installation Suggestions

• A single cable is permitted to occupy 53% and two cables are limited to 31% conduit fill. For a single cable use .5927 in step 2, for two cables use 1.1034, and three or more cables use .7854.

• This chart is based on the maximum number of cable per mitted in conduit under the National Electrical Code, and is calculated on the area of the cable with 40% of the conduit filled. For conduit runs of 50 to 100 feet, the installed number should be reduced by 15%, or use the next larger size conduit. If more than two 90 degree bends are to be used in the conduit run, or if the run is to be over 100 feet in length, insert a pull box.

• An anti-friction agent is recommended in pulling operations.

*CAUTION: Select an anti-friction agent which is suitable for the cable jacket material. The electronic characteristics of unjacketed cable may change due to the application of anti-friction agents.

* COLD ENVIRONMENT PRECAUTION: Due to the nature of PVC compounds to become non-pliable when stored or handled in ambient temperatures of 32 degrees F or less, we recommend the following:

"Prior to installation, condition the cable for at least 24 hours at room temperature to provide the best flexproperties for ease of installation."

• Permissible area chart does not apply to metallic and non-metallic surface raceways; consult the NEC for recommendations.

THE NATIONAL ELECTRICAL CODE FORBIDS THE INSTALLATION OF COMMUNICATION CABLE IN THE SAME CONDUIT AS POWER CABLE.

Pulling Tensions

Under the stress of approximately 15,000 lbs./sq. in. annealed copper will begin to permanently stretch. The table below lists the absolute maximum recommended pulling tensions for conductor sizes. For multiple conductor cable, multiply the appropriate value by the total number of conductors. These pulling tensions must be equally distributed among the conductors.

THESE LIMITS MUST NEVER BE EXCEEDED EVEN MOMENTARILY! DON'T JERK THE CABLE!

The electronic characteristics of a cable may change due to excessive tension and crushing.

Gauge	Max. Pulling Tension
24 AWG	4 lbs
22 AWG	7 lbs
20 AWG	12 lbs
18 AWG	19 lbs
16 AWG	30 lbs
14 AWG	48 lbs
12 AWG	77 lbs

Conduit Capacity Chart

Conduit Size		1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4
I.D. Inches		.622	.824	1.049	1.380	1.610	2.067	2.469	3.068	3.548	4.026
Permissible Area*		0.12	0.21	0.34	0.60	0.82	1.34	1.92	2.95	3.96	5.09
Cable O.D Inch	Cable Area sq. Inch										
.100	.00785	15	27	44	76	103	171	298	450	588	751
.125	.01227	10	17	28	48	66	109	191	288	376	481
.150	.01767	7	12	19	34	46	76	132	200	261	334
.175	.02405	5	9	14	25	34	56	97	147	192	245
.200	.03142	4	6	11	19	26	42	74	112	147	188
.225	.03976	3	5	8	15	20	33	59	89	116	148
.250	.04909	2	4	7	12	16	27	47	72	94	120
.275	.0594	1	3	6	10	13	22	39	59	77	99
.300	.07069	1	3	5	8	11	19	33	50	65	83
.325	.08296	1	2	4	7	10	16	28	42	55	71
.350	.09621	1	1	3	6	8	14	24	36	48	61
.375	.011045	1	1	3	5	7	12	21	32	42	53
.400	.012566	1	1	2	4	6	10	18	28	36	47
.425	.14186	1	1	2	4	5	9	16	25	32	41
.450	.15904	1	1	1	3	5	8	14	22	29	37
.475	.17721	1	1	1	3	4	7	13	20	26	33
.500	.19635	1	1	1	3	4	7	12	18	23	30
.525	.21648	0	1	1	2	3	6	11	16	21	27
.550	.23758	0	1	1	2	3	5	10	15	19	25
.575	.25967	0	1	1	1	3	5	9	13	17	22
.600	.28274	0	1	1	1	3	4	8	12	16	21
.625	.3068	0	1	1	1	2	4	7	11	15	19
.650	.33183	0	1	1	1	2	4	7	10	14	17
.675	.35785	0	0	1	1	1	3	6	10	13	16
.700	.38484	0	0	1	1	1	3	6	9	12	15
.725	.41282	0	0	1	1	1	3	5	8	11	14
.750	.44179	0	0	1	1	1	3	5	8	10	13
.775	.47173	0	0	1	1	1	3	5	7	9	12
.800	.50265	0	0	1	1	1	2	4	7	9	11
.825	.53456	0	0	1	1	1	2	4	6	8	11
.850	.56745	0	0	1	1	1	2	4	6	8	10
.875	.60132	0	0	0	1	1	1	4	6	7	10
.900	.63617	0	0	0	1	1	1	3	5	7	9
.925	.67201	0	0	0	1	1	1	3	5	7	9
.950	.70882	0	0	0	1	1	1	3	5	6	8
.975	.74662	0	0	0	1	1	1	3	4	6	8
1.00	.7854	0	0	0	1	1	1	3	4	6	7
1.025	0.825	0	0	0	0	0	1	3	4	6	7
1.05	0.866	0	0	0	0	0	1	2	3	4	5
1.075	0.908	0	0	0	0	0	1	2	3	4	5
1.100	0.950	0	0	0	0	0	1	2	3	4	5
1.125	0.994	0	0	0	0	0	1	1	2	3	5
1.150	1.039	0	0	0	0	0	1	1	2	3	4
1.175	1.084	0	0	0	0	0	1	1	2	3	4
1.20	1.131	0	0	0	0	0	1	1	2	3	4
1.225	1.179	0	0	0	0	0	1	1	2	3	4
1.250	1.227	0	0	0	0	0	1	1	2	3	4
1.275	1.277	0	0	0	0	0	1	1	2	3	3
1.300	1.327	0	0	0	0	0	1	1	2	3	3
1.325	1.379	0	0	0	0	0	0	1	2	3	3
1.350	1.431	0	0	0	0	0	0	1	2	2	3
1.375	1.485	0	0	0	0	0	0	1	1	2	3
1.400	1.539	0	0	0	0	0	0	1	1	2	3
1.425	1.595	0	0	0	0	0	0	1	1	2	3
1.450	1.651	0	0	0	0	0	0	1	1	2	3
1.475	1.709	0	0	0	0	0	0	1	1	2	2
1.500	1.767	0	0	0	0	0	0	1	1	2	2

EXAMPLES:

Example A.

Sample Cable:
227- .269″ O.D.

Go down the Cable O.D. inch column. Find the number equal to or greater than the cable O.D. Go across to find the number of cables in the appropriate conduit size.

.269″- Closest .275″
13 in a $1^{1/2}$″ Conduit.

Example B.

Three different Cables:

227 - .269″ sqd. = .0724
434 - .411″ sqd. = .1689
6350 - .275″ sqd. = .0756
+
.3169
x .7854
.2489

On the Permissible Area- equal to or greater. The closest area is .034
Use a 1″ Conduit

Important Note: This conduit capacity chart is to be used as a general guideline. Because local codes can vary from the NEC. West Penn Wire cannot be held responsible for this information as it pertains to your installation. Proper conduit fill is the sole responsibility of the installer and it is your responsibility to see that your installation will pass local codes.

Cable Termination Techniques

Cable Termination

There is a variety of termination methods for cable. The termination method utilized depends basically on the system installed, type of cable used and type of connector. Using the proper termination method allows for good mechanical and electrical integrity. No matter what type of termination you will be performing, the most important thing is to use the proper tools and materials for the type of termination. For example, a crimp using pliers will work, but using a crimp tool and the proper die designed for your type of cable and connector is better. Using the proper solder type and the right temperature for solder type connections will ensure a lasting connection. We will review four basic termination techniques. This is just to provide some general guidelines. The termination method may vary somewhat based on system requirements and connector manufacture design methods.

Termination Types

Solder Type

A solder type connection allows for a strong, solid mechanical and electrical connection. Clean the connection well. For electrical circuits you must use a rosin type flux to clean all connections. Do not use acid flux that is commonly used for plumbing installation. The acid based flux will cause corrosion and inherently cause intermittent problems with the electrical signal. The choice of solder is also important. Using a solder standard 60/40 formula will meet the majority of your soldering needs. However, lead-free and high-grade silver solder is available for special applications. Also, use a soldering iron of the proper wattage. If the soldering iron is not hot enough, you may not be able heat the connection enough to get a good solder joint. This may cause what is known as a "cold" solder joint and can cause intermittent problems like opens to occur. However, if the soldering iron is too hot, you can cause damage to the components of the system near the connection. This can also cause the insulation to possibly melt causing the bare primaries to make contact with each other resulting in a short.

Crimp Type

A crimp type connection allows for quick and simple installation while still maintaining a mechanical and electrical connection fairly close to a solder type termination. Solid or stranded wire can be used in this type of termination.

Some of the key points to remember for a good clean connection are as follows:

1. Make sure you use the proper size connector for the type of cable you are using.
2. Make sure all of your cuts and stripping are clean.
3. Avoid nicks as much as possible.
4. Use the proper crimp tool, don't try to improvise with pliers, etc.

The most common crimp method involves two crimps, one on the insulation for a stronger mechanical connection and one on the conductor or shield for a good electrical connection. A crimp tool is designed specifically for this type of termination for the type of connector you are using. This allows for good connections both mechanical and electrical. Using pliers will allow connection. However, it may not be a solid mechanical or electrical connection and can cause the connector to eventually come loose and intermittent problems with the electrical signal can occur.

Insulation Displacement

This type of termination is usually used in punch down blocks, wall connectors, and in the back of patch panels. This type of termination eliminates the need for stripping the conductor insulation. As the conductor is pushed though the clip, the insulation is cut into and the metal clip contact makes contact with the wire.

The best type of wire to use is a solid conductor. If you use a stranded conductor the force of the termination may allow the clip to cut some of the strands. Also, stranded wire will "crush" somewhat which will not allow for a solid connection. However, both types of conductors are used in various systems.

The connection is made by using a punch down tool. Some patch panel manufacturers supply a termination cap that terminates several wires at once without the use of a tool. Some tools will allow use of different bits for use with various terminations. (i.e. 66 block, 110 block, etc.). Just like the crimping type termination, it is important to use the correct bit for the type of termination you are doing.

Direct Connection (Utility Block/ Screw Terminals)

This type of termination has several names. Utility block, barrier strip, or screw
terminals are just a few. This type of termination can use either solid or stranded conductors. It allows for easy termination as well as quick changing of wire in the future. The main point to remember about a screw connection is to strip back the insulation only to the amount of conductor that will wrap around the screw and to place the wire in the same direction as the screw turns when tightening. This will "pull" the wire in tighter as the screw tightens. If you wrap the wire around the screw opposing the tightening rotation of the screw, the wire will be pulled outward and will become unwrapped around the screw.

Splicing

It is recommended to avoid splicing whenever possible, however, when splicing of cables becomes necessary, there are several methods to do this. Splicing can be as simple as twisting conductors together, soldering and then taping. Splicing can also be more elaborate by using a variety of inline connectors and adapters. The method used is based on the type of system used, the electrical signal characteristics, and type of cable used. A simple audio or intercom system can be spliced by just connecting the conductor together with the twist method. However, a CCTV or high speed data system will require inline connectors and adapters due to the construction of the cable as well as to maintain proper impedance, resistance, and capacitance characteristics for the cable run. If the location of the splice is outdoor or in underground environments, it is recommended that a waterproof splice kit be utilized.

Connector Termination/Basic Guidelines

Cable Termination

There are a variety of termination methods for cables. The termination method utilized depends basically on the system installed, type of cable used, and type of connector. Using the proper termination method allows for good mechanical and electrical integrity. No matter what type of termination you will be performing, the most important thing to remember is to use the proper tools and materials for your type of termination. For example, a crimp using pliers will work, but using a crimp tool and the proper die designed for your type of cable and connector is better. Using the proper solder type and the right temperature for solder type connections will ensure a lasting connection. We will review some basic termination techniques. This is just to provide some general guidelines. The termination method may vary somewhat based on system requirements and connector manufacturer design methods.

Crimp Type Termination

A crimp type connection allows for quick and simple installation while still maintaining a mechanical and electrical connection fairly close to a solder type termination. Solid or stranded wire can be used in this type of termination.

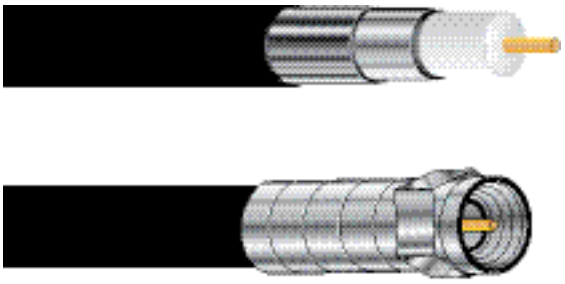
Some of the key points to remember for a good clean connection are as follows: make sure to use the proper size connector for the type of cable you are using. Make sure all your cuts and stripping are clean. Avoid nicks as much as possible. Use the proper crimp tool, don't try to improvise with pliers, etc.

The most common crimp method involves two crimps. One is on the insulation for a stronger mechanical connection and one is on the conductor or shield for a good electrical connection. A crimp tool is designed specifically for this type of termination, for the type of connector you are using. This allows for good connections, both mechanical and electrical. Using pliers will allow a connection; however, it may not be a solid mechanical or electrical connection, and can cause the connector to eventually come loose, which can cause intermittent problems with the electrical signal.

Splicing

It is recommended to avoid splicing whenever possible, however, when splicing of cables becomes necessary, there are several methods to do this. Splicing can be as simple as twisting conductors together, soldering, and then taping. Splicing can also be more elaborate by using a variety of inline connectors and adapters. The method used is mainly based on the type of system used, the electrical signal characteristics, and type of cable used. A simple audio or intercom system can be spliced by just connecting the conductor together with the twist method. However, a CCTV or high speed data system will require inline connectors and adapters due to the construction of the cable as well as to maintain proper impedance, resistance, and capacitance characteristics for the cable run. If the location of the splice is outdoor or in underground environments, it is recommended that a waterproof splice kit be utilized.

"F" Type Connector



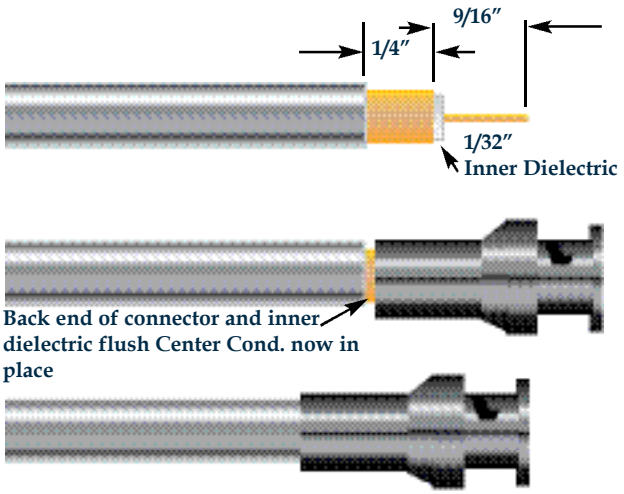
1. Strip 1/2" of the jacket to expose the braid shield.

2. Bend the exposed shield (Braid) back over the outer jacket. Do not disturb the foil shield beneath the braid.

3. Strip core back to expose conductor 1/4".

4. Slide the shank of the "F" connector over the foil shield and under the braid shield. Push the connector onto the cable, until the shoulder of the connector is
firmly seated against the braid shield. Crimp connector with proper tool as recommended by your connector
manufacturer.

BNC - Connector Termination



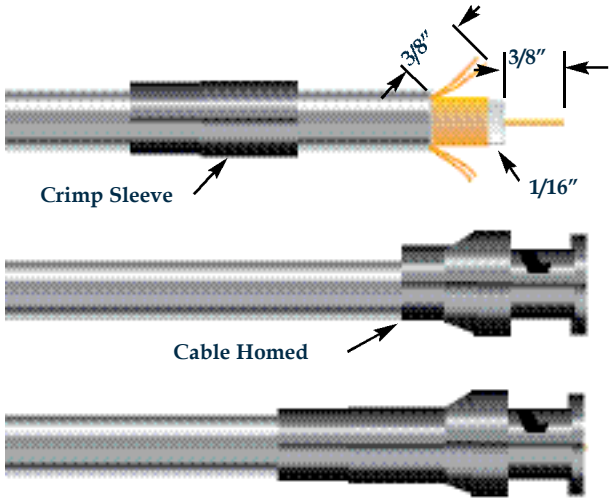
Twist On BNC Connector

1. Trim cable as shown, taking care not to nick the center conductor or outer braid.

2. Twist the outer braid in a clockwise direction in such a manner that at least 1/32″ of the inner dielectric is bared, and the braid is left flat. (Stray or loose braid can cause shorts).

3. Gently insert the center conductor down into the back end of the connector, feeling it into the guide hole. When the center conductor is not in place approx. 1/8″ of center conductor will show.

4. Firmly push the cable home as far as possible. Then screw the connector on the cable in a clockwise direction until it stops.



2 Piece BNC Connector

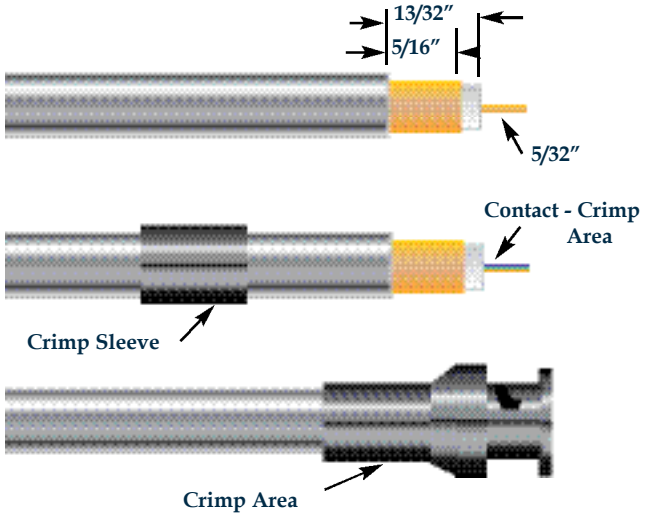
1. Run crimp sleeve down cable.

2. Trim cable as shown. Taking care not to nick the center conductor or outer braid

3. Gently insert the center conductor into the guide hole, in the rear of the connector, and firmly push the cable home.

4. Push crimp sleeve into place. Sandwiching the braid between the connector and sleeve.

5. Crimp the sleeve into place with the proper crimp tool.



3 Piece BNC Connector

1. Trim cable as shown. Taking care not to nick the center conductor or outer braid.

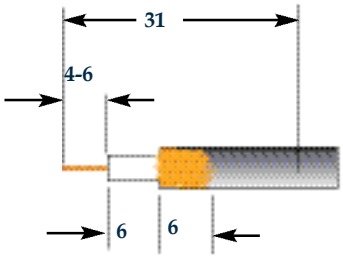
2. Slip crimp sleeve over cable. Place inner conductor into contact, note that the end of the contact and inner dielectric must be butting and square. Crimp with proper crimp tool.

3. Flair outer braid, and gently but firmly push the contact into the connector housing until a gentle snap is felt. Indicating the contact is in place. Slip the crimp sleeve in place, butting the flange against the connector body, and crimp with proper tooling.

Coaxseal Compression- Connector Termination

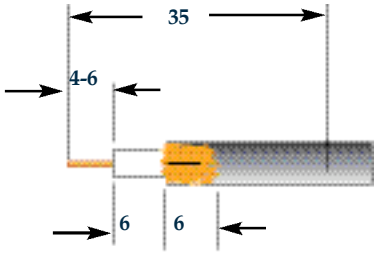
BNC

RG59/U Plenum RCA
RG6/U Plenum and RG6/U Quad-shield Plenum BNC
RG59/U Plenum and RG59/U Quad-shield Plenum BNC
RG6/U and RG6/U BNC, BNC Right angle, BNC Jack
RG59/U BNC, BNC Right angle, BNC Jack



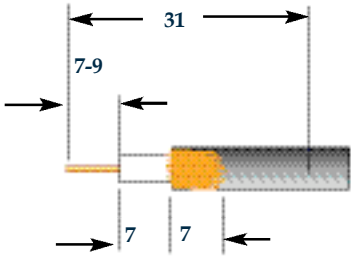
RCA

RG6/U and RG6/U Plenum Quad-shield RCA, RCA Jack
RG6/U -RG6/U Quad Shield RCA Right angle
RG6/U Quad Shield RCA Jack
RG59/U RCA, RCA Right angle, RCA Jack



" F" Type

All "F" Type Compression Connectors

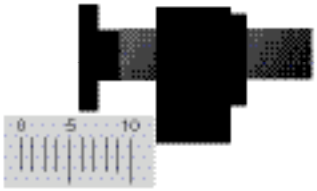


NOTE:
By slitting the jacket 3-4 mm will help in seating the connector properly.
Mark the jacket at 31 or 35 mm to help guide the connector to the appropriate location.

" F" Type

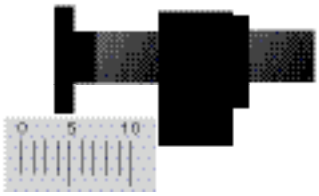
"F" Type compression connectors set the adjustable crimp ferrule to 1.

BNC



BNC Type compression connector set the adjustable crimp ferrule to 6.

RCA



RCA Type compression connectors set the adjustable crimp ferrule to 4.

NOTE:
Adjustments apply only to the SNS Style compression connectors.
Slight adjustments may be necessary

Connector Cross-Reference

Cable Part No.	Connector Type	Connector Part No.	Crimp Tool	Strip Tool
1100	"F"	CN-F11ALX	TL-112	TL-124**
	Comp. "F"	CN-FSNS-11	TL-SNS11	TL-SNS11ST
1110	"F"	CN-F11ALX	TL-112	TL-124**
	Comp. "F"	CN-FSNS-11	TL-SNS11	TL-SNS11ST
1130	"F"	CN-F11ALX	TL-112	TL-124**
	Comp. "F"	CN-FSNS-11	TL-SNS11	TL-SNS11ST
1135	"F"	CN-F11ALX	TL-112	TL-124**
	Comp. "F"	CN-FSNS-11	TL-SNS11	TL-SNS11ST
	3 Pc. BNC	BN-BM53-26	TL-113	TL-124
1150	Triax Female	7703-1	KTH-1000	--
	Triax Male	7705-1	KTH-1000	--
	Die		KTH-2040	--
1165	Triax Female	7703-3	KTH-1000	--
	Triax Male	7705-3	KTH-1000	--
	Die		KTH-2041	--
252815	1Pc. BNC	CN-BM51-10	--	TL-120
	2Pc. BNC	CN-BM52-10	TL-100	TL-120**
	3PC. BNC	CN-BM53-30	TL-103	TL-121
	75Ω 3Pc. BNC	CN-BM74-32 CN-BM73-30	TL-104	TL-121
	Comp. BNC	CN-CSBNC-59	TL-SNSA	TL-SNSST
252825	SVHS	CN-SVHS-M	--	--
	75Ω 3Pc. BNC	CN-BM74-18	TL-105	TL-825
	Comp. BNC	CN-CSBNC-25	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-25	TL-SNSA	TL-CSST
	Female BNC	CN-BF74-18	TL-105	TL-825
253815	Triax Female	7703-6	KTH-1000	--
	Triax Male	7705-4	KTH-1000	--
	Die		KTH-2002	--
255CRGB 252CSVHS	Comp. BNC	CN-FS1BNC	TL-SNSA	TL-CSST
	Comp. RCA	CN-FS1RCA	TL-SNSA	TL-CSST
256350	"F"	CN-F56TFE	TL-111	TL-120
	Comp. "F"	CN-CSF-6	TL-SNSA	TL-SNSST
	75Ω 3Pc. BNC	CN-BM73-4	--	TL-121
	Comp. BNC	CN-CSBNC-6	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-6	TL-SNSA	TL-SNSST

Cable Part No.	Connector Type	Connector Part No.	Crimp Tool	Strip Tool
256CRGB2P	Comp. BNC	CN-FS1BNC	TL-SNSA	TL-CSST
	Comp. RCA	CN-FS1RCA	TL-SNSA	TL-CSST
25806	1Pc. BNC	CN-BM51-4	--	TL-120
	2Pc. BNC	CN-BM52-4	TL-101	TL-120**
	3PC. BNC	CN-BM53-4	TL-104	TL-121
	75Ω 3Pc. BNC	CN-BM73-4	TL-107	TL-121
	Comp. BNC	CN-CSBNC-6	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSRCA-6	TL-SNSA	TL-CSST
25810	3PC. BNC	CN25810KBNC	TL-115	TL-124
25811	"F"	CN-F11TFE	TL-115	TL-124**
25812	3PC. BNC	CN-BM53-25	TL-105	TL-121
25815	1Pc. BNC	CN-BM51-10	--	TL-120
	2Pc. BNC	CN-BM52-10	TL-100	TL-120**
	3PC. BNC	CN-BM53-30	TL-103	TL-121
	75Ω 3Pc. BNC	CN-BM74-32 CN-BM73-30	TL-104	TL-121
	Comp. BNC	CN-CSBNC-59	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSBNC-59	TL-SNSA	TL-CSST
25819	"F"	CN-F59TFE/WP	TL-111	TL-120
	Comp. "F"	CN-FSNS-2	TL-SNSA	TL-SNSST
	75Ω 3Pc. BNC	CN-BM73-32 CN-BM73-30	TL-104	TL-121
	Comp. BNC	CN-CSBNC-59	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSBNC-59	TL-SNSA	TL-CSST
25821	"F"	CN-F11TFE	TL-115	TL-124**
25825	75Ω 3Pc. BNC	CN-BM74-18	TL-105	TL-825
	Comp. BNC	CN-CSBNC-25	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-25	TL-SNSA	TL-CSST
	Female BNC	CN-BF74-18	TL-105	TL-825
25841	"F"	CN-F56TFE	TL-111	TL-120
	Comp. "F"	CN-CSF-6	TL-SNSA	TL-SNSST
25Q821	"F"	CN-F11TFE	TL-115	TL-124**

Note: ** Center Conductor blade must be removed before using

Connector Cross-Reference

Cable Part No.	Connector Type	Connector Part No.	Crimp Tool	Strip Tool
25Q841	"F"	CN-F56ALM	TL-111	TL-120
	Comp. "F"	CN-CSF-6	TL-SNSA	TL-SNSST
25843	"F"	CN-F59TFE/W	TL-111	TL-120
25Q843	"F"	CN-F59ALX	TL-111	TL-120
2806B	75Ω 3Pc. BNC	CN-BM73-5	TL-107	TL-121
	Comp. BNC	CN-CSBNC-6	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSRCA-6	TL-SNSA	TL-CSST
2815B	1Pc. BNC	CN-BM51-2	--	TL-120
	2Pc. BNC	CN-BM52-2	TL-101	TL-120**
	3PC. BNC	CN-BM53-2	TL-104	TL-121
	75Ω 3Pc. BNC	CN-BM73-2 CN-BM74-32	TL-104	TL-121
	Comp. BNC	CN-BNCSNS-2	TL-SNSA	TL-SNSST
2825	SVHS	CN-SVHS-M	--	--
	75Ω 3Pc. BNC	CN-BM74-18	TL-105	TL-825
	Comp. BNC	CN-CSBNC-25	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-25	TL-SNSA	TL-CSST
	Female BNC	CN-BF74-18	TL-105	TL-825
3811	Triax Female	7703-1	KTH-1000	--
	Triax Male	7705-1	KTH-1000	--
	Die		KTH-2040	-
3815	Triax Female	7703-9	KTH-1000	--
	Triax Male	7705-9	KTH-1000	--
	Die		KTH-2002	--
4806	1Pc. BNC	CN-BM51-5	--	TL-120
	75Ω 3Pc. BNC	CN-BM73-5	TL-107	TL-121
4811	3PC. BNC	CN-BM53-26	TL-113	TL-124**
4815	1Pc. BNC	CN-BM51-2	--	TL-120
	3PC. BNC	CN-BM53-2	TL-104	TL-124
	75Ω 3Pc. BNC	CN-BM74-32 CN-BM73-2	TL-104	TL-121
5990	1Pc. BNC	CN-BM51-2	--	TL-120
	3PC. BNC	CN-BM53-2	TL-104	TL-121
	75Ω 3Pc. BNC	CN-BM74-32 CN-BM73-2	TL-104	TL-121
5992	Triax Female	7703-9	KTH-1000	--
	Triax Male	7705-9	KTH-1000	--
	Die		KTH-2002	--

Cable Part No.	Connector Type	Connector Part No.	Crimp Tool	Strip Tool
5994	Triax Female	7703-2	KTH-1000	--
	Triax Male	7705-2	KTH-1000	--
	Die		KTH-2002	-
5CRGB	Comp. BNC	CN-CSBNC-26	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-26	TL-SNSA	TL-CSST
6100	"F"	CN-F56ALM	TL-111	TL-120
	Comp. "F"	CN-FSNS-6	TL-SNSA	TL-SNSST
6140	"F"	CN-F56ALM	TL-111	TL-120
	Comp. "F"	CN-FSNS-6	TL-SNSA	TL-SNSST
6150	"F"	CN-F56ALM	TL-111	TL-120
	Comp. "F"	CN-FSNS-6	TL-SNSA	TL-SNSST
6300 6310	"F"	CN-F56ALX	TL-111	TL-120
	Comp. "F"	CN-FSNSQS-6	TL-SNSA	TL-SNSST
6350	"F"	CN-F56ALM	TL-111	TL-120
	Comp. "F"	CN-FSNS-6	TL-SNSA	TL-SNSST
	75Ω 3Pc. BNC	CN-BM73-5	TL-107	TL-121
	Comp. BNC	CN-CSBNC-6	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSRCA-6	TL-SNSA	TL-CSST
6500	"F"	CN-F56ALM	TL-111	TL-120
	Comp. "F"	CN-FSNQS-6	TL-SNSA	TL-SNSST
6CRGB2P 6CRGB4P	Comp. BNC	CN-CSBNC-26	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-26	TL-SNSA	TL-CSST
806 806R	75Ω 3Pc. BNC	CN-BM73-5	TL-107	TL-121
	Comp. BNC	CN-CSBNC-6	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-6	TL-SNSA	TL-CSST
807	3PC. BNC	CN-BM53-8X	TL-119	--
	"N" Type	CN-NM53-8X	TL-119	--
810	3PC. BNC	CN-BM53-8	TL-113	TL-124
	"N" Type	CN-NM53/110	TL-106	TL-124
811	3PC. BNC	CN-BM53-26	TL-113	TL-124
812	3PC. BNC	CN-BM53-13	TL-103	TL-121
813	1PC. BNC	CN-BM51-1	--	TL-120
	3PC. BNC	CN-BM53-13	TL-103	TL-121
815 815E 815R	1Pc. BNC	CN-BM51-2	--	TL-120
	2Pc. BNC	CN-BM52-2	TL-101	TL-120**
	3PC. BNC	CN-BM53-2	TL-104	TL-121
	75Ω 3Pc. BNC	CN-BM73-2 CN-BM74-32	TL-104	TL-121
	Comp. BNC	CN-CSBNC-59	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSRCA-59	TL-SNSA	TL-CSST

Note: ** Center Conductor blade must be removed before using

Connector Cross-Reference

Cable Part No.	Connector Type	Connector Part No.	Crimp Tool	Strip Tool
819	"F"	CN-F59ALM	TL-111	TL-120
	Comp. "F"	CN-FSNS-2	TL-SNSA	TL-SNSST
	75Ω 3Pc. BNC	CN-BM74-32 CN-BM73-2	TL-104	TL-121
	Comp. BNC	CN-CSBNC-59	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSRCA-59	TL-SNSA	TL-CSST
821	"F"	CN-F11ALX	TL-112	TL-124**
	Comp. "F"	CN-FSNS-11	TL-SNS11	TL-SNS11ST
825	75Ω 3Pc. BNC	CN-BM74-18	TL-105	TL-825
	Comp. BNC	CN-CSBNC-25	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-25	TL-SNSA	TL-CSST
	Female BNC	CN-BF74-18	TL-105	TL-825
841	"F"	CN-F56ALM	TL-111	TL-120
	Comp. "F"	CN-FSNS-6	TL-SNSA	TL-SNSST
A2815	1Pc. BNC	CN-BM51-2	--	TL-120
	2Pc. BNC	CN-BM52-2	TL-101	TL-120**
	3PC. BNC	CN-BM53-2	TL-104	TL-121
	75Ω 3Pc. BNC	CN-BM73-2 CN-BM74-32	TL-104	TL-121
	Comp. BNC	CN-CSBNC-59	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSRCA-59	TL-SNSA	TL-CSST
AQC2806 AQC806	1PC. BNC	CN-BM51-5	--	TL-120
	75Ω 3Pc. BNC	CN-BM73-5	TL-107	TL-121
	Comp. BNC	CN-CSBNC-6	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-6	TL-SNSA	TL-CSST
AQC815 AQC819	1Pc. BNC	CN-BM51-2	--	TL-120
	2Pc. BNC	CN-BM52-2	TL-101	TL-120**
	3PC. BNC	CN-BM53-2	TL-104	TL-121
	75Ω 3Pc. BNC	CN-BM74-32 CN-BM73-2	TL-104	TL-121
	Comp. BNC	CN-CSBNC-59	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSRCA-59	TL-SNSA	TL-CSST
AQC841	"F"	CN-F56AQ	TL-111	TL-120
	Comp. "F"	CN-FSNS-6	TL-SNSA	TL-SNSST

Cable Part No.	Connector Type	Connector Part No.	Crimp Tool	Strip Tool
HD825 HD25825	75Ω 3Pc. BNC	CN-BM74-18	TL-105	TL-825
	Comp. BNC	CN-CSBNC-25	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSRCA-25	TL-SNSA	TL-CSST
	Female BNC	CN-BF74-18	TL-105	TL-825
HQ841 Q841	"F"	CN-F56ALX	TL-111	TL-120
	Comp. "F"	CN-FSNSQS-6	TL-SNSA	TL-SNSST
Q821	Comp. "F"	CN-FSNS-11	TL-SNS11	TL-SNS11ST
WP258195	75Ω 3Pc. BNC	CN-BM74-32 CN-BM73-2	TL-104	TL-121
	Comp. BNC	CN-CSBNC-59	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSRCA-59	TL-SNSA	TL-CSST
WP8253 WP8255 WP258255	75Ω 3Pc. BNC	CN-BM74-18	TL-105	TL-825
	Comp. BNC	CN-CSBNC-25	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-25	TL-SNSA	TL-CSST
	Female BNC	CN-BF74-18	TL-105	TL-825
WP258263 WP258265	75Ω 3Pc. BNC	CN-BM74-19	TL-105	TL-825
	Comp. BNC	CN-CSBNC-26	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-26	TL-SNSA	TL-CSST
WP6355	75Ω 3Pc. BNC	CN-BM73-5	TL-107	TL-121
	Comp. BNC	CN-CSBNC-6	TL-SNSA	TL-CSST
	Comp. RCA	CN-CSRCA-6	TL-SNSA	TL-CSST
WP8195	75Ω 3Pc. BNC	CN-BM74-32 CN-BM73-2	TL-104	TL-121
	Comp. BNC	CN-BNCSNS-2	TL-SNSA	TL-SNSST
	Comp. RCA	CN-CSRCA-59	TL-SNSA	TL-CSST

SPECIALTY CABLES:

PAN TILT ZOOM CABLE:

PTZ815 - SEE 815 CABLE
PTZ25815- SEE 25815 CABLE
PTZ825 - SEE 825 CABLE
PTZ25825 - SEE 25825 CABLE

HOMENETWORKING COMPOSITE CABLES:

•HN5161 • HN5162 • HN5261 • HN5262 • HN5262F
•LSHN6262 • LSHN5262 • LSHN6262F
SEE HQ841 CABLE

MEDIA CONTROL CABLE: (ELAN)

E1854 - SEE 815 CABLE