TECHNICAL TRAINING
CONDUIT AND CABLE

INTRODUCTION

All electrical system products used in commercial and residential buildings must meet any and all applicable requirements of the National Electric Code (NEC). Within the NEC, there is a provision for third-party testing and verification to specifications based on the NEC and others like the American Society for Testing and Materials (ASTM) or the National Electric Manufacturing Association (NEMA). All approved, 3rd party testing laboratories are identified by the US Department of Labor Occupational Safety & Heath Administration (OSHA) and listed on the Nationally Recognized Testing Laboratories (NRTL's) list.

Underwriters Laboratories (UL) is an approved NRTL, as well as CSA and ETL. In addition to testing and compliance services, UL has created many individual specifications for electrical products. Regarding cable and conduit fittings, UL514B, is one of the major specifications that Bridgeport designs its product to meet. UL has created specifications for Conduit and Cable such as UL1, UL4, UL5, UL6, etc.

One major requirement of the NEC is to make sure certain product is listed and remains so throughout the life of the product line. This means it must pass occasional and random inspection and verification testing by the listing service (i.e. UL, CSA, ETL etc).

This module is intended to familiarize you with many different types of cable and conduit available for residential and commercial building electrical systems.

WHAT IS ELECTRICAL CONDUIT?

An **electrical conduit** is a purpose-designed electrical raceway system used for protection and routing of electrical wiring. Electrical conduit may be made of metal, plastic, fiberglass, or even fired clay. Flexible conduit is available for certain applications. Conduit is generally installed by electricians at the site of installation of electrical equipment and/or building electrical systems. Its use, form, and installation details are often specified by wiring regulations, such as the NEC and/or local electrical building codes.

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Conduit systems are classified by the wall thickness of tubing, mechanical stiffness of the tubing, and the material. Tubing with thicker walls in the same material offers better protection from impact, but increases the weight and cost of the conduit, and also increases labor cost to install the system. Conduit is primarily used to protect insulated electrical conductors from damage or the environment. In addition, metallic types of conduit may also be used to function as an electrical bond from one point to another. Typically, separate conductors are pulled through conduit and terminated in junction boxes or other types of enclosures.

It helps to understand the different, major types of electrical system conduit specified in North America construction. The following is a description of the different types of conduit used in these electrical systems.

Electrical Metallic Tubing (EMT)

Electrical Metallic Tubing (EMT), sometimes referred to as “thin-wall conduit”, is commonly used instead of Intermediate Metal Conduit (IMC), Galvanized Rigid Conduit (GRC), or Rigid Metal Conduit (RMC), as it is less costly, lighter, and easier to install. However, EMT cannot be threaded due to its thin wall thickness. Lengths of EMT conduit are connected to each other, and to equipment with setscrew or compression-type conduit fittings. Like GRC and RMC, EMT is more common in commercial and industrial buildings than in residential applications. EMT is generally made of zinc galvanized steel, though it also may be specified in aluminum or stainless steel. EMT sizes of 2½" and larger have the same outside diameter as corresponding sizes of RMC.

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Intermediate Metal Conduit (IMC)

Intermediate Metal Conduit (IMC) is medium-walled tubing, heavier than EMT but lighter than RMC or GRC, and typically made of zinc plated steel. It may be threaded or used with setscrew or compression fittings.

Rigid Metal Conduit (RMC)

Rigid Metal Conduit (RMC) is thick-walled tubing, usually made of zinc galvanized steel, although it may be aluminum or stainless steel. It is used in installations where the most protection is needed for conductors. RMC is thicker-walled than IMC. Typically threaded, and used with threaded fittings or locknuts, however it can also be used with setscrew or compression fittings.

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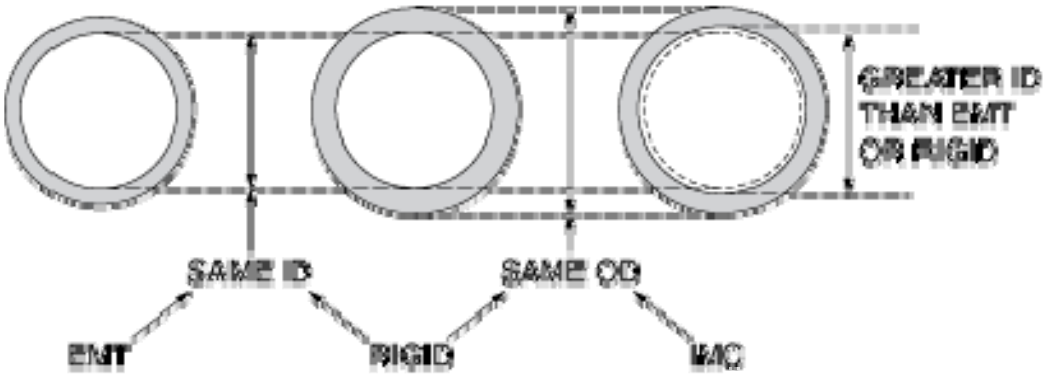
Galvanized Rigid Conduit (GRC)

Galvanized Rigid Conduit (GRC) is galvanized steel tubing, similar to RMC, with a hot-dipped galvanized coating which gives it a higher corrosion resistance than standard RMC. It is commonly specified for industrial applications.

A basic size comparison of EMT, RMC, and IMC conduits



Note that the primary difference is the wall thickness of the conduit.

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Rigid Nonmetallic Conduit (RNC)

Rigid Nonmetallic Conduit (RNC) is non-metallic, unthreaded tubing. This is also a generic term for PVC (polyvinylchloride) conduit. RNC is the lightest in weight compared to other rigid conduit materials, and usually lower in cost than other forms of conduit. In North America, it is available in three different wall thicknesses (SCH 80, SCH 40, & Type TC or Type A), with the thin-wall variety only suitable for embedded use in concrete, and heavier grades suitable for direct burial and exposed work. The various fittings are also made from PVC. The plastic material resists moisture and many corrosive substances, but since the tubing is non-conductive, an extra bonding (grounding) conductor must be pulled into each conduit. PVC conduit may be heated and bent in the field. Joints to fittings are made with slip-on, solvent-welded connections, which set up rapidly after assembly, and attain full strength in about one day. Since slip-fit sections do not need to be rotated during assembly, the special union fittings used with threaded conduit (i.e. “Three-Piece” Couplings) are not required. Since PVC conduit has a higher thermal coefficient of expansion than other types, long runs must be installed with expansion couplings to allow for expansion and contraction of each run.

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Flexible Metallic Conduit (FMC)

Flexible Metallic Conduit (FMC) (also known as “Greenfield’) is made through the coiling of a self-interlocked, ribbed strip of aluminum or steel, forming a flexible, hollow tube through which insulated conductors are pulled. FMC is used primarily in dry areas where it would be impractical to install EMT or other non-flexible conduit, yet where metallic strength to protect conductors is still required. The flexible tubing does not maintain any permanent bend. Cutting FMC requires a specialized hand tool with a rotary abrasive disc to create a small incision into the ribbing so that a twisting motion separates the segments. The disc cuts deep enough to sever the armor coil, but not so deep that it could damage the inside conductors.

Short segments of FMC called whips are often used as circuit "pigtails" between fixtures and a junction box, especially in suspended ceilings. Whip assemblies save a great deal of repetitive labor when installations require several pigtails for several fixtures. Flexible metal conduit, coated with a UV-resistant polymer, is liquid-tight (see: LFMC) when installed with appropriate glandular fittings containing liquid-tight features such as O-rings or rubber bushings.

Wiring regulations vary; in locales following the U.S. NEC, flexible metallic conduit may serve as an equipment-grounding conductor. Other areas may require a separate bonding wire for equipment grounding.

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Liquidtight Flexible Metal Conduit (LFMC)

Liquidtight Flexible Metal Conduit (LFMC) is a non-metallic and liquidtight jacket (usually PVC) covering a flexible metal interior. The metal interior is similar in construction to FMC.

Flexible Metallic Tubing (FMT)

Flexible Metallic Tubing (FMT) is **liquidtight** metallic tubing but unlike LFMC, it lacks a non-metallic outer cover. Its thin wall, combined with it's corrugated, one piece construction make it very flexible.

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Liquidtight Flexible Nonmetallic Conduit (LNFC)

Liquidtight Flexible Nonmetallic Conduit (LNFC) “Type-B” refers to several types of flame-resistant, non-metallic tubing. Interior surfaces may be smooth or corrugated. There may or may not be integral reinforcement within the conduit wall. It is also known as FNMC.

Image Courtesy Carlon

Image Courtesy Carlon

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Electrical Nonmetallic Tubing (ENT)

Electrical Nonmetallic Tubing (ENT) (slang: “smurf tube”) is thin-walled, corrugated tubing that is moisture-resistant and flame retardant. It is extremely flexible and can bend easily by hand. It is not threaded due to its shape and the plastic fittings are specially designed to interlock with the special corrugated shape. It is typically used in concrete work as well as commercial building systems.

Image Courtesy Carlon

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WHAT IS CABLE?

In addition to conduit fittings, Bridgeport also designs and manufactures numerous **cable fittings**. These cable fittings are used on the following major types of cable commonly used in North American electrical systems.

Metal Clad Cable (MC)

Metal Clad Cable (MC) has typically two or more, insulated conductors enclosed in an armor of interlocking metal tape, or a smooth corrugated metal sheath typically made of aluminum or galvanized steel. Typically, a polyester (Mylar®), or polypropylene insulating tape is wrapped around the insulated conductor bundle, and the metal sheath wrapped around on top. MC Cable is manufactured with a green insulated grounding conductor, and this conductor, in combination with the metallic armor, comprises the equipment grounding path when used with approved fittings.

A new style of MC Cable known as MCI-A, is a variation of the standard construction, whereas an un-insulated, aluminum conductor is in intimate contact with the entire length or the metal sheath and there is no need for an additional, insulated grounding conductor. This allows the MCI-A sheath to be used as the equipment grounding conductor ***and*** the equipment bond. The MCI-A cable armor grounding path is equivalent to the green insulated grounding conductor in conventional MC Cable.

Type TECK cable (another MC Cable variant), has a flexible aluminum or steel armor and overall flame-retardant PVC jacket, and is used in industry for wet or dry locations, cable tray runs, or attached to building structure, above grade or buried in earth.

MC Cable

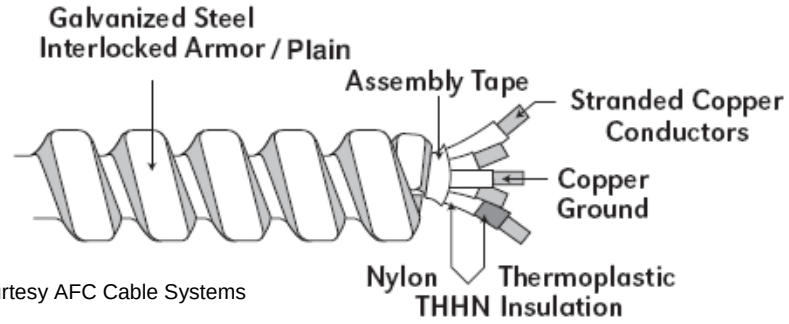

Image Courtesy AFC Cable Systems

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TECK Cable

Image Courtesy Southwire

MCI-A

MC^{AP} ® Cable$^{(1)}$

Image Courtesy Southwire

(1) MC^{AP} - Is a Registered Trademark of Southwire Co.

Armor Clad Cable (AC)

Armor Clad Cable (AC) or also known in older installations as “BX”, has typically has two or more, insulated conductors wrapped in paper, enclosed in an armor of interlocking metal tape, or a smooth corrugated metal sheath typically made of galvanized steel or aluminum. It also has an un-insulated, internal bonding strip wrapped around the insulated conductors which is in intimate contact with the ID of the metal sheath. This metal strip provides proper bonding of the sheath so that it can be used as a redundant electrical bonding path when connected to metallic enclosures using approved fittings.

AC cable may have up to 4 insulated conductors only; a fifth insulated conductor is allowed by UL if it is a green insulated grounding conductor. This cable also must be used with anti-short insulator bushings that are placed between the stripped metal sheath end and the insulated conductors to prevent the cut sheath from damaging the conductor insulation.

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AC Cable

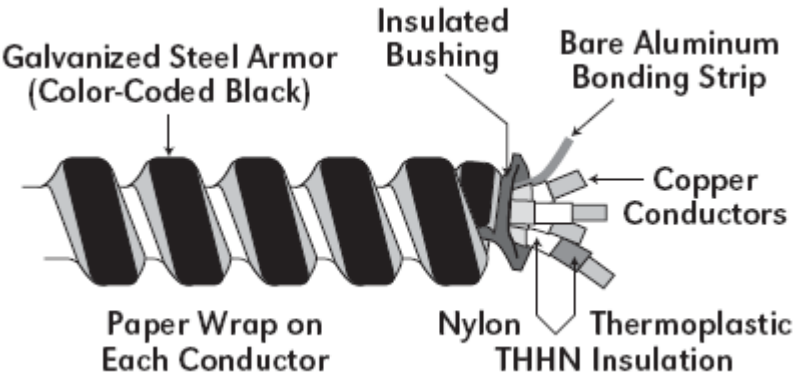

Image Courtesy AFC Cable Systems

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Heath Care Facility Cable (HCF)

Health Care Facility Cable (HCF) is constructed in the same manner as standard AC cable with the addition of an insulated, green grounding conductor. This additional ground allows HCF to be used in patient care areas of health care facilities (other than hazardous locations or emergency circuits in a health care setting) including hospitals, nursing homes, dental offices and medical centers. The bond wire and armor combination provides the cable's equipment ground while the insulated green grounding conductor provides a redundant ground. HCF cable is typically colored green for identification.

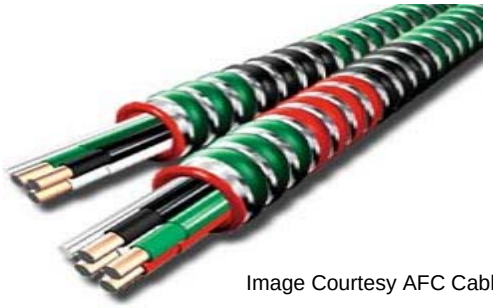

Image Courtesy AFC Cable Systems

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Summary of major differences between AC and MC cables

	TYPE AC CABLE	TYPE MC CABLE
NUMBER OF CONDUCTORS	Limited to a maximum of 4 conductors plus a grounding conductor.	Not limited to the number of conductors.
SIZE OF CONDUCTORS	14 AWG to 1 AWG	18 AWG or larger
GROUNDING	Contains a 16 AWG bond wire in constant contact with the metal armor allowing the armor and bond wire combination to be used as an equipment ground.	Does not contain a bonding wire and the armor is not an equipment ground, but supplements the internal grounding conductor equaling one grounding path.
CONDUCTOR WRAPPING	Individual conductors are wrapped in a moisture resistant, fire retardant paper.	Individual conductors are not wrapped in paper but do have an overall polypropylene assembly tape.

Image Courtesy AFC Cable Systems

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Non-Metallic Sheathed Cable (NM-B)

Non-Metallic Sheathed Cable (NM-B) or commonly referred to as “Romex” in North America has an outer sheath made of non-metallic material (i.e. PVC) and two or more insulated conductors along with and a bare conductor used for equipment grounding purposes only. This cable is the most widely used type in residential electrical systems due to its low cost and ease of termination with approved fittings.

Image Courtesy Southwire

Underground Feeder Cable (UF)

Underground Feeder Cable (UF) has two or more insulated conductors with an integral or overall covering of non-metallic material (i.e. PVC) that is suitable for direct burial in the earth. Typically, the outer covering is thicker to withstand abrasion and moisture.

Image Courtesy Southwire

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Service Entrance Cable (i.e. Types SER & SEU)

Service Entrance Cable (SE) is an insulated, single conductor or multi conductor assembly provided with or without an overall covering of non-metallic material (i.e. PVC) and webbing to strengthen the sheath. It is primarily used for service entrances and may have a flame-retardant, moisture-resistant insulation. Another variation of this cable would be a version made for underground use.

Image Courtesy Southwire

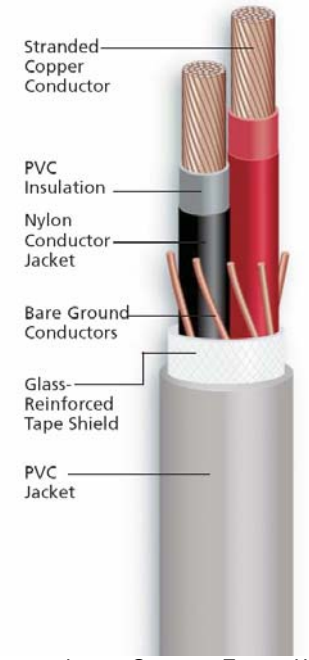

Image Courtesy Encore Wire

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Flexible Cord/Cable (i.e. Types SO, SJOW, SOOW, SPT-2, G, etc.)

Flexible Cord or Cable is one or more, over-molded, insulated conductors, and may be combined with a non-metallic covering or sheath. Additional materials such as filler cords may be used to make the cord round and to increase durability. There are hundreds of variations of flexible cord or cable, all of which have different performance characteristics and may be application specific. Here are a few popular configurations:

Image Courtesy Southwire

TYPE SOOW CORD

Image Courtesy Southwire

TYPE G CABLE

Image Courtesy Southwire

TYPE SPT-2 CORD

TYPE SJOW CORD

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SUMMARY

With all of the conduit and cable variants in the market, it is imperative that the specifier, supplier, installer, or contractor know which fittings to use on which cable or conduit type. While some fittings may look similar to others, there are usually differences that will mean the difference between a compliant installation and a non-compliant installation. When in doubt, call Bridgeport's engineering department for an analysis of your application.