Raceways, Boxes, and Fittings

26108-05

Rocky Mountain Energy Center

The Rocky Mountain Energy Center provides 60,000 people with electricity. Fueled by clean natural gas, it produces electricity using combined-cycle technology, integrating two combustion turbines and a single steam turbine. Located outside Hudson, Colorado, the Rocky Mountain facility is one of the larger and more environmentally sensitive power projects of its kind in Colorado.

26108-05
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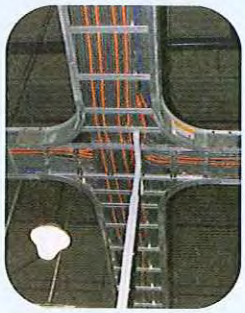
Topics to be presented in this module include:

Overview



The *National Electrical Code®* defines a raceway as an "enclosed channel of metal or nonmetallic materials designed expressly for holding wires, cables, or busbars." Raceways include conduit, wireways, ducting, and cable trays. Raceways protect the wiring and provide a means of identifying one type of wiring when it is located next to another type.

Each type of raceway is suited to a particular purpose. Different installation methods are required depending on the construction environment in which the raceway is to be installed.

Every type of raceway is interconnected with a specifically designed series of boxes and fittings. Boxes and fittings provide ease of raceway installation, as well as an access point or outlet for circuit conductors. Boxes are also used as convenient pull points in the raceway system when installing large conductors or a great number of conductors. It is important to always match the boxes and fittings with the type of raceway being installed.

Objectives

When you have completed this module, you will be able to do the following:

1. Describe various types of cable trays and raceways.
2. Identify and select various types and sizes of raceways.
3. Identify and select various types and sizes of cable trays.
4. Identify and select various types of raceway fittings.
5. Identify various methods used to install raceways.
6. Demonstrate knowledge of *National Electrical Code®* raceway requirements.
7. Describe procedures for installing raceways and boxes on masonry surfaces.
8. Describe procedures for installing raceways and boxes on concrete surfaces.
9. Describe procedures for installing raceways and boxes in a metal stud environment.
10. Describe procedures for installing raceways and boxes in a wood frame environment.
11. Describe procedures for installing raceways and boxes on drywall surfaces.
12. Recognize safety precautions that must be followed when working with boxes and raceways.

Trade Terms

Accessible
Approved
Bonding wire
Cable trays
Conductors
Conduit
Exposed location
Kick
Raceways
Splice
Tap
Trough
Underwriters Laboratories, Inc. (UL)
Wireways

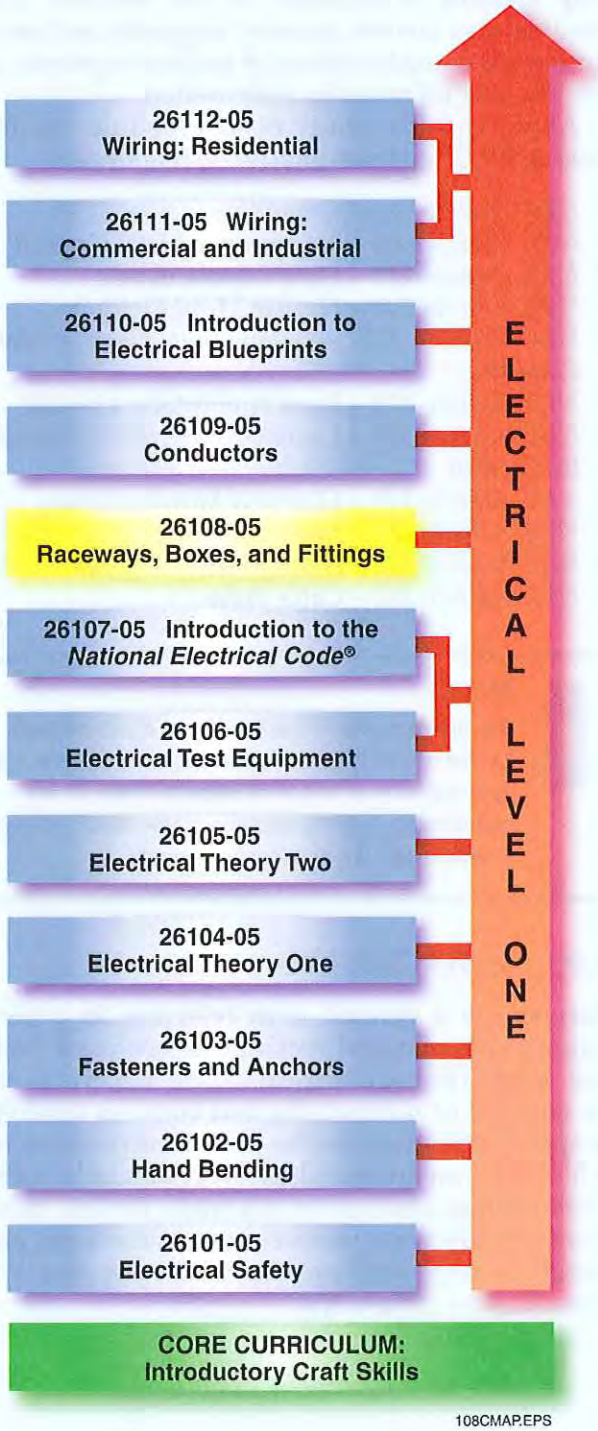
Required Trainee Materials

1. Paper and pencil
2. Copy of the latest edition of the *National Electrical Code®*
3. Appropriate personal protective equipment

Prerequisites

Before you begin this module, it is recommended that you successfully complete *Core Curriculum* and *Electrical Level One*, Modules 26101-05 through 26107-05.

This course map shows all of the modules in *Electrical Level One*. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map. The local Training Program Sponsor may adjust the training order.



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1.0.0 ◆ INTRODUCTION

Electrical raceways present challenges and new requirements involving proper installation techniques, general understanding of raceway systems, and applications of the *NEC*® to raceway systems. Acquiring quality installation skills for raceway systems requires practice, knowledge, and training.

A presentation of the various types of raceway systems and fittings, basic raceway installation skills, and *NEC*® requirements applicable to raceway systems is included in this module. This module also covers raceway supports and environmental considerations for raceway systems, as well as general raceway information.

Along with the study of this module, the following *NEC*® Articles should be referenced:

- *NEC Article 250 – Grounding*
- *NEC Article 342 – Intermediate Metal Conduit*
- *NEC Article 344 – Rigid Metal Conduit*
- *NEC Article 348 – Flexible Metal Conduit*
- *NEC Article 350 – Liquidtight Flexible Metal Conduit*
- *NEC Article 352 – Rigid Nonmetallic Conduit*
- *NEC Article 356 – Liquidtight Flexible Nonmetallic Conduit*
- *NEC Article 358 – Electrical Metallic Tubing*
- *NEC Article 376 – Metal Wireways*
- *NEC Article 378 – Nonmetallic Wireways*
- *NEC Article 392 – Cable Trays*

NOTE

Mandatory rules in the *NEC*® are characterized by the use of the word *shall*. Explanatory material is in the form of fine print notes (FPNs). When referencing specific sections of the *NEC*®, always check to see if any exceptions apply.

2.0.0 ◆ RACEWAYS

Raceway is a general term referring to a wide range of circular and rectangular enclosed channels used to house electrical wiring. Raceways can be metallic or nonmetallic and come in different shapes. Depending on the particular purpose for which they are intended, raceways include enclosures such as underfloor raceways, flexible metal conduit, wireways, surface metal raceways, and surface nonmetallic raceways and support systems such as cable trays.

3.0.0 ◆ CONDUIT

Conduit is a raceway with a circular cross section, similar to pipe, that contains wires or cables. Conduit is used to provide protection for conductors and route them from one place to another. In addition, conduit makes it easier to replace or add wires to existing structures. Metal conduit also provides a permanent electrical path to ground. This equipment should be listed per the *NEC*®.

3.1.0 Conduit as a Ground Path

For safety reasons, most equipment that receives electrical power and has a metallic frame is grounded. In order to ground the equipment, an electrical connection must be made to connect the metal frame of the electrically powered equipment to the grounding point at the service-entrance equipment. This is usually done in one or both of the following ways:

- The frame of the equipment is connected to a wire (equipment grounding conductor), which is directly connected to the ground point at the grounding terminal.
- The frame of the equipment is connected (bonded) to a metal conduit or other type of raceway system, which provides an uninterrupted and low-impedance circuit to the ground point at the service-entrance equipment. The metal raceway or conduit acts as the equipment grounding conductor.

NOTE

According to *NEC Section 250.96*, metal raceways, cable trays, cable armor, cable sheath, enclosures, frames, fittings, and other metal noncurrent-carrying parts that are to serve as grounding conductors with or without the use of supplementary equipment grounding conductors shall be effectively bonded where necessary to ensure electrical continuity and the capacity to safely conduct any fault current likely to be imposed on them. The purpose of the equipment grounding conductor is to provide a low resistance path to ground for all equipment that receives power. This is done so that if an ungrounded conductor comes in contact with the frame of a piece of equipment, the circuit overcurrent device immediately acts to open the circuit. It also reduces the voltage to ground that would be present on the faulted equipment if a person came in contact with the equipment frame.

3.2.0 Types of Conduit and Tubing

There are many types of conduit used in the construction industry. The size of conduit to be used is determined by engineering specifications, local codes, and the *NEC*®. Refer to *NEC Chapter 9, Tables 1 through 8 and Annex C* for conduit fill with various conductors. There are several common types of conduit to examine.

3.2.1 Electrical Metallic Tubing

Electrical metallic tubing (EMT) is the lightest duty tubing available for enclosing and protecting electrical wiring. EMT is widely used for residential, commercial, and industrial wiring systems. It is lightweight, easily bent and/or cut to shape, and is the least costly type of metallic conduit. Because the wall thickness of EMT is less than that of rigid conduit, it is often referred to as thinwall conduit. A comparison of inside and outside diameters of EMT to rigid metal conduit (RMC) and intermediate metal conduit (IMC) is shown in *Figure 1*.

NEC Section 358.10(A) permits the installation of EMT for either exposed or concealed work where it will not be subject to severe physical damage during installation or after construction. Installation of EMT is permitted in wet locations such as outdoors or indoors in dairies, laundries, and canneries using waterproof fittings.

NOTE

Refer to *NEC Section 358.12* for restrictions that apply to the use of EMT.

EMT shall not be used (1) where, during installation or afterward, it will be subject to severe physical damage; (2) where protected from corrosion solely by enamel; (3) in cinder concrete or cinder fill where subject to permanent moisture unless protected on all sides by a layer of noncinder concrete at least two inches thick or unless the tubing is at least 18 inches under the fill; (4) in any hazardous (classified) locations except as permitted by *NEC Sections 502.10(B)(2), 503.10, and 504.20;* or (5) for the support of fixtures or other equipment.

In a wet area, EMT and other conduit must be installed to prevent water from entering the conduit system. In locations where walls are subject to regular wash-down [see *NEC Section 300.6(D)*], the entire conduit system must be installed to provide a ¼-inch air space between it and the wall or supporting surface. The entire conduit system is considered to include conduit, boxes, and fittings. To ensure resistance to corrosion caused by wet environments, EMT is galvanized. The term galvanized is used to describe the procedure in which the interior and exterior of the conduit are coated with a corrosion-resistant zinc compound.

EMT, being a good conductor of electricity, may be used as an equipment grounding conductor. In order to qualify as an equipment grounding conductor [see *NEC Section 250.118(4)*], the conduit system must be tightly connected at each joint and provide a continuous grounding path from each electrical load to the service equipment. The connectors used in an EMT system ensure electrical and mechanical continuity throughout the system (see *NEC Sections 250.96, 300.10, and 358.42*).

EMT fittings are manufactured in two basic types. One type of fitting is the compression coupling. (See *Figure 2*.)

NOTE

Support requirements for EMT are also covered in *NEC Section 358.30*. The types of supports will be discussed later in this module.

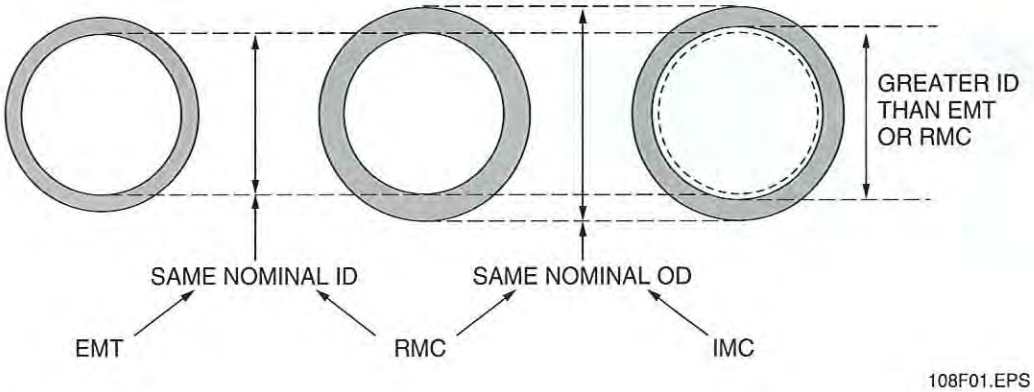

Figure 1 ◆ Conduit comparison.

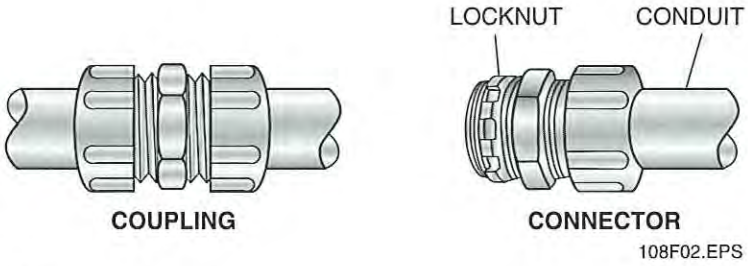

Figure 2 ◆ Compression fittings.

EMT Use

Where would you use EMT? Are there any circumstances where EMT cannot be run through a suspended ceiling? What are some differences between EMT and rigid conduit?

Because EMT is too thin for threads, special fittings must be used. For wet or damp locations, compression fittings such as those shown in *Figure 2* are used. These fittings contain a compression ring made of metal that forms a watertight seal.

When EMT compression couplings are used, they must be securely tightened, and when installed in masonry concrete, they must be of the concrete-tight type. If installed in a wet location, they must be the raintight type. Refer to *NEC Section 358.42.*

EMT fittings for dry locations can be either the setscrew type or the indenting type. To use the setscrew type, the ends of the EMT are inserted into the sleeve and the setscrews are tightened to make the connection. Various types of setscrew fittings are shown in *Figure 3.*

EMT sizes of 2½ inches and larger have the same outside diameter as corresponding sizes of galvanized RMC. RMC threadless connectors may be used to connect EMT.

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Figure 3 ◆ Setscrew fittings.

NOTE

EMT connectors, although they are the same size as RMC threadless connectors, may not be used to connect RMC.

Both setscrew and compression couplings are available in die-cast or steel construction. Steel couplings are stronger than die-cast couplings and have superior quality.

Support requirements for EMT are presented in *NEC Section 358.30.* As with most other metal conduit, EMT must be supported at least every 10 feet and within 3 feet of each outlet box, junction box, cabinet, fitting, or terminating end of the conduit. An exception to *NEC Section 358.30(A), Exception 1* allows the fastening of unbroken lengths of EMT to be increased to a distance of 5 feet where structural members do not readily permit fastening within 3 feet.

Electrical nonmetallic tubing (ENT) is also available. It provides an economical alternative to EMT, but it can only be used in certain applications. See *NEC Article 362.*

3.2.2 Rigid Metal Conduit

Rigid metal conduit (RMC) is conduit that is constructed of metal having sufficient thickness to permit the cutting of pipe threads at each end. RMC provides the best physical protection for

conductors of any of the various types of conduit. RMC is supplied in 10-foot lengths including a threaded coupling on one end.

NOTE

Specific information on RMC may be found in *NEC Article 344.*

RMC may be fabricated from steel or aluminum. Rigid metal steel conduit may be galvanized, or enamel-coated inside and out. Because of its threaded fittings, RMC provides an excellent equipment grounding conductor as defined in *NEC Section 250.118(2).* A piece of RMC is shown in *Figure 4*. The support requirements for RMC are presented in *NEC Table 344.30(B)(2).*

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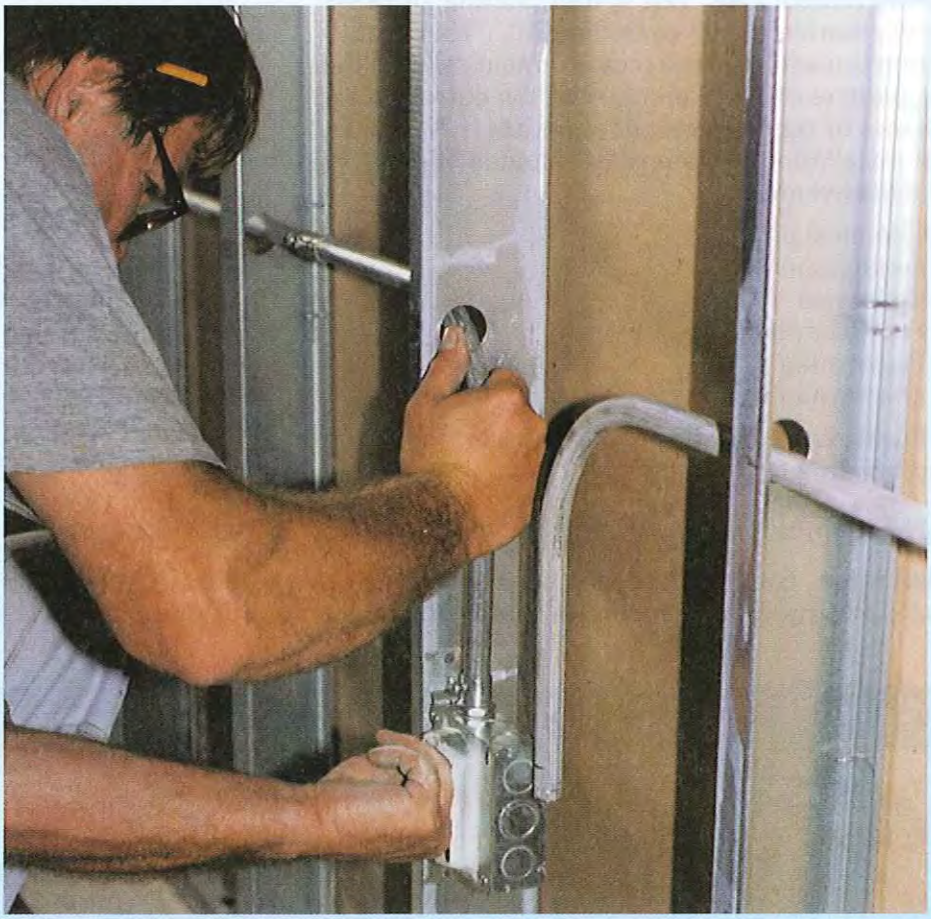
Figure 4 ◆ Rigid metal conduit.

INSIDE TRACK

EMT Installation

When installing EMT, hook your index finger up through the box to check that the conduit is seated in the connector. If you feel a lip between the conduit and the connector, the conduit is not properly seated.



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INSIDE TRACK

RMC Installations

Use RMC in hazardous environments, such as feed mills, or in areas where there is a chance of physical abuse or extreme moisture, such as outdoor environments. The *NEC®* does allow EMT to be buried in the ground or in concrete, but galvanized RMC is more commonly used.

RMC is mostly used in industrial applications. RMC is heavier than EMT and IMC. It is more difficult to cut and bend, usually requires threading of cut ends, and has a higher purchase price than EMT and IMC. As a result, the cost of installing RMC is generally higher than the cost of installing EMT and IMC.

3.2.3 Plastic-Coated RMC

Plastic-coated RMC has a thin coating of polyvinyl chloride (PVC) over the RMC. This combination is useful when an environment calls for the ruggedness of RMC along with the corrosion resistance of rigid nonmetallic conduit (RNC). Typical installations where plastic-coated RMC may be required are:

- Chemical plants
- Food plants
- Refineries
- Fertilizer plants
- Paper mills
- Wastewater treatment plants

Plastic-coated RMC requires special threading and bending techniques.

3.2.4 Aluminum Conduit

Aluminum conduit has several characteristics that distinguish it from steel conduit. Because it has better resistance to wet environments and some chemical environments, aluminum conduit generally requires less maintenance in installations such as sewage treatment plants.

Direct burial of aluminum conduit results in a self-stopping chemical reaction on the conduit surface, which forms a coating on the conduit. This coating acts to prevent further corrosion, increasing the life of the installation.

NOTE

Caution must be exercised to avoid burial of aluminum conduit in soil or concrete that contains calcium chloride. Calcium chloride may interfere with the corrosion resistance of aluminum conduit. Calcium chloride and similar materials are often added to concrete to speed concrete setting. It is important to determine if chlorides are to be used in the concrete prior to installing aluminum conduit. If chlorides are to be used, aluminum conduit must be avoided. Check with local authorities regarding this type of usage.

Since aluminum conduit is lighter than steel conduit, there are some installation advantages to using aluminum. For example, a 10-foot section of 3-inch aluminum conduit weighs about 23 pounds, compared to the 68-pound weight of its steel counterpart.

3.2.5 Black Enamel Steel Conduit

Rigid black enamel steel conduit (often called black conduit) is steel conduit that is coated with a black enamel. In the past, this type of conduit was used exclusively for indoor wiring. Black enamel steel conduit is no longer manufactured for sale in the United States. It is mentioned only because it may still be found in existing installations.

3.2.6 Intermediate Metal Conduit

Intermediate metal conduit (IMC) has a wall thickness that is less than RMC but greater than

INSIDE TRACK

Use of Aluminum Conduit

Aluminum conduit is used for special purposes such as high-cycle lines (400 cycles or above); around cooling towers, food service areas, and other applications in which corrosion is a factor; or where magnetic induction is a concern, such as near magnetic resonance imaging (MRI) equipment in hospitals.

that of EMT. The weight of IMC is approximately ⅔ that of RMC. Because of its lower purchase price, lighter weight, and thinner walls, IMC installations are generally less expensive than comparable RMC installations. However, IMC installations still have high strength ratings.

NOTE

Additional information on IMC may be found in *NEC Article 342.*

The outside diameter of a given size of IMC is the same as that of the comparable size of RMC. Therefore, RMC fittings may be used with IMC. Since the threads on IMC and RMC are the same size, no special threading tools are needed to thread IMC. Some electricians feel that threading IMC is more difficult than threading RMC because IMC is somewhat harder.

The internal diameter of a given size of IMC is somewhat larger than the internal diameter of the same size of RMC because of the difference in wall thickness. Bending IMC is considered easier than bending RMC because of the reduced wall thickness. However, bending is sometimes complicated by kinking, which may be caused by the increased hardness of IMC.

The *NEC*® requires that IMC be identified along its length at 5-foot intervals with the letters IMC. *NEC Sections 110.21 and 342.120* describe this marking requirement.

Like RMC, IMC is permitted to act as an equipment grounding conductor, as defined in *NEC Section 250.118(3).* The use of IMC may be restricted in some jurisdictions. It is important to investigate the requirements of each jurisdiction before selecting any materials.

3.2.7 Rigid Nonmetallic Conduit

The most common type of rigid nonmetallic conduit (RNC) is manufactured from polyvinyl chloride (PVC). Because RNC is noncorrosive, chemically inert, and non-aging, it is often used for installation in wet or corrosive environments. Corrosion problems found with steel and aluminum RMC do not occur with RNC. However, RNC may deteriorate under some conditions, such as extreme sunlight, unless marked sunlight resistant.

All RNC is marked according to standards established by the National Electrical Manufacturers Association (NEMA) or Underwriters Laboratories, Inc. (UL). A section of RNC is shown in *Figure 5.*

Since RNC is lighter than steel or aluminum rigid conduit, IMC, or EMT, it is considered easier to handle. RNC can usually be installed much faster than other types of conduit because the joints are made up with cement and require no threading.

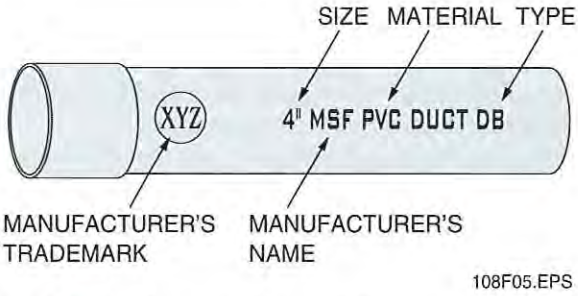

Figure 5 Rigid nonmetallic conduit.

RNC contains no metal. This characteristic reduces the voltage drop of conductors carrying alternating current in RNC compared to identical conductors in steel conduit.

Because RNC is nonconducting, it cannot be used as an equipment grounding conductor. An equipment grounding conductor sized in accordance with *NEC Table 250.122* must be pulled in each RNC conductor run (except for underground service-entrance conductors).

RNC is available in lengths up to 20 feet. However, some jurisdictions require it to be cut to 10-foot lengths prior to installation. RNC is subject to expansion and contraction directly related to the difference in temperature, plus any radiating effects on the conduit. In moderate climates, even a 10-foot installation of RNC would require an expansion joint per the *NEC*®. Each straight section of conduit run must be treated independently from other sections when connected by elbows. To avoid damage to RNC caused by temperature changes, expansion couplings are used. (See *Figure 6.*) The inside of the coupling is sealed with one or more O-rings. This type of coupling may allow up to six inches of movement. Check the requirements of the local jurisdiction prior to installing RNC.

RNC is manufactured in two types:

- *Type EB* – Thin wall for underground use only when encased in concrete. Also referred to as Type I.
- *Type DB* – Thick wall for underground use without encasement in concrete. Also referred to as Type II.

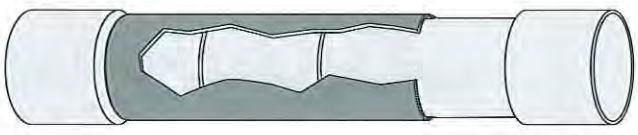

Figure 6 RNC expansion coupling.

Type DB is available in two wall thicknesses, Schedule 40 and Schedule 80.

- Schedule 40 is heavy wall for direct burial in the earth and above-ground installations.
- Schedule 80 is extra heavy wall for direct burial in the earth, above-ground installations for general applications, and installations where the conduit is subject to physical damage.

RNC is affected by higher-than-usual ambient temperatures. Support requirements for RNC are found in *NEC Table 352.30(B)*. As with other conduit, it must be supported within three feet of each termination, but the maximum spacing between supports depends upon the size of the conduit. Some of the regulations for the maximum spacing of supports are:

- ½- to 1-inch conduit: every 3 feet
- 1¼- to 2-inch conduit: every 5 feet
- 2½- to 3-inch conduit: every 6 feet
- 3½- to 5-inch conduit: every 7 feet
- 6-inch conduit: every 8 feet

3.2.8 Liquidtight Flexible Nonmetallic Conduit

Liquidtight flexible nonmetallic conduit (LFNC) was developed as a raceway for industrial equipment where flexibility was required and protection of conductors from liquids was also necessary. This is covered by *NEC Article 356*. Usage of LFNC has been expanded from industrial applications to outside and direct burial usage where listed.

Several varieties of LFNC have been introduced. The first product (LFNC-A) is commonly referred to as hose. It consists of an inner and outer layer of neoprene with a nylon reinforcing web between the layers. A second-generation product (LFNC-B), and most widely used, consists of a smooth wall, flexible PVC with a rigid PVC integral reinforcement rod. The third product (LFNC-C) is a nylon corrugated shape without any integral reinforcements. These three permitted LFNC raceway designs must be flame resistant with fittings **approved** for installation of electrical conductors. Nonmetallic connectors are listed for use and some liquidtight metallic flexible conduit connectors are dual-listed for both metallic and nonmetallic liquidtight flexible conduit.

LFNC is sunlight-resistant and suitable for use at conduit temperatures of 80°C dry and 60°C wet. It is available in ⅜-inch through 4-inch sizes. *NEC Section 356.12* states that LFNC cannot be used where subject to physical damage or LFNC-A in lengths longer than six feet, except where properly secured, where flexibility is required, or as permitted by *NEC Section 356.10*. Also, it cannot be used to contain conductors in excess of 600 volts nominal except as permitted by *NEC Section 600.7(C)*.

Liquidtight flexible metal conduit is a raceway of circular cross section having an outer liquidtight, nonmetallic, sunlight-resistant jacket over an inner flexible metal core with associated couplings and connectors covered by *NEC Article 350*.

Flex connectors are used to connect flexible conduit to boxes or equipment. They are available in straight, 45°, and 90° configurations (*Figure 7*).

3.2.9 Flexible Metal Conduit

Flexible metal conduit, also called flex, may be used for many kinds of wiring systems. Flexible metal conduit is made from a single strip of steel or aluminum, wound and interlocked. It is typically available in sizes from ⅜ inch to 4 inches in diameter. An illustration of flexible metal conduit is shown in *Figure 8*.

Flexible metal conduit is often used to connect equipment or machines that vibrate or move slightly during operation. Also, final connection to equipment having an electrical connection point that is marginally **accessible** is often accomplished with flexible metal conduit.

Figure 7 ◆ Flex connectors.

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Figure 8 ◆ Flexible metal conduit.

Flexible metal conduit is easily bent, but the minimum bending radius is the same as for other types of conduit. It should not be bent more than the equivalent of four quarter bends (360° total) between pull points (e.g., conduit bodies and boxes). It can be connected to boxes with a flexible conduit connector and to rigid conduit or EMT by using a combination coupling.

Two types of combination couplings are shown in *Figure 9*.

Flexible metal conduit is generally available in two types: nonliquidtight and liquidtight. *NEC Articles 348 and 350* cover the uses of flexible metal conduit.

Applications of RNC

What installations would be suitable for the use of RNC? For what situations would RNC be a poor choice?

Liquidtight flexible metal conduit has an outer covering of liquidtight, sunlight-resistant flexible material that acts as a moisture seal. It is intended for use in wet locations. It is used primarily for equipment and motor connections when movement of the equipment is likely to occur. The number of bends, size, and support requirements for liquidtight conduit are the same as for all flexible conduit. Fittings used with liquidtight conduit must also be of the liquidtight type.

Liquidtight Conduit

Liquidtight conduit protects conductors from vapors, liquids, and solids. Liquidtight conduit that includes an inner metal core is widely used in commercial construction.

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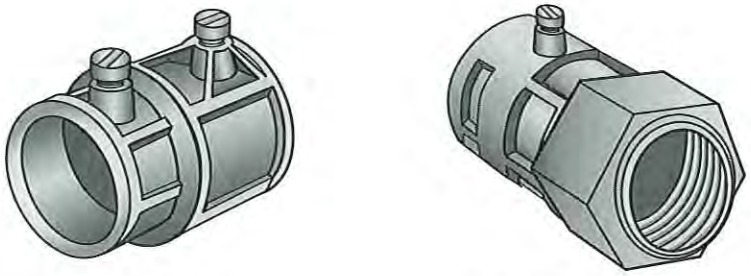

Figure 9 ◆ Combination couplings.

Support requirements for flexible metal conduit are found in *NEC Sections 348.30 and 350.30.* Straps or other means of securing the flexible metal conduit must be spaced every 4½ feet and within 12 inches of each end. (This spacing is closer together than for rigid conduit.) However, at terminals where flexibility is necessary, lengths of up to 36 inches without support are permitted. Failure to provide proper support for flexible conduit can make pulling conductors difficult.

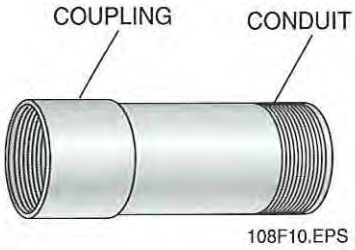

Figure 10 ◆ Conduit and coupling.

4.0.0 ◆ METAL CONDUIT FITTINGS

A large variety of conduit fittings are available to do electrical work. Manufacturers design and construct fittings to permit a multitude of applications. The type of conduit fitting used in a particular application depends upon the size and type of conduit, the type of fitting needed for the application, the location of the fitting, and the installation method. The requirements and proper applications of boxes and fittings (conduit bodies) are found in *NEC Section 300.15.* Some of the more common types of fittings are examined in the following sections.

NOTE

When using a combination coupling, be sure the flexible conduit is pushed as far as possible into the coupling. This covers the end and protects the conductors from damage.

4.1.0 Couplings

Couplings are sleeve-like fittings that are typically threaded inside to join two male threaded pieces of rigid conduit or IMC. A piece of conduit with a coupling is shown in *Figure 10.*

Other types of couplings may be used depending upon the location and type of conduit. Several types are shown in *Figure 11.*

4.2.0 Conduit Bodies

Conduit bodies are a separate portion of a conduit or tubing system that provide access through a removable cover(s) to the interior of the system at a junction of two or more sections of the system, a pull point, or at a terminal point of the system. They are usually cast and are significantly higher in cost than the stamped steel boxes permitted with EMT. However, there are situations in which conduit bodies are preferable, such as in outdoor locations, for appearance's sake in an **exposed location,** or to change types or sizes of raceways. Also, conduit bodies do not have to be supported, as do stamped steel boxes. They are also used when elbows or bends would not be appropriate.

NEC Section 314.16(C)(2) states that conduit bodies cannot contain **splices, taps,** or devices unless they are durably and legibly marked by the manufacturer with their cubic inch capacity. The maximum number of conductors permitted in a conduit body is found using *NEC Table 314.16(B).* (See *Table 1.*)

4.2.1 Type C Conduit Bodies

Type C conduit bodies may be used to provide a pull point in a long conduit run or a conduit run that has bends totaling more than 360°. A Type C conduit body is shown in *Figure 12.*

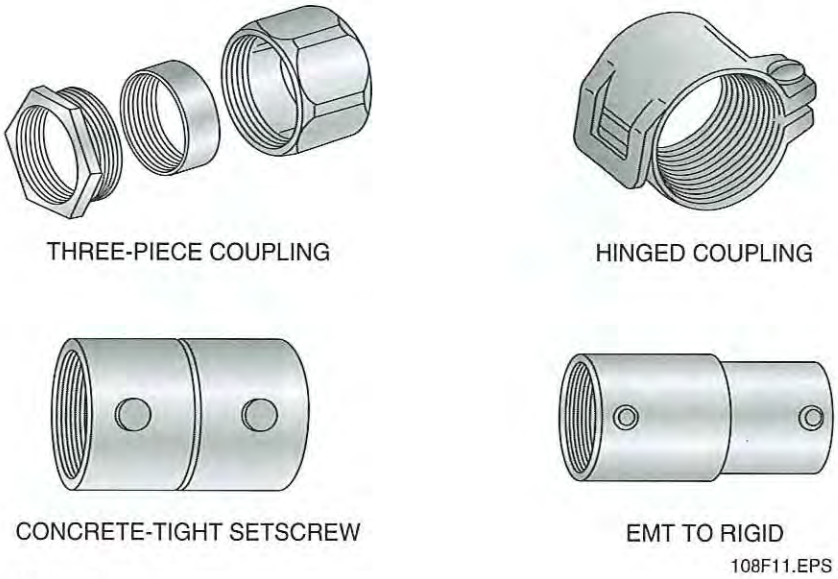

Figure 11 ◆ Metal conduit couplings.

Table 1 Volume Required per Conductor

Size of Conductor	Free Space Within Box for Each Conductor
No. 18	1.5 cubic inches
No. 16	1.75 cubic inches
No. 14	2.0 cubic inches
No. 12	2.25 cubic inches
No. 10	2.5 cubic inches
No. 8	3.0 cubic inches
No. 6	5.0 cubic inches

4.2.2 Type L Conduit Bodies

When referring to conduit bodies, the letter L represents an elbow. A Type L conduit body is used as a pulling point for conduit that requires a 90° change in direction. The cover is removed, then the wire is pulled out, coiled on the ground or floor, reinserted into the other conduit body's opening, and pulled. The cover and its associated gasket are then replaced. Type L conduit bodies are available with the cover on the back (Type LB), on the sides (Type LL or LR), or on both sides (Type LRL). Several Type L conduit bodies are shown in *Figure 13*.

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Figure 12 ◆ Type C conduit body.

NOTE

The cover and gasket must be ordered separately. Do not assume that these parts come with conduit bodies when they are ordered.

To identify Type L conduit bodies, use the following method:

Step 1 Hold the body like a pistol.

Step 2 Locate the opening on the body:

- If the opening is to the left, it is a Type LL.
- If the opening is to the right, it is a Type LR.
- If the opening is on top (back), it is a Type LB.
- If there are openings on both the left and the right, it is a Type LRL.

4.2.3 Type T Conduit Bodies

Type T conduit bodies are used to provide a junction point for three intersecting conduits and are used extensively in conduit systems. A Type T conduit body is shown in *Figure 14*.

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108F13B.EPS

Figure 13 ◆ Type L conduit bodies and how to identify them.

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Figure 14 ◆ Type T conduit body.

4.2.4 Type X Conduit Bodies

Type X conduit bodies are used to provide a junction point for four intersecting conduits. The removable cover provides access to the interior of the X so that wire pulling and splicing may be performed. A Type X conduit body is shown in *Figure 15.*

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Figure 15 ◆ Type X conduit body.

4.2.5 Threaded Weatherproof Hub

Threaded weatherproof hubs are used for conduit entering a box in a wet location. *Figure 16* shows typical threaded weatherproof hubs.

4.3.0 Insulating Bushings

An insulating bushing is either nonmetallic or has an insulated throat. Insulating bushings are installed on the threaded end of conduit that enters a sheet metal enclosure.

4.3.1 Nongrounding Insulating Bushings

The purpose of a nongrounding insulating bushing is to protect the conductors from being damaged by the sharp edges of the threaded conduit end. *NEC Section 300.15(C)* states that where a conduit enters a box, fitting, or other enclosure, a bushing must be provided to protect the wire

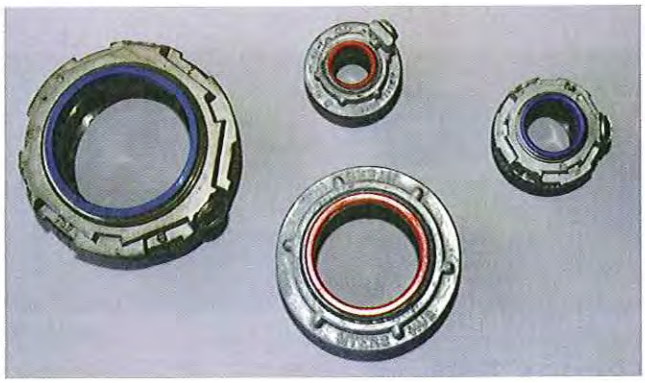

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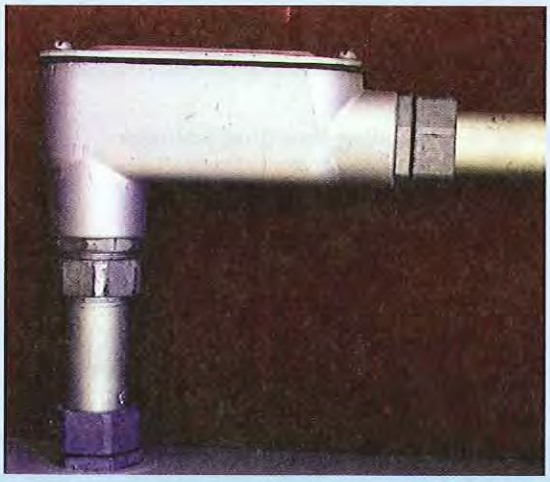
Figure 16 ◆ Threaded weatherproof hubs.

INSIDE TRACK

Installation of Conduit Bodies

It will be much easier to identify conduit bodies once you begin to see them in use. Here we show liquidtight nonmetallic conduit entering a Type T conduit body (A) and a Type LB conduit body in an outdoor commercial application (B).

(A) 108PO803.EPS



(B) 108PO804.EPS

from abrasion unless the design of the box, fitting, or enclosure is such as to afford equivalent protection. *NEC Section 312.6(C)* references *Section 300.4(F),* which states that where ungrounded conductors of No. 4 or larger enter a raceway in a cabinet or box enclosure, the conductors shall be protected by a substantial fitting providing a smoothly rounded insulating surface, unless the conductors are separated from the raceway fitting by substantial insulating material securely fastened in place. An exception is where threaded hubs or bosses that are an integral part of a cabinet, box enclosure, or raceway provide a smoothly rounded or flared entry for conductors. Insulating bushings are shown in *Figure 17.*

4.3.2 Grounding Insulating Bushings

Grounded insulating bushings, usually called grounding bushings, are used to protect conductors and also have provisions for connection of an equipment grounding conductor. The ground wire, once connected to the grounding bushing, may be connected to the enclosure to which the conduit is connected. Grounding insulating bushings are shown in *Figure 18.*

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Figure 17 ◆ Insulating bushings.

108F18.EPS

Figure 18 ◆ Grounding insulating bushings.

4.4.0 Offset Nipples

Offset nipples are used to connect two pieces of electrical equipment in close proximity where a slight offset is required. They come in sizes ranging from ½" to 2" in diameter. See *Figure 19*.

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Figure 19 ◆ Offset nipples.

5.0.0 ◆ BOXES

A box is installed at each outlet, switch, or junction point for all wiring installations and branch circuits. Boxes are made from either metallic or nonmetallic material. *Figure 20* shows various boxes used in raceway systems.

5.1.0 Metal Boxes

Metal boxes are made from sheet steel. The surface is galvanized to resist corrosion and provide a continuous ground. Refer to *NEC Section 314.40* for information on thickness and grounding provisions. Metal boxes are made with removable circular sections called pryouts or knockouts. These circular sections are removed to make openings for conduit or cable connections.

5.1.1 Pryouts

In a pryout, a section is cut completely through the metal but only part of the way around, leaving solid metal tabs at two points. A slot is cut in the center of the pryout. To remove the pryout, a screwdriver is inserted into the slot and twisted to break the solid tabs (*Figure 21*).

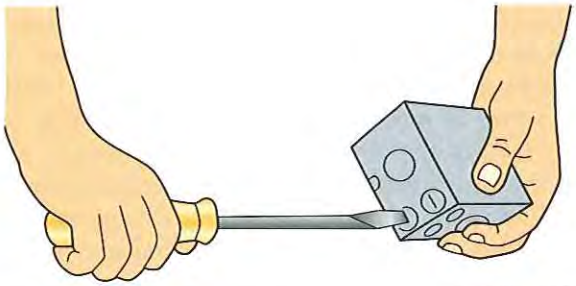

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Figure 21 ◆ Pryout removal.

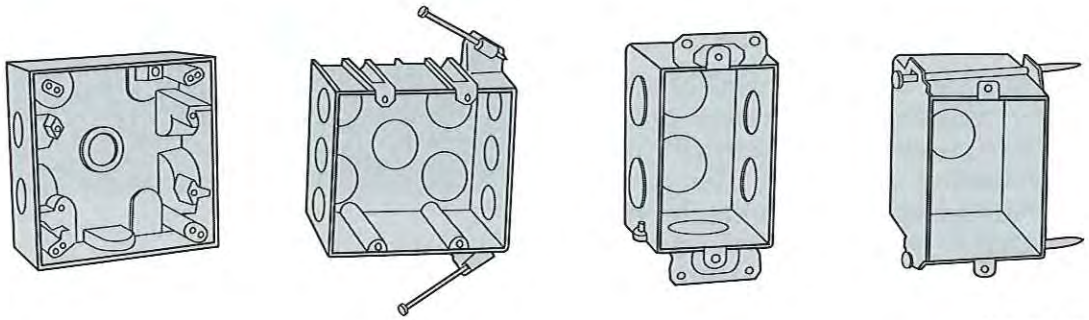

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Figure 20 ◆ Various boxes used in raceway systems.

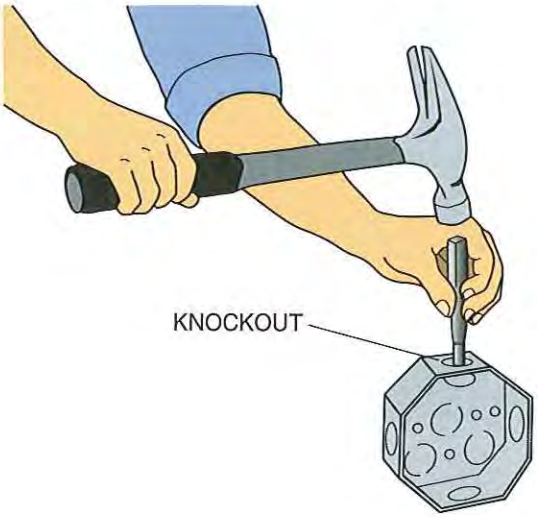

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Figure 22 ◆ Knockout removal.

5.1.2 Knockouts

Knockouts are pre-punched circular sections that do not include a pryout slot. The knockout is easily removed when sharply hit by a hammer and punch, as shown in *Figure 22*.

Often conduit must enter boxes, cabinets, or panels that do not have pre-cut knockouts. In these cases, a knockout punch can be used to make a hole for the conduit connection. A knockout punch kit is shown in *Figure 23*.

5.2.0 Nonmetallic Boxes

Nonmetallic boxes are made of PVC or Bakelite (a fiber-reinforced plastic). Nonmetallic boxes are often used in corrosive environments. *NEC Section 314.3* covers the use of nonmetallic boxes and the types of conduit, fittings, and grounding requirements for specific applications.

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Figure 23 ◆ Knockout punch kit.

6.0.0 ◆ BUSHINGS AND LOCKNUTS

Conduit is joined to boxes by connectors, adapters, threaded hubs, or locknuts.

Bushings protect the wires from the sharp edges of the conduit. Bushings are usually made of plastic or metal. Some metal bushings have a grounding screw to permit a **bonding wire** to be installed. Some different types of plastic and metal bushings are shown in *Figure 24*.

Locknuts are used on the inside and outside walls of the box to which the conduit is connected. A grounding locknut may be needed if a bonding wire is to be installed. Special sealing locknuts are also used in wet locations. Several types of locknuts are shown in *Figure 25*.

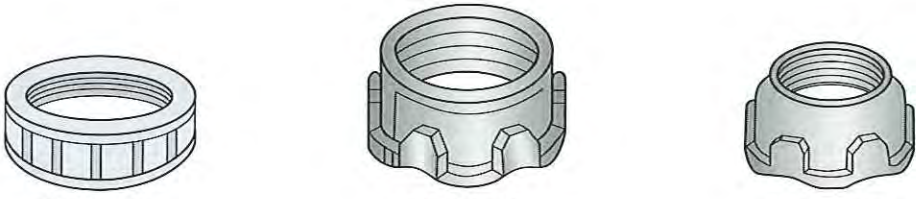

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Figure 24 ◆ Bushings.

Using a Punch

INSIDE TRACK

To cut a hole with a knockout punch, first measure for the center and drill a pilot hole large enough to insert the drive screw. Turn the drive nut with a wrench until the punch cuts through the box wall.

Removing Knockouts

INSIDE TRACK

For concentric or eccentric knockouts, first drive down one section of the smallest ring and cut it in half, then drive down the next section of the ring and cut it in half. Finally, twist off the attached portion of the knockout.

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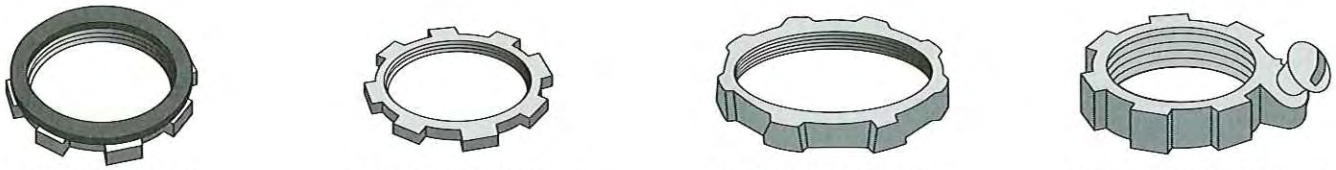

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Figure 25 ◆ Locknuts.

7.0.0 ◆ SEALING FITTINGS

Hazardous locations in manufacturing plants and other industrial facilities involve a wide variety of flammable gases and vapors and ignitable dusts. These hazardous substances have widely different flash points, ignition temperatures, and flammable limits requiring fittings that can be sealed. Sealing fittings are installed in conduit runs to minimize the passage of gases, vapors, or flames through the conduit and reduce the accumulation of moisture. They are required by *NEC Article 500* in hazardous locations where explosions may occur. They are also required where conduit passes from a hazardous location of one classification to another or to an unclassified location. Several types of sealing fittings are shown in *Figure 26*.

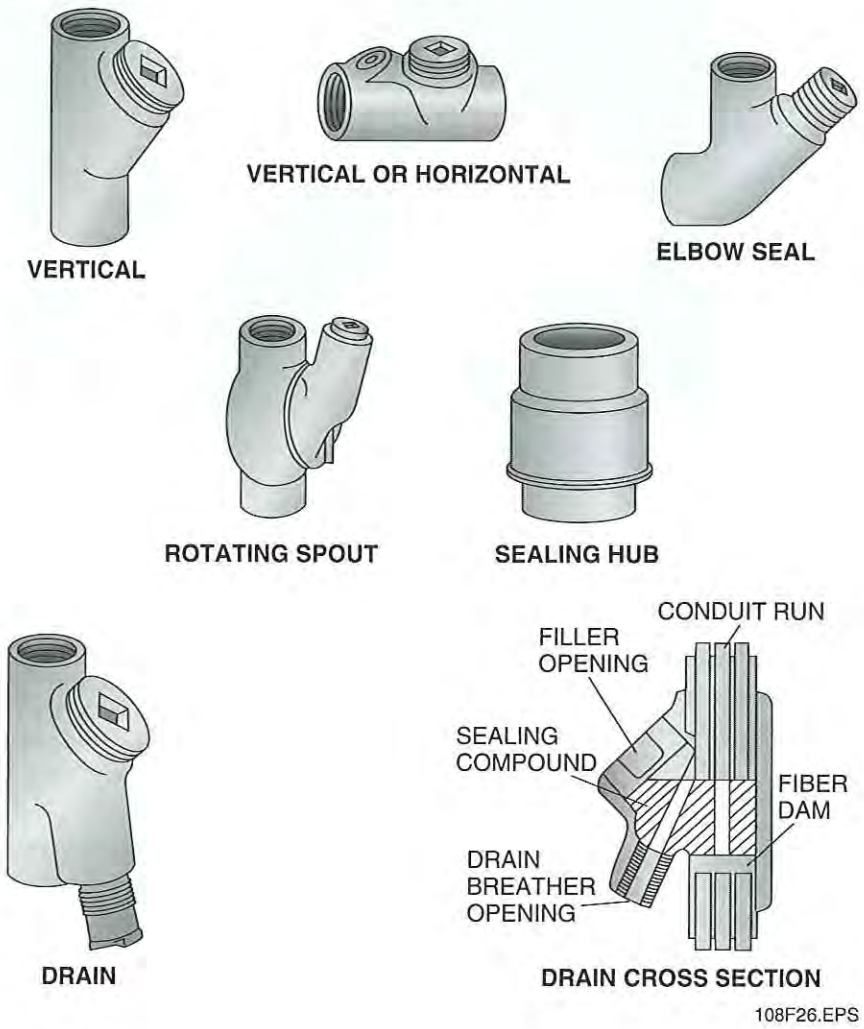

Figure 26 ◆ Sealing fittings.

INSIDE TRACK

Installing Sealing Fittings

These fittings must be sealed after the wires are pulled. A fiber dam is first packed into the base of the fitting between and around the conductors, then the liquid sealing compound is poured into the fitting.

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8.0.0 ◆ RACEWAY SUPPORTS

Raceway supports are available in many types and configurations. This section discusses the most common conduit supports found in electrical installations. *NEC Section 300.11* discusses the requirements for branch circuit wiring that is supported from above suspended ceilings. Electrical equipment and raceways must have their own supporting methods and may not be supported by the supporting hardware of a fire-rated roof/ceiling assembly.

8.1.0 Straps

Straps are used to support conduit to a surface (see *Figure 27*). The spacing of these supports must conform to the minimum support spacing requirements for each type of conduit. One- and two-hole straps are used for all types of conduit: EMT, RMC, IMC, RNC, and flex. The straps can be flexible or rigid. Two-part straps are used to secure conduit to electrical framing channels (struts). Parallel and right angle beam clamps are also used to support conduit from structural members.

Clamp back straps can also be used with a backplate to maintain the ¼-inch spacing from the surface required for installations in wet locations.

8.2.0 Standoff Supports

The standoff support, often referred to as a Minerallac® (the name of a manufacturer of this type of support), is used to support conduit away from the supporting structure. In the case of the one-hole and two-hole straps, the conduit must be kicked up wherever a fitting occurs. If standoff supports are used, the conduit is held away from the supporting surface, and no offsets (**kicks**) are required in the conduit at the fittings. Standoff supports may be used to support all types of conduit including RMC, IMC, EMT, RNC, and flex, as well as tubing installations. A standoff support is shown in *Figure 28*.

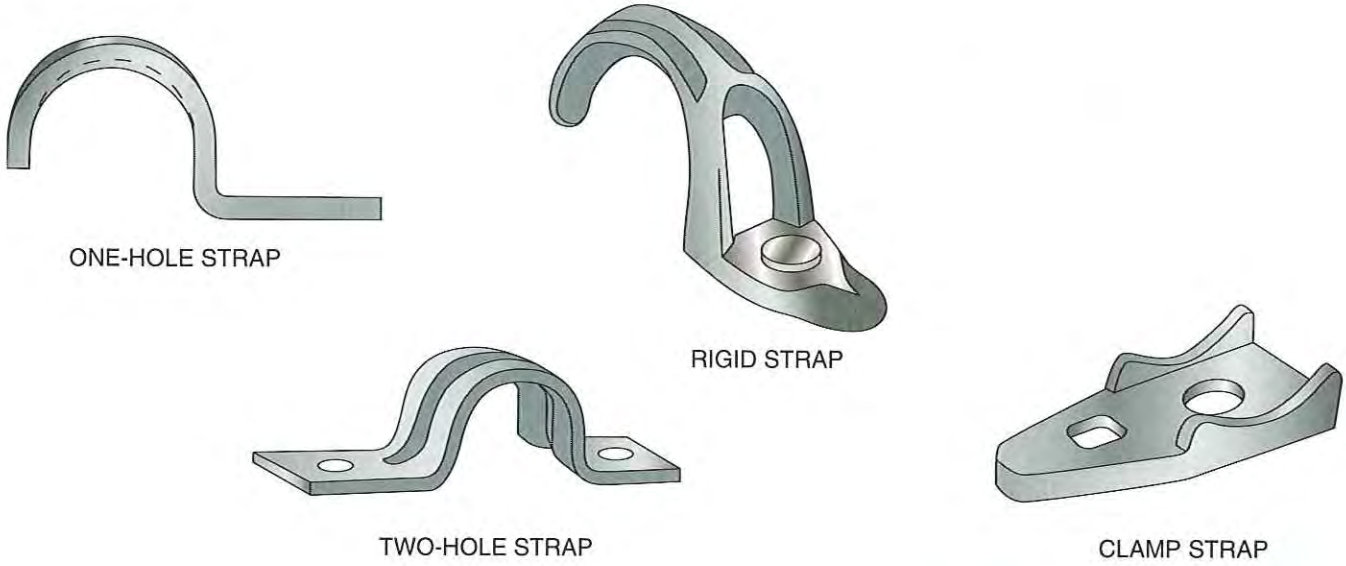

Figure 27 ◆ Straps.

Figure 28 ◆ Standoff support.

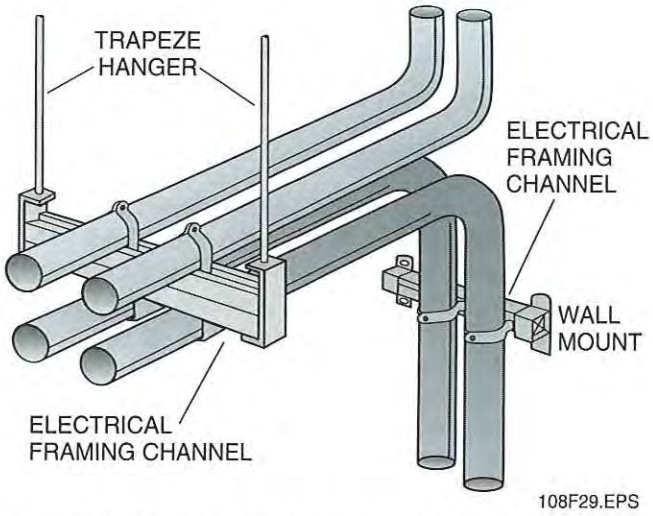

Figure 29 ◆ Electrical framing channels.

8.3.0 Electrical Framing Channels

Electrical framing channels or other similar framing materials are used together with Unistrut®-type conduit clamps to support conduit (see *Figure 29*). They may be attached to a ceiling, wall, or other surface or be supported from a trapeze hanger.

8.4.0 Beam Clamps

Beam clamps are used with suspended hangers. The raceway is attached to or laid in the hanger. The hanger is suspended by a threaded rod. One end of the threaded rod is attached to the hanger and the other end is attached to a beam clamp. The beam clamp is then attached to a beam. A beam clamp with wireway support assembly is shown in *Figure 30*.

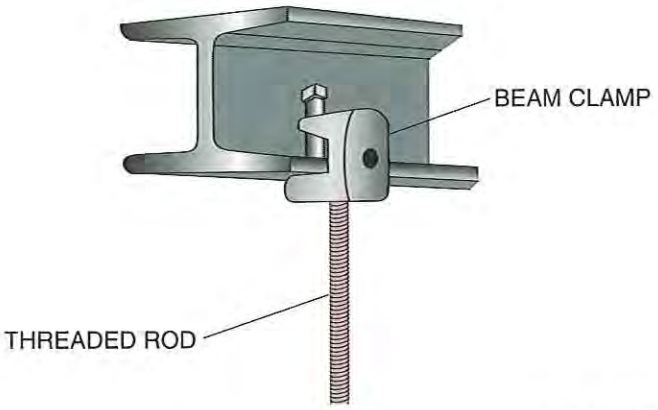

Figure 30 ◆ Beam clamp.

INSIDE TRACK

Bundling Conductors

When conductors are bundled together in a wireway their magnetic fields tend to cancel, thus minimizing inductive heating in the conductors.

9.0.0 ◆ WIREWAYS

Wireways are sheet metal troughs provided with hinged or screw-on removable covers. Like other types of raceways, wireways are used for housing electric wires and cables. Wireways are available in various lengths, including 1, 2, 3, 4, 5, and 10 feet. The availability of various lengths allows runs of any exact number of feet to be made without cutting the wireway ducts. Wireways are dealt with specifically in *NEC Article 376.*

As listed in *NEC Section 376.22,* the sum of the cross-sectional areas of all contained conductors at any cross section of a wireway shall not exceed 20% of the interior cross-sectional area of the wireway. The derating factors in *NEC Table 310.15(B)(2)(a)* shall be applied only where the number of current-carrying conductors exceeds 30, including neutral conductors classified as current-carrying under the provisions of *NEC Section 310.15(B)(4).* Conductors for signaling or controller conductors between a motor and its starter used only for starting duty shall not be considered current-carrying conductors.

It is also noted in *NEC Section 376.56* that conductors, together with splices and taps, must not fill the wireway to more than 75% of its cross-sectional area. No conductor larger than that for which the wireway is designed shall be installed in any wireway. Be sure to check *NEC Article 378* for the requirements of nonmetallic wireways.

9.1.0 Auxiliary Gutters

Strictly speaking, an auxiliary gutter is a wireway that is intended to add to wiring space at switchboards, meters, and other distribution locations. Auxiliary gutters are dealt with specifically in *NEC Article 366.* Even though the component parts of wireways and auxiliary gutters are identical, you should be familiar with the differences in their use. Auxiliary gutters are used as parts of complete assemblies of apparatus such as switchboards, distribution centers, and control equipment. However, an auxiliary gutter may only contain conductors or busbars, even though it looks like a surface metal raceway that may contain devices and equipment. Unlike auxiliary gutters, wireways represent a type of wiring because they are used to carry conductors between points located considerable distances apart.

The allowable ampacities for insulated conductors in wireways and gutters are given in *NEC Tables 310.16 and 310.18.* It should be noted that these tables are used for raceways in general. These *NEC*® tables and the notes are often used to determine if the correct materials are on hand for an installation. They are also used to determine if it is possible to add conductors in an existing wireway or gutter.

In many situations, it is necessary to make extensions from the wireways to wall receptacles and control devices. In these cases, *NEC Section 376.70* specifies that these extensions be made using any wiring method presented in *NEC Chapter 3* that includes a means for equipment grounding. Finally, as required in *NEC Section 376.120,* wireways must be marked in such a way that their manufacturer's name or trademark will be visible.

As you can see in *Figure 31,* a wide range of fittings is required for connecting wireways to one another and to fixtures such as switchboards, power panels, and conduit.

9.2.0 Types of Wireways

Rectangular duct-type wireways come as either hinged-cover or screw-cover troughs. Typical lengths are 1, 2, 3, 4, 5, and 10 feet. Shorter lengths are also available. Raintight troughs are permitted to be used in environments where moisture is not permitted within the raceway. However, the raintight trough should not be confused with the

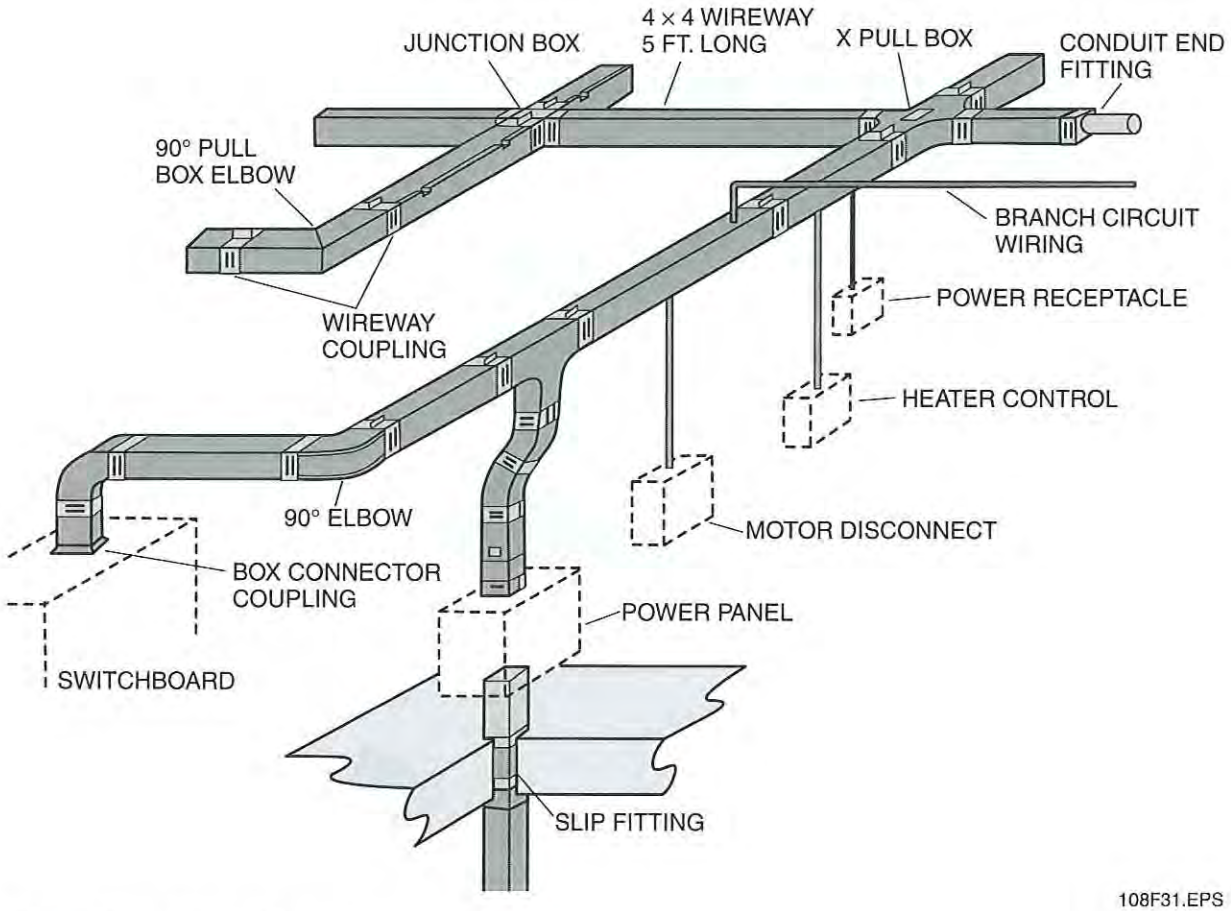

Figure 31 Wireway system layout.

raintight lay-in wireway, which has a hinged cover. *Figure 32* shows a raintight trough with a removable side cover.

Wireway troughs are exposed when first installed. Whenever possible, they are mounted on the ceilings or walls, although they may sometimes be suspended from the ceiling. Note that in *Figure 33*, the trough has knockouts similar to those found on junction boxes. After the wireway system has been installed, branch circuits are brought from the distribution panels using conduit. The conduit is joined to the wireway at the most convenient knockout possible.

Wireway components such as trough crosses, 90° internal elbows, and tee connectors serve the same function as fittings on other types of raceways. The fittings are attached to the duct using slip-on connectors. All attachments are made with nuts and bolts or screws. When assembling wireways, always place the head of the bolt on the inside and the nut on the outside so that the conductors will not be resting against a sharp edge. It is usually best to assemble sections of the wireway system on the floor, and then raise the sections into position. An exploded view of a section of wireway is shown in *Figure 34*. Both the wireway fittings and the duct come with screw-on, hinged, or snap-on covers to permit conductors to be laid in or pulled through.

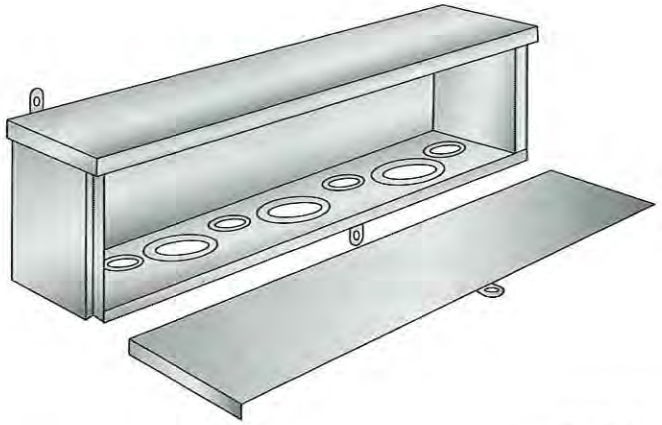

Figure 32 Raintight trough.

The *NEC*® specifies that wireways may be used only for exposed work. Therefore, they cannot be

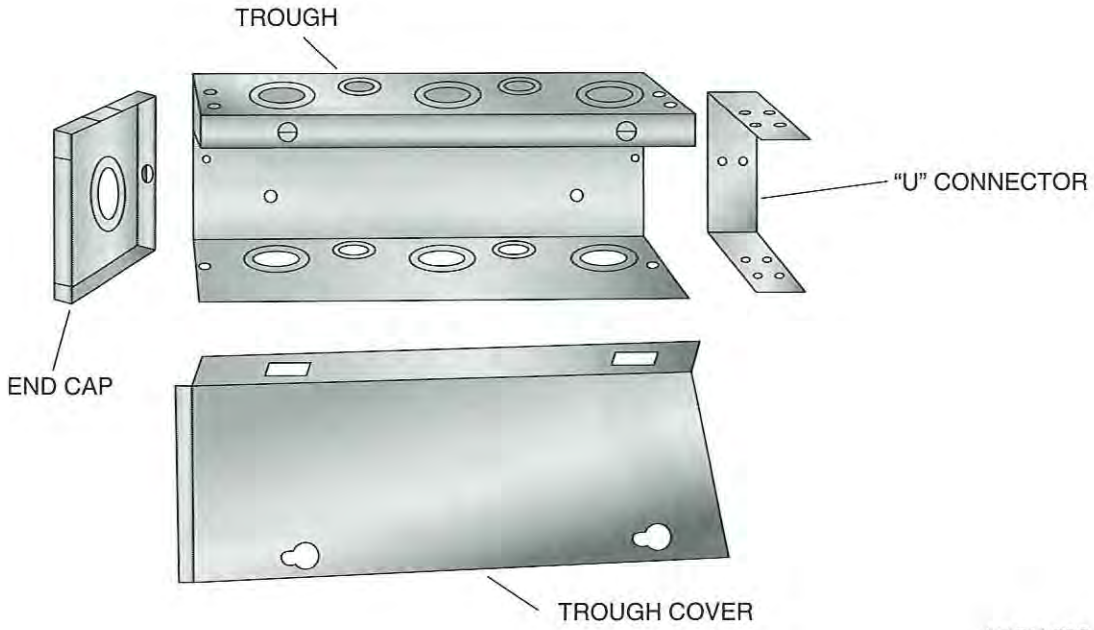

Figure 33 ◆ Trough.

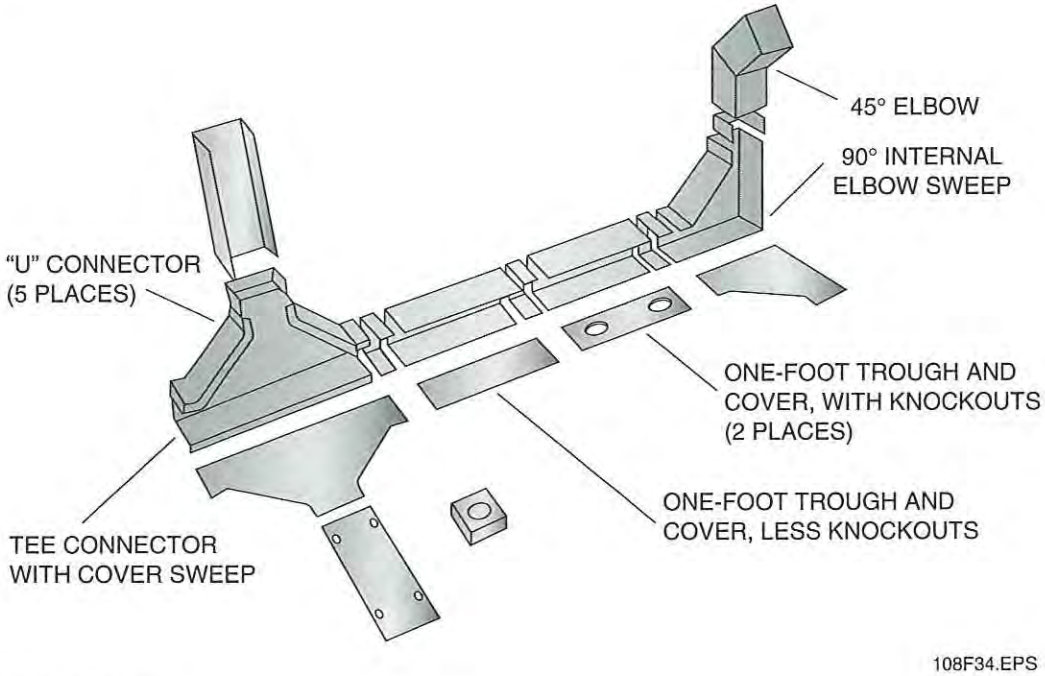

Figure 34 ◆ Wireway sections.

used in underfloor installations. If they are used for outdoor work, they must be of an approved raintight construction. It is important to note that wireways must not be installed where they are subject to severe physical damage, corrosive vapors, or hazardous locations.

Wireway troughs must be installed so that they are supported at distances not exceeding 5 feet. When specially approved supports are used, the distance between supports must not exceed 10 feet.

9.2.1 Wireway Fittings

Many different types of fittings are available for wireways, especially for use in exposed, dry locations. The following sections explain fittings commonly used in the electrical craft.

9.2.2 Connectors

Connectors are used to join wireway sections and fittings. Connectors are slipped inside the end of a

INSIDE TRACK

Wireway or Trough?

A raintight lay-in wireway has a hinged cover as shown here. A raintight trough simply has a removable cover.

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wireway section and are held in place by small bolts and nuts. Alignment slots allow the connector to be moved until it is flush with the inside surface of the wireway. After the connector is in position, it can be bolted to the wireway. This helps to ensure a strong rigid connection. Connectors have a friction hinge that helps hold the wireway cover open when needed. A connector is shown in *Figure 35*.

9.2.3 End Plates

End plates, or closing plates, are used to seal the ends of wireways. They are inserted into the end of the wireway and fastened by screws and bolts. End plates contain knockouts so that conduit or cable may be extended from the wireway. An end plate is shown in *Figure 36*.

9.2.4 Tees

Tee fittings are used when a tee connection is needed in a wireway system. A tee connection is used where circuit conductors may branch in different directions. The tee fitting's covers and

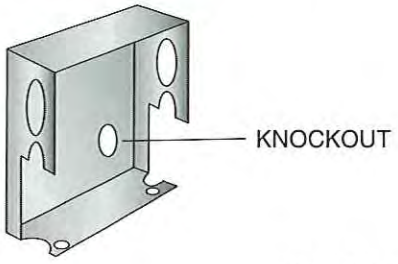

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Figure 36 ◆ End plate.

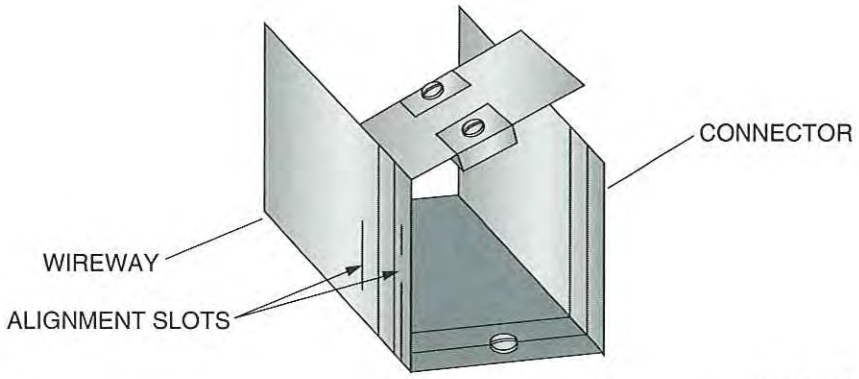

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Figure 35 ◆ Connector.

sides can be removed for access to splices and taps. Tee fittings are attached to other wireway sections using standard connectors. A tee is shown in *Figure 37*.

9.2.5 Crosses

Crosses have four openings and are attached to other wireway sections with standard connectors. The cover is held in place by screws and can be easily removed for laying in wires or for making connections. A cross is shown in *Figure 38*.

9.2.6 Elbows

Elbows are used to make a bend in the wireway. They are available in angles of 22½°, 45°, or 90°, and are either internal or external. They are attached to wireway sections with standard connectors. Covers and sides can be removed for wire installation. The inside corners of elbows are rounded to prevent damage to conductor insulation. An inside elbow is shown in *Figure 39*.

9.2.7 Telescopic Fittings

Telescopic or slip fittings may be used between lengths of wireway. Slip fittings are attached to standard lengths by setscrews and usually adjust from ½ inch to 11½ inches. Slip fittings have a removable cover for installing wires and are similar in appearance to a nipple.

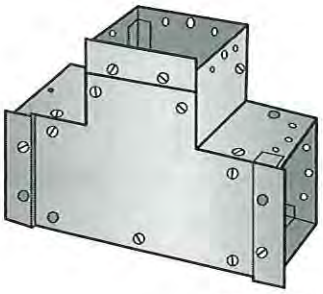

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Figure 37 ◆ Tee.

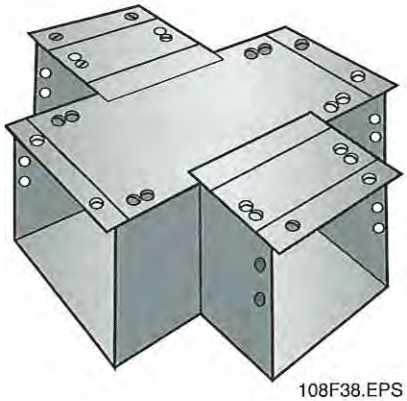

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Figure 38 ◆ Cross.

9.3.0 Wireway Supports

Wireways should be securely supported where run horizontally at each end and at intervals of no more than 5 feet or for individual lengths greater than 5 feet at each end or joint, unless listed for other support intervals. In no case shall the support distance be greater than 10 feet, in accordance with *NEC Section 376.30*. If possible, wireways can be mounted directly to a surface. Otherwise, wireways are supported by hangers or brackets.

9.3.1 Suspended Hangers

In many cases, the wireway is supported from a ceiling, beam, or other structural member. In such installations, a suspended hanger (*Figure 40*) may be used to support the wireway.

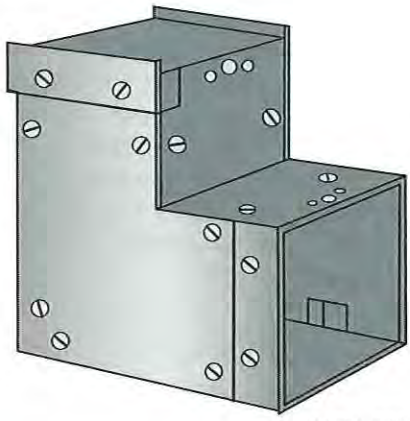

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Figure 39 ◆ 90° inside elbow.

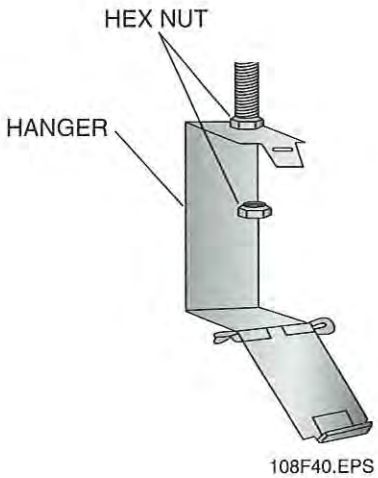

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Figure 40 ◆ Suspended hanger.

The wireway is attached to or laid in the hanger. The hanger is suspended by a threaded rod. One end of the rod is attached to the hanger with hex nuts. The other end of the rod is attached to a beam clamp or anchor.

9.3.2 Gusset Brackets

Another type of support used to mount wireways is a gusset bracket. This is an L-type bracket that is mounted to a wall. The wireway rests on the bracket and is attached by screws or bolts. A gusset bracket is shown in *Figure 41*.

9.3.3 Standard Hangers

Standard hangers are made in two pieces. The two pieces are combined in different ways for different installation requirements. The wireway is attached to the hanger by bolts and nuts. A standard hanger is shown in *Figure 42*.

9.3.4 Wireway Hangers

When a larger wireway must be suspended, a wireway hanger may be used. A wireway hanger is made by suspending a piece of strut from a ceiling, beam, or other structural member. The strut is suspended by threaded rods attached to beam clamps or other ceiling anchors, as shown in *Figure 43*.

9.4.0 Other Types of Raceways

In this section, other types of raceways will be discussed. Depending on the particular purpose for which they are intended, raceways include enclosures such as surface metal and nonmetallic raceways, and underfloor raceways.

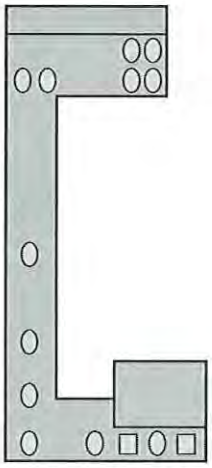

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Figure 42 ◆ Standard hanger.

9.4.1 Surface Metal and Nonmetallic Raceways

Surface metal raceways consist of a wide variety of special raceways designed primarily to carry power and communications wiring to locations on the surface of ceilings or walls of building interiors.

Installation specifications of both surface metal raceways and surface nonmetallic raceways are listed in detail in *NEC Articles 386 and 388,* respectively. All these raceways must be installed in dry, interior locations. The number of conductors, their amperage, and the allowable cross-sectional area of the conductors, as well as regulations for combination raceways, are specified in *NEC Tables 310.16 and 310.18* and *NEC Articles 386 and 388.*

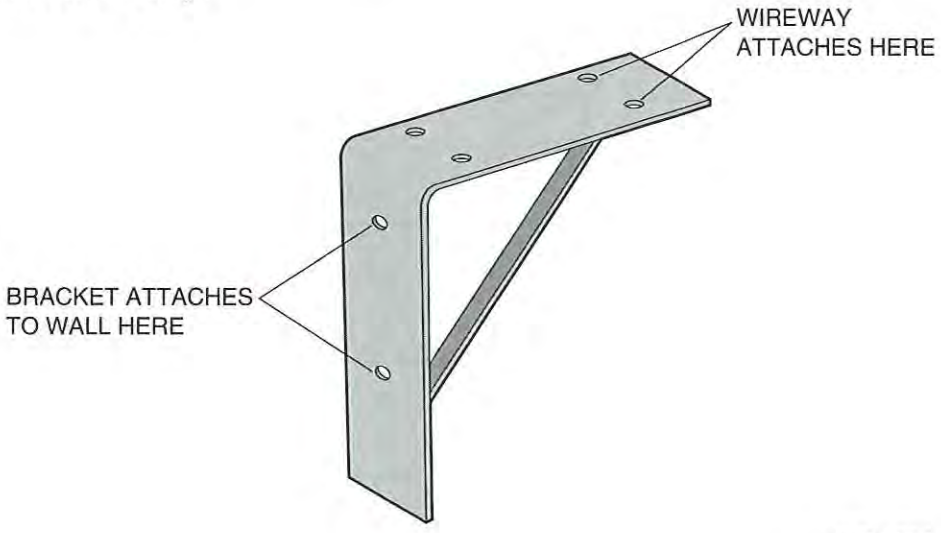

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Figure 41 ◆ Gusset bracket.

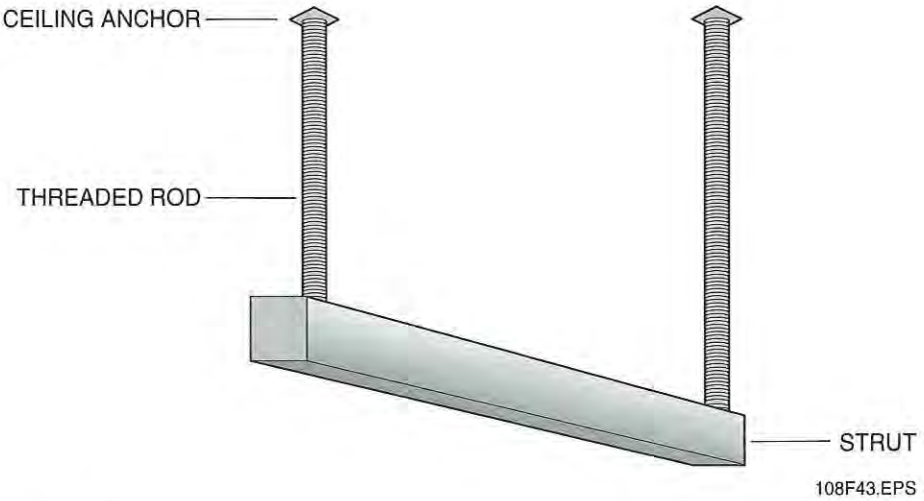

Figure 43 Wireway hanger.

One use of surface metal raceways is to protect conductors that run to non-accessible outlets.

Surface metal and nonmetallic raceways have been divided into subgroups based on the specific purpose for which they are intended. There are three small surface raceways that are primarily used for extending power circuits from one point to another. In addition, there are six larger surface raceways that have a much wider range of applications. Typical cross sections of the first three smaller raceways are shown in *Figure 44*.

Additional surface metal raceway designs are referred to as pancake raceways, because their flat cross sections resemble pancakes. Their primary use is to extend power, lighting, telephone, or signal wire to locations away from the walls of a room without embedding them under the floor. A pancake raceway is shown in *Figure 45*.

There are also surface metal raceways available that house two or three different conductor raceways. These are referred to as twinduct or triple-duct. These raceways permit different circuits, such as power and signal, to be placed within the same raceway.

The number and types of conductors permitted to be installed and the capacity of a particular surface raceway must be calculated and matched with *NEC*® requirements, as discussed previously. *NEC Tables 310.16 through 310.19* are used for surface raceways in the same manner in which they are used for wireways. For surface raceway installations with more than three conductors in each raceway, particular reference must be made to *NEC Table 310.15(B)(2)(a)*.

9.4.2 Plugmold® Multi-Outlet Systems

Plugmold® multi-outlet systems are covered in *NEC Article 380*. Manufacturers offer a wide variety of Plugmold® multi-outlet surface raceways. Their function is to hold receptacles and other

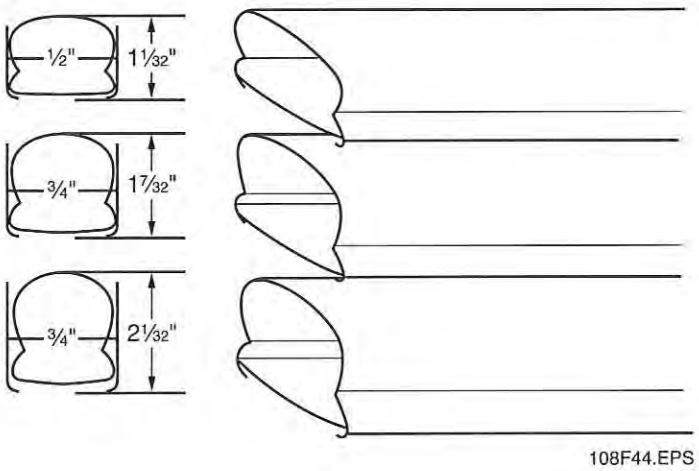

Figure 44 Smaller surface raceways.

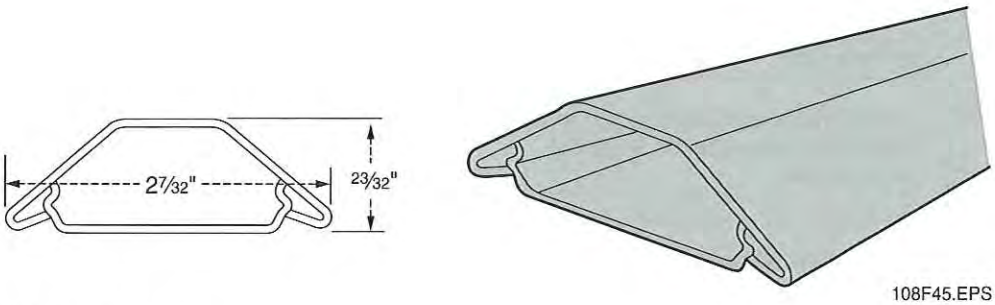

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Figure 45 ◆ Pancake raceway.

INSIDE TRACK

Surface Raceways

Surface raceways with multiple channels are commonly used in computer networking applications to provide conductors for AC power to the computers, as well as telephone and other specialized wiring.

108PO808.EPS

devices within the raceway. When the surface raceways are used in this manner, the assembly is referred to as a multi-outlet assembly.

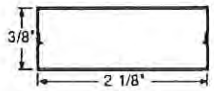
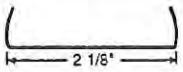
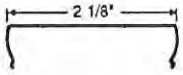
Plugmold® systems are either wired in the field or come pre-wired from the factory. *Figure 46* shows typical Plugmold® cross sections, wiring configurations, and some of the available fittings for the system.

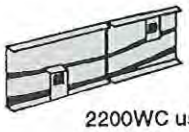
9.4.3 Pole Systems

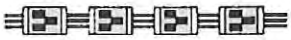
There are many situations in which power and other electric circuits have to be carried from overhead wiring systems to devices that are not located near existing wall outlets or control circuits. This type of wiring is typically used in open office spaces where cubicles are provided by temporary dividers. Poles are used to accomplish this. Some common manufacturers' names for these poles include Tele-Power® poles, Quick-E Poles®, and Walkerpoles®. The poles usually come in lengths suitable for 10-, 12-, or 15-foot ceilings. *Figure 47* shows a typical pole base.

9.4.4 Underfloor Systems

Underfloor raceway systems were developed to provide a practical means of bringing conductors for lighting, power, and signaling to cabinets and consoles. Underfloor raceways are available in 10-foot lengths and widths of 4 and 8 inches. The sections are made with inserts spaced every 24 inches. The inserts can be removed for outlet installation. These are explained in *NEC Article 390.*

DESCRIPTION	
	**2200B Base: .040" steel; 3200C Cover: .040" steel; Packed (10) 5ft. lengths of ea. per carton.
	** .040" steel; 10ft. lengths. Packed (10) 10 ft lengths per carton.
	.040" steel; 10ft. lengths. Packed (10) 10 ft lengths per carton.

ITEM	FITTING SPECIFICATIONS
WIRE AND DEVICE CLIP (PLATED)	 Holds conductors in place in cover or base. Also used to hold Plugmold® receptacles in cover.  2200WC used as a device clip and as a wire clip
COUPLING (PLATED)	 For joining lengths of 2200.

WIRING CONFIGURATION	
 **GB Series:** 3-wire, 1 circuit; has insulated grounding conductor.	 **GBA Series:** 4-wire, 2 circuit, outlets wired alternately, has insulated grounding conductor.
 **DGB Series:** 3-wire, 1 circuit, duplex outlets, has insulated grounding conductor.	 **DGBA Series:** 4-wire, duplex outlets, 2-circuit grounding. Each Duplex wired alternately. Used where multiple circuits are required, has insulated grounding conductor.

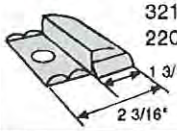
ITEM	FITTING SPECIFICATIONS
BLANK END FITTING	 For closing open end of 2200.
TRIM END FITTING	Serves dual purpose of closing open end of 2200 and providing a trim end.  32108T installed in 2200 at door casing. 

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Figure 46 ◆ Plugmold® system.

NOTE

Inserts must be installed so that they are flush with the finished grade of the floor.

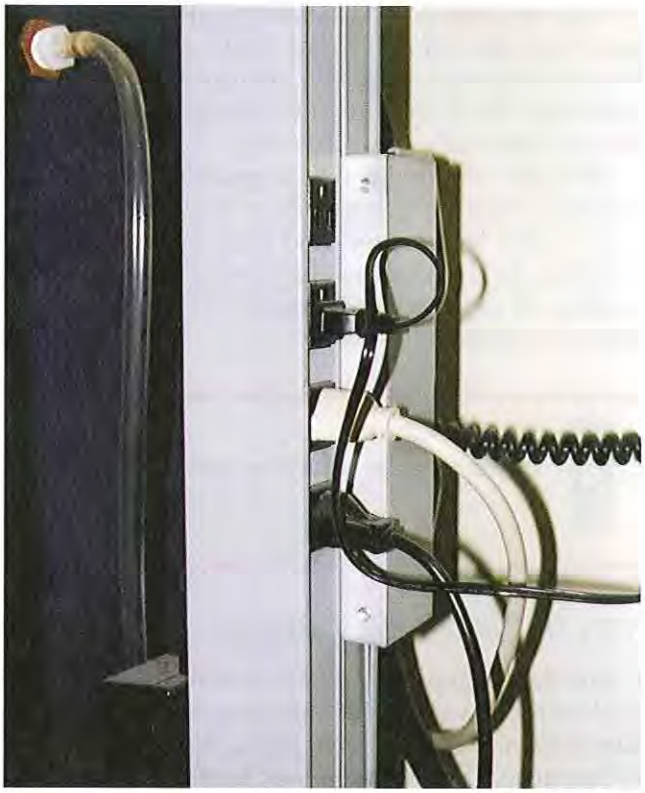
Junction boxes are used to join sections of underfloor raceways. Conduit is also used with underfloor raceways by using a raceway-to-conduit connector (conduit adapter). A typical underfloor raceway duct with fittings is shown in *Figure 48*.

This wiring method makes it possible to place a desk or table in any location where it will always be over, or very near to, a duct line. The wiring method for lighting and power between cabinets and the raceway junction boxes may be conduit, underfloor raceway, wall elbows, and cabinet connectors. *NEC Article 390* covers the installation of underfloor raceways.

9.4.5 Cellular Metal Floor Raceways

A cellular metal floor raceway is a type of floor construction designed for use in steel-frame buildings. In these buildings, the members supporting the floor between the beams consist of sheet steel rolled into shapes. These shapes are combined to form cells, or closed passageways, which extend across the building. The cells are of various shapes and sizes, depending upon the structural strength required. The cells of this type of floor construction form the raceways, as shown in *Figure 49*.

Connections to the cells are made using headers that extend across the cells. A header connects only to those cells to be used as raceways for conductors. A junction box or access fitting is necessary at each joint where a header connects to a cell. Two or three separate headers, connecting to different sets of cells, may be used for different systems. For example, light and power,



108F47.EPS

Figure 47 ◆ Power pole.

signaling systems, and public telephones would each have a separate header. A special elbow fitting is used to extend the headers up to the distribution equipment on a wall or column. *NEC Article 374* covers the installation of cellular metal floor raceways.

9.4.6 Cellular Concrete Floor Raceways

The term precast cellular concrete floor refers to a type of floor used in steel-frame, concrete-frame, and wall-bearing construction. In this type of system, the floor members are precast with hollow voids that form smooth, round cells. The cells form raceways, which can be adapted, using fittings, for use as underfloor raceways. A precast cellular concrete floor is fire-resistant and requires no further fireproofing. The precast reinforced concrete floor members form the structural floor and are supported by beams or bearing walls. Connections to the cells are made with headers that are secured to the precast concrete floor. *NEC Article 372* covers the installation of cellular concrete floor raceways.

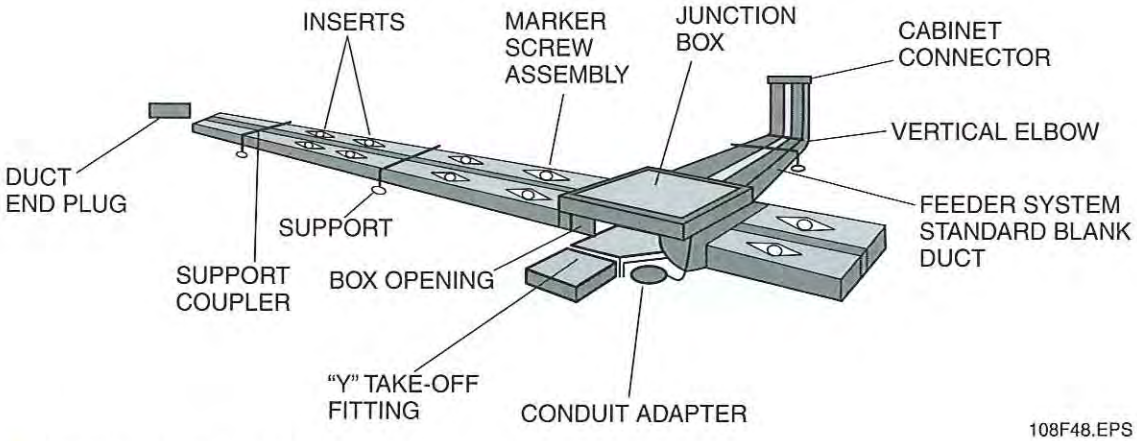


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Figure 48 ◆ Underfloor raceway duct.

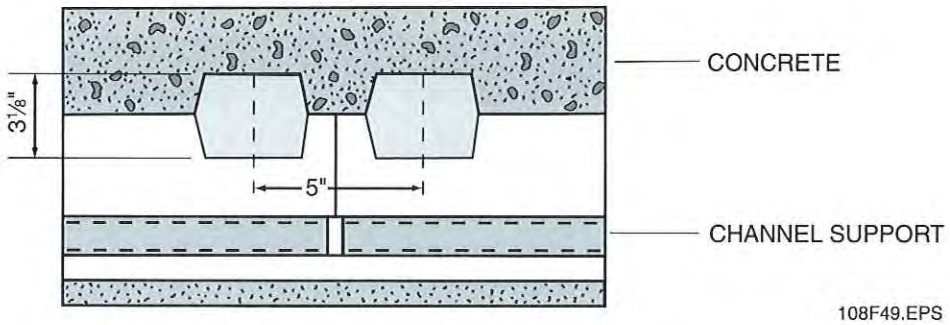

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Figure 49 ◆ Cross section of a cellular floor.

10.0.0 ◆ CABLE TRAYS

Cable trays function as a support for conductors and tubing (see *NEC Article 392*). A cable tray has the advantage of easy access to conductors, and thus lends itself to installations where the addition or removal of conductors is a common practice. Cable trays are fabricated from aluminum, steel, and fiberglass. Cable trays are available in two basic forms: ladder and trough. Ladder tray, as the name implies, consists of two parallel channels connected by rungs. Trough consists of two parallel channels (side rails) having a corrugated, ventilated bottom, or a corrugated, solid bottom. (There is also a special center rail cable tray available for use in light-duty applications such as telephone and sound wiring. We will discuss this type of cable tray in more detail in Level 2.)

Cable trays are commonly available in 12- and 24-foot lengths. They are usually available in widths of 6, 9, 12, 18, 24, 30, and 36 inches, and load depths of 4, 6, and 8 inches.

Cable trays may be used in most electrical installations. Cable trays may be used in air handling ceiling space, but only to support the wiring methods permitted in such spaces by *NEC Section 300.22(C)(1)*. Also, cable trays may be used in Class 1, Division 2 locations according to *NEC Section 501.10(B)*. Cable trays may also be used above a suspended ceiling that is not used as an air handling space. Some manufacturers offer an aluminum cable tray that is coated with PVC for installation in caustic environments. A typical cable tray system with fittings is shown in *Figure 50*.

Wire and cable installation in cable trays is defined by the *NEC®*. Read *NEC Article 392* to become familiar with the requirements and restrictions made by the *NEC®* for safe installation of wire and cable in a cable tray.

Metallic cable trays that support electrical conductors must be grounded as required by *NEC Article 250*. Where steel and aluminum cable tray systems are used as an equipment grounding conductor, all of the provisions of *NEC Section 392.7* must be complied with.

WARNING!

Do not stand on, climb in, or walk on a cable tray.

10.1.0 Cable Tray Fittings

Cable tray fittings are part of the cable tray system and provide a means of changing the direction or dimension of the different trays. Some of the uses of horizontal and vertical tees, horizontal and vertical bends, horizontal crosses, reducers, barrier strips, covers, and box connectors are shown in *Figure 50*.

10.2.0 Cable Tray Supports

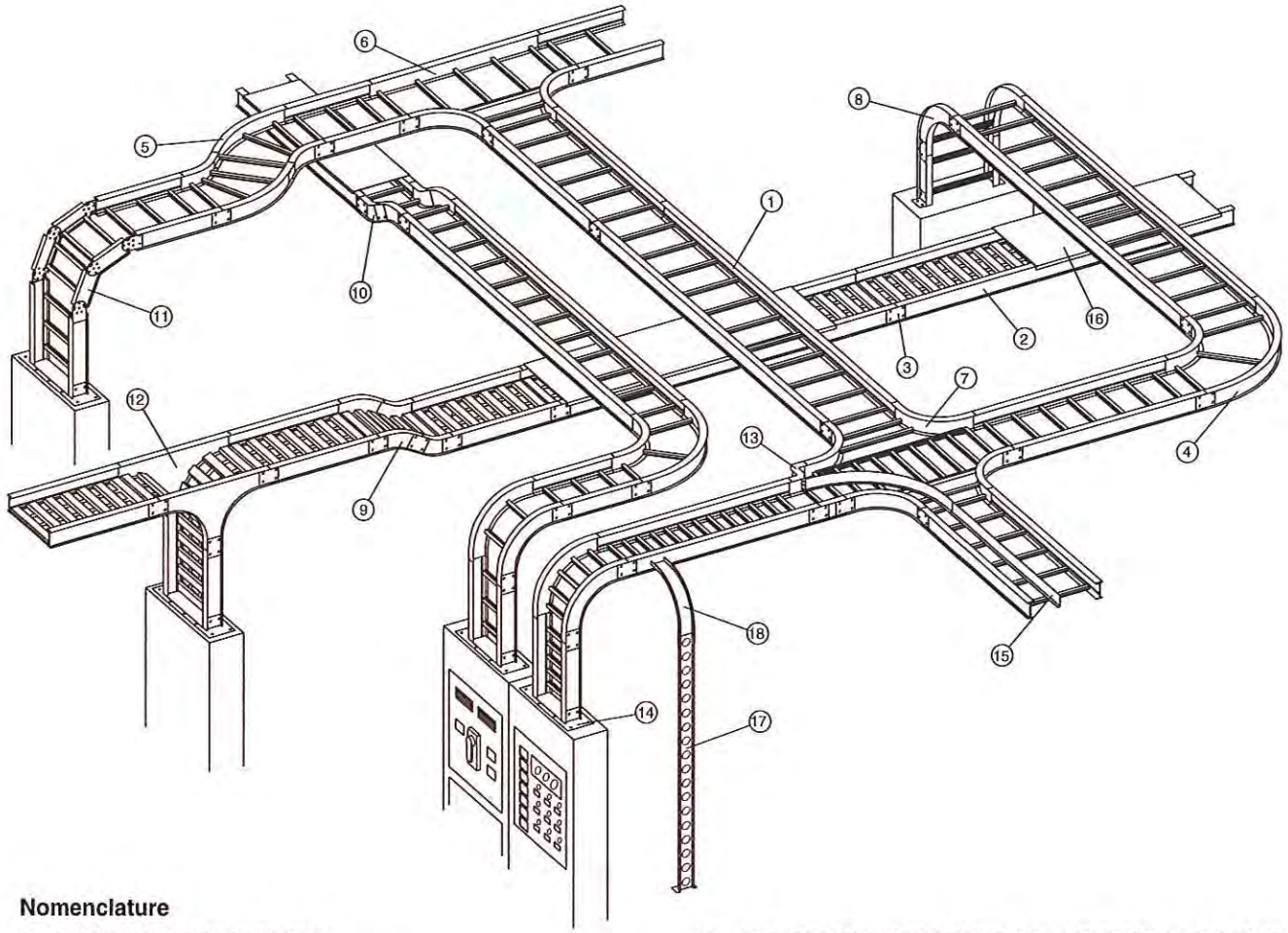
Cable trays are usually supported in one of five ways: direct rod suspension, trapeze mounting, center hung, wall mounting, and pipe rack mounting.

Cable Trays and Wireways

What is the difference between a wireway and a cable tray? What kinds of conductors would you expect to find in a cable tray as compared to a wireway?

Cable Tray Systems

Cable tray systems must be continuous and grounded. One of the advantages of using a cable tray system is that it makes it easy to expand or modify the wiring system following installation. Unlike conduit systems, wires can be added or changed by simply laying them into (or lifting them out of) the tray.



Nomenclature

1. LADDER TYPE CABLE TRAY
2. VENTILATED TROUGH TYPE CABLE TRAY
3. STRAIGHT SPLICE PLATE
4. 90° HORIZONTAL BEND, LADDER TYPE CABLE TRAY
5. 45° HORIZONTAL BEND, LADDER TYPE CABLE TRAY
6. HORIZONTAL TEE, LADDER TYPE CABLE TRAY
7. HORIZONTAL CROSS, LADDER TYPE CABLE TRAY
8. 90° VERTICAL OUTSIDE BEND, LADDER TYPE CABLE TRAY
9. 45° VERTICAL OUTSIDE BEND, VENTILATED TYPE CABLE TRAY
10. 30° VERTICAL INSIDE BEND, LADDER TYPE CABLE TRAY
11. VERTICAL BEND SEGMENT (VBS)
12. VERTICAL TEE DOWN, VENTILATED THROUGH TYPE CABLE TRAY
13. LEFT HAND REDUCER, LADDER TYPE CABLE TRAY
14. FRAME TYPE BOX CONNECTOR
15. BARRIER STRIP STRAIGHT SECTION
16. SOLID FLANGED TRAY COVER
17. VENTILATED CHANNEL STRAIGHT SECTION
18. CHANNEL CABLE TRAY, 90° VERTICAL OUTSIDE BEND

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Figure 50 ◆ Cable tray system.

10.2.1 Direct Rod Suspension

The direct rod suspension method of supporting cable tray uses threaded rods and hanger clamps. One end of the threaded rod is connected to the ceiling or other overhead structure. The other end is connected to hanger clamps that are attached to the cable tray side rails. A direct rod suspension assembly is shown in *Figure 51*.

10.2.2 Trapeze Mounting and Center Hung Support

Trapeze mounting of cable tray is similar to direct rod suspension mounting. The difference is in the method of attaching the cable tray to the threaded rods. A structural member, usually a steel channel or strut, is connected to the vertical supports to provide an appearance similar to a swing or

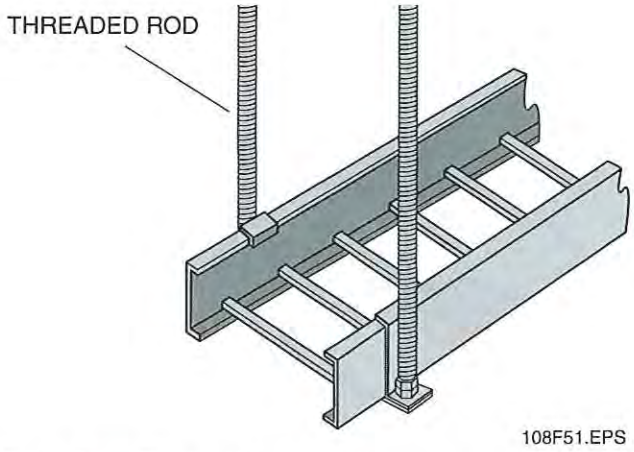

Figure 51 ◆ Direct rod suspension.

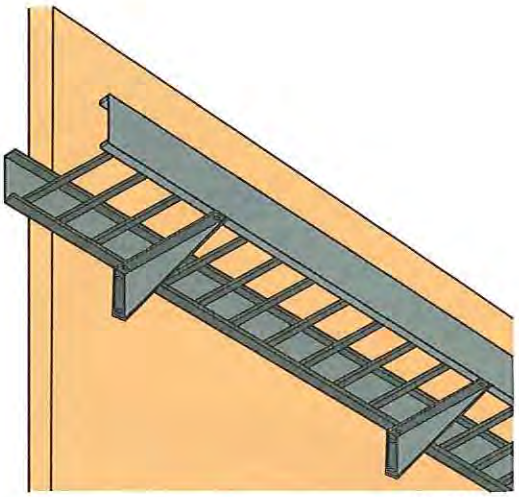

Figure 53 ◆ Wall mounting.

trapeze. The cable tray is mounted to the structural member. Often, the underside of the channel or strut is used to support conduit. A trapeze mounting assembly is shown in *Figure 52*.

A method that is similar to trapeze mounting is a center hung tray support (*Figure 52*). In this case, only one rod is used and it is centered between the cable tray side rails.

10.2.3 Wall Mounting

Wall mounting is accomplished by supporting the cable tray with structural members attached to the wall. This method of support is often used in tunnels and other underground or sheltered installations where large numbers of conductors interconnect equipment that is separated by long distances. A wall mounting assembly is shown in *Figure 53*.

10.2.4 Pipe Rack Mounting

Pipe racks are structural frames used to support piping that interconnects equipment in outdoor industrial facilities. Usually, some space on the rack is reserved for conduit and cable tray. Pipe rack mounting of cable tray is often used when power distribution and electrical wiring is routed over a large area.

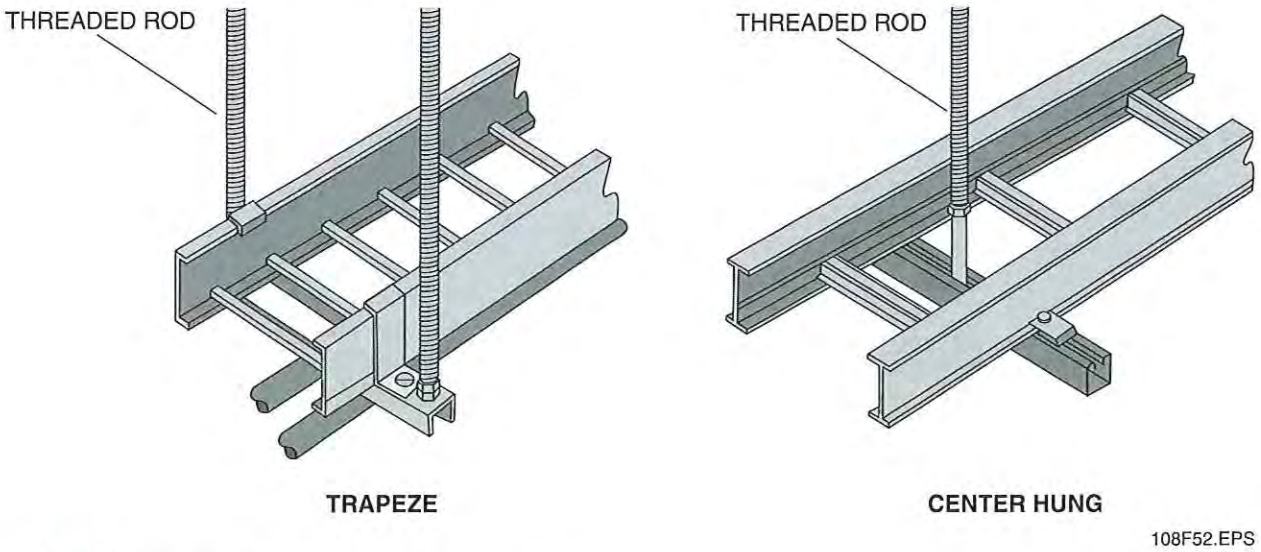

Figure 52 ◆ Trapeze mounting and center hung support.

11.0.0 ◆ STORING RACEWAYS

Proper and safe methods of storing conduit, wireways, raceways, and cable trays may sound like a simple task, but improper storage techniques can result in wasted time and damage to the raceways, as well as personal injury. There are correct ways to store raceways that will help avoid costly damage, save time in identifying stored raceways, and reduce the chance of personal injury.

Pipe racks are commonly used for storing conduit. The racks provide support to prevent bending, sagging, distorting, scratching, or marring of conduit surfaces. Most racks have compartments where different types and sizes of conduit can be separated for ease of identification and selection. The storage compartments in racks are usually elevated to help avoid damage that might occur at floor level. Conduit that is stored at floor level is easily damaged by people and other materials or equipment in the area.

The ends of stored conduit should be sealed to help prevent contamination and damage. Conduit ends can be capped, taped, or plugged.

Always inspect raceway before storing it to make sure that it is clean and not damaged. It is discouraging to get raceway for a job and find that it is dirty or damaged. Also, make sure that the raceway is stored securely so that when someone comes to get it for a job, it will not fall in any way that could cause injury.

To prevent contamination and corrosion of stored raceway, it should be covered with a tarpaulin or other suitable covering. It should also be separated from non-compatible materials such as hazardous chemicals.

Wireways, surface metal raceways, and cable trays should always be stored off the ground on boards in an area where people will not step on it and equipment will not run over it. Stepping or running over raceway bends the metal and makes it unusable.

12.0.0 ◆ HANDLING RACEWAYS

Raceway is made to strict specifications. It can be easily damaged by careless handling. From the time raceway is delivered to a job site until the installation is complete, use proper and safe handling techniques. These are a few basic guidelines for handling raceway that will help avoid damaging or contaminating it:

- Never drag raceway off a delivery truck or off other lengths of raceway.
- Never drag raceway on the ground or floor. Dragging raceway can cause damage to the ends.
- Keep the thread protection caps on when handling or transporting conduit raceway.
- Keep raceway away from any material that might contaminate it during handling.
- Flag the ends of long lengths of raceway when transporting it to the job site.
- Never drop or throw raceway when handling it.
- Never hit raceway against other objects when transporting it.
- Always use two people when carrying long pieces of raceway. Make sure that you both stay on the same side and that the load is balanced. Each person should be about ¼ of the length of the raceway from the end. Lift and put down the raceway at the same time.

13.0.0 ◆ DUCTING

In the common vocabulary of the electrical trade, a duct is a single enclosed raceway, or runway, through which conductors or cables can be led. Basically, ducting is a system of ducts. However, underground duct systems include manholes, transformer vaults, and risers.

There are several reasons for running power lines underground rather than overhead. In some situations, an overhead high-voltage line would be dangerous, or the space may not be adequate. For aesthetic reasons, architectural plans may require buried lines throughout a subdivision or a planned community. Tunnels may already exist, or be planned, for carrying steam or water lines. In any of these situations, underground installations are appropriate. Underground cables may be buried directly in the ground or run through conduit.

In underground construction, a duct system provides a safe passageway for power lines, communication cables, or both. In buildings, underfloor raceways and cellular floor raceways are built to provide ducting so that electricity will be available throughout a large area. As an electrician, you need to know the approved methods of constructing underground ducting. You also need to know how to avoid potential electrical hazards in both original construction and maintenance. It is essential to understand the requirements and limitations imposed on running wires through underfloor and cellular floor raceways and ducts.

14.0.0 ◆ UNDERGROUND SYSTEMS

There are five different ways to install cable underground:

- Duct line
- Conductors located in tunnels
- Conductors buried directly in the earth
- RNC
- RMC

The method used will depend on the materials that are available, the number of conductors to be pulled, and the type of wiring to be done (service drop, branch circuit, commercial, etc.).

14.1.0 Duct Line

A duct line consists of at least one subway placed in a trench and covered with earth. Conduit, in some cases, can be classified as a subway. Subways may come in a single duct line or multiple duct lines (2, 3, 4, and 6 subways per section). The depth at which the duct will be placed is determined using *NEC Table 300.5.* The conduit subways are encased in concrete or other materials. This provides good mechanical strength and allows for power losses from the cable to be dissipated into the earth.

In underground cable installations, a duct is a buried conduit through which a cable passes. Manholes are set at intervals in an underground duct run. Manholes provide access through throats (sometimes called chimneys). At ground level, or street surface level, a manhole cover closes off the manhole area tightly. An individual cable length running underground normally terminates at a manhole, where it is spliced to another length of cable. A duct line may consist of a single conduit or several, each carrying a cable length from one manhole to the next.

Manholes provide room for installing lengths of cable in conduit lines. They are also used for maintenance work and for performing tests. Workers enter a manhole from above. In a two-way manhole, cables enter and leave in only two directions. There are also three-way and four-way manholes. Often manholes are located at the intersection of two streets so that they can be used for cables leaving in four directions. Manholes are usually constructed of brick or concrete. Their design must provide room for drainage and for workers to move around inside them. A similar opening known as a handhole is sometimes provided for splicing on lateral two-way duct lines.

Transformer vaults house power transformers, voltage regulators, network protectors, meters, and circuit breakers. A cable may end at a transformer vault. Other cables end at a customer's substation or terminate as risers that connect with overhead lines.

14.2.0 Duct Materials

Underground duct lines can be made of fiber, vitrified tile, iron conduit, plastic, or poured concrete. The inside diameter of the ducting for a specific job is determined by the size of the cable that will be drawn into the duct. Sizes from two to six inches (inside diameter) are available for most types of ducting.

WARNING!

Be careful when working with unfamiliar duct materials. In older installations, asbestos/cement duct may have been used. You must be certified to remove or disturb asbestos.

14.3.0 Rigid Nonmetallic Conduit

Rigid nonmetallic conduit (RNC) may be made of PVC (polyvinyl chloride), PE (polyethylene), or styrene. Since this type of conduit is available in lengths up to 20 feet, fewer couplings are needed than with other types of ducting. RNC is popular because it is easy to install, requires less labor than other types of conduit, and is low in cost.

14.4.0 Monolithic Concrete Duct

Monolithic concrete duct is poured at the job site. Multiple duct lines can be formed using rubber tubing cores on spacers. The cores may be removed after the concrete has set. A die containing steel tubes, known as a boat, can also be used to form ducts. It is pulled slowly through the trench on a track as concrete is poured from the top. Poured concrete ducting made by either method is relatively expensive, but offers the advantage of creating a very clean duct interior with no residue that can decay. The rubber core method is especially useful for curving or turning part of a duct system.

14.5.0 Cable-in-Duct

One of the most popular duct types is the cable-in-duct. This type of duct comes from the manufacturer with cables already installed. The duct comes in a reel and can be laid in the trench with ease. The installed cables can be withdrawn in the future, if necessary. This type of duct, because of the form in which it comes, reduces the need for fittings and couplings. It is most frequently used for street lighting systems.

15.0.0 ◆ MAKING A CONDUIT-TO-BOX CONNECTION

A proper conduit-to-box connection is shown in *Figure 54*.

In order to make a good connection, use the following procedure:

Step 1 Thread the external locknut onto the conduit. Run the locknut to the bottom of the threads.

Step 2 Insert the conduit into the box opening.

Step 3 If an inside locknut or grounding locknut is required, screw it onto the conduit inside the box opening.

Step 4 Screw the bushing onto the threads projecting into the box opening. Make sure the bushing is tightened as much as possible.

Step 5 Tighten the external locknut to secure the conduit to the box.

It is important that the bushings and locknuts fit tightly against the box. For this reason, the conduit must enter straight into the box (*Figure 55*). This may require that a box offset or kick be made in the conduit.

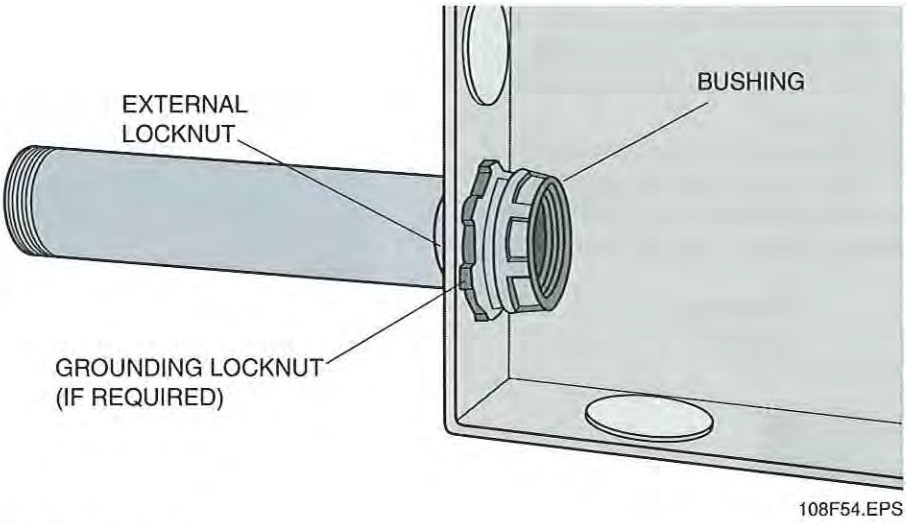

Figure 54 ◆ Conduit-to-box connection.

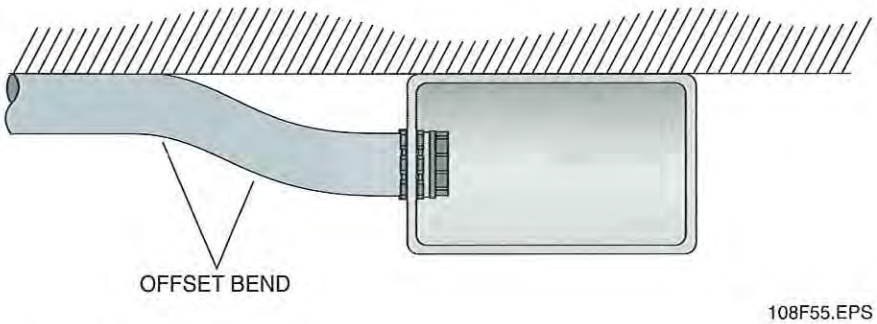

Figure 55 ◆ Correct entrance angle.

16.0.0 ◆ VARIOUS CONSTRUCTION PROCEDURES

16.1.0 Masonry and Concrete Flush-Mount Construction

In a reinforced concrete construction environment, the conduit and boxes must be embedded in the concrete to achieve a flush surface. Ordinary boxes may be used, but special concrete boxes are preferred and are available in depths up to six inches. These boxes have special ears by which they are nailed to the wooden forms for the concrete. When installing them, stuff the boxes tightly with paper to prevent concrete from seeping in. *Figure 56* shows an installed box.

Flush construction can also be done on existing concrete walls, but this requires chiseling a channel and box opening, anchoring the box and conduit, and then resealing the wall.

To achieve flush construction with masonry walls, the most acceptable method is for the electrician to work closely with the mason laying the blocks. When the construction blocks reach the convenience outlet elevation, boxes are made up as shown in *Figure 57*. The figure shows a raised tile ring or box device cover.

Figure 58 shows the use of a 4-S extension ring installed to bring the box to the masonry surface. *Figure 59* shows a masonry box that needs no extension or deep plaster ring to bring it to the surface.

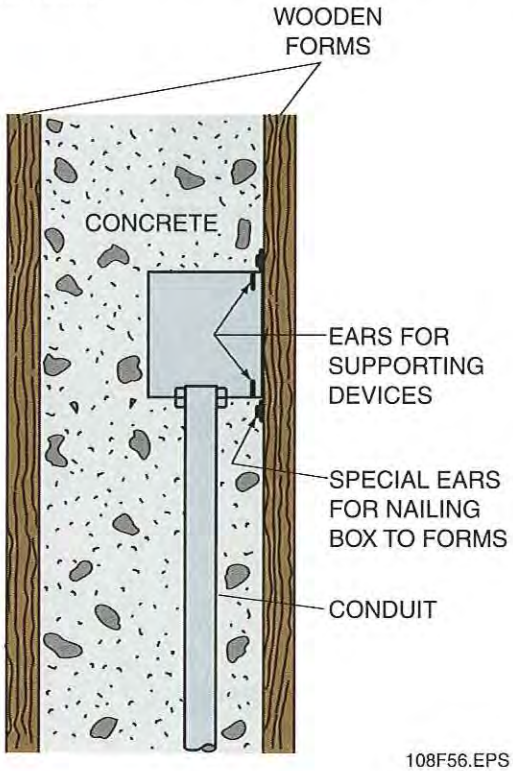

Figure 56 ◆ Concrete flush-mount installation.

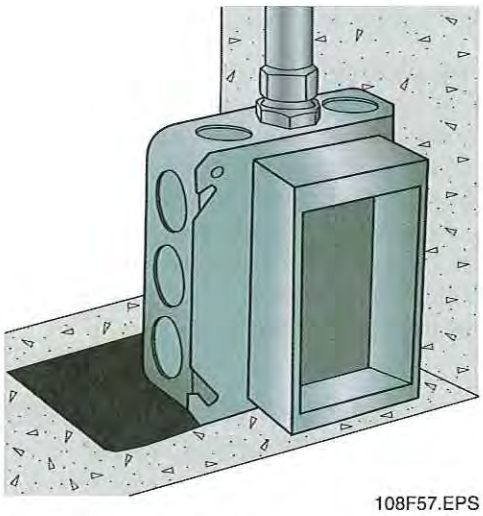

Figure 57 ◆ Concrete outlet box.

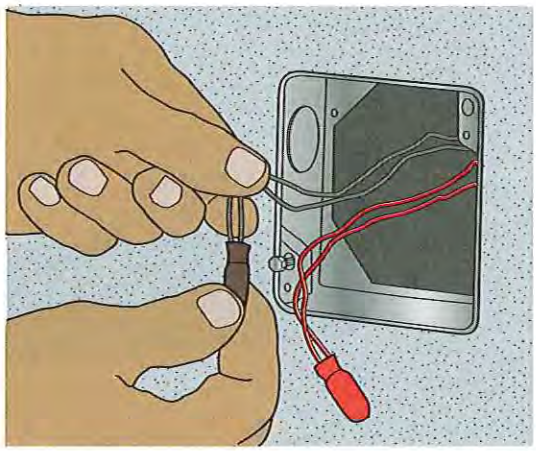

Figure 58 ◆ 4-S extension ring used to bring the box to the masonry surface.

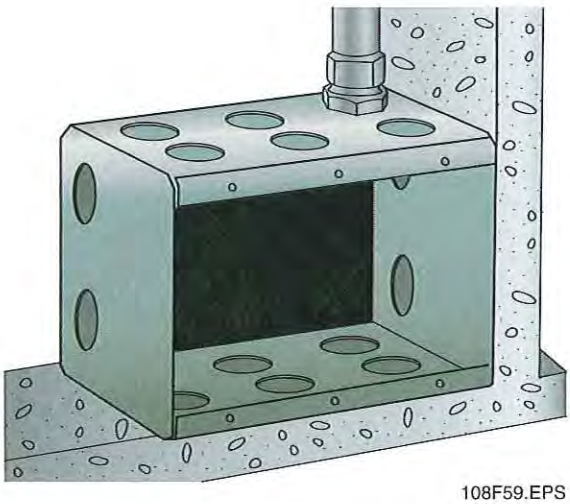

Figure 59 ◆ Three-gang switchbox.

NOTE
The electrician must work with the mason to ensure the box is properly grouted and sealed.

NOTE
Conduit should be installed in the rear knockout of this masonry switch box.

Sections of conduit are then coupled in short (4- or 5-foot) lengths. This is done because it is impractical for the mason to maneuver blocks over 10-foot sections of conduit.

16.2.0 Metal Stud Environment

Metal stud walls are a popular method of construction for the interior walls of commercial buildings. Metal stud framing consists of relatively thin metal channel studs, usually constructed of galvanized steel and with an overall dimension the same as standard 2 × 4 wooden studs. Wiring in this type of construction is relatively easy when compared to masonry.

EMT conduit is the most common type of raceway specified for metal stud wiring. Metal studs usually have some number of pre-punched holes that can be used to route the conduit. If a pre-punched hole is not located where it needs to be, holes can be easily punched in the metal stud with a hole cutter or knockout punch.

WARNING!
Cutting or punching metal studs can create sharp edges. Avoid contact that can result in cuts.

Boxes can be secured to the metal stud using self-tapping screws or one of the many types of box supports available. EMT conduit is supported by the metal studs using conduit straps or other approved methods. It is important that the conduit be properly supported to facilitate pulling the conductors through the tubing. Boxes are mounted on the metal studs so that the box will be flush with the finished walls. You must know what the finished wall thickness is going to be to properly secure the boxes to the metal studs. For example, if the finished wall will be ⅝-inch drywall, then the box must be fastened so that it protrudes ⅝ of an inch from the metal stud.

WARNING!
When using a screw gun or cordless drill to mount boxes to studs, keep the hand holding the box away from the gun/drill to avoid injury.

Figure 60 shows several examples of clips known as caddy-fastening devices that are used in metal stud environments.

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Figure 60 ◆ Caddy-fastening devices.

INSIDE TRACK

Conductors Through Metal Framing

Single cables should not be run through holes drilled in metal studs unless they are fully grommeted. This protects the cables from the friction of pulling during installation and from the weight of the cable and vibrations following the installation.

16.3.0 Wood Frame Environment

At one time, the use of rigid conduit in partitions and ceilings was a laborious and time-consuming operation. Thinwall conduit makes an easier and far quicker job, largely because of the types of fittings that are specially adapted to it.

Figure 61 shows two methods of running thinwall conduit in these locations: boring timbers and notching them. When boring, holes must be drilled large enough for the tubing to be inserted between the studs. The tubing is cut rather short, calling for multiple couplings. EMT can be bowed quite a bit while threading through holes in studs. Boring is the preferred method.

WARNING!
Always wear safety goggles when boring wood.

NEC Section 300.4 addresses the requirements to prevent physical damage to conductors and cabling in wood members. By keeping the edge of the drilled hole 1¼ inches from the closest edge of the stud, nails are not likely to penetrate the stud far enough to damage the cables. The building codes provide maximum requirements for bored or notched holes in studs.

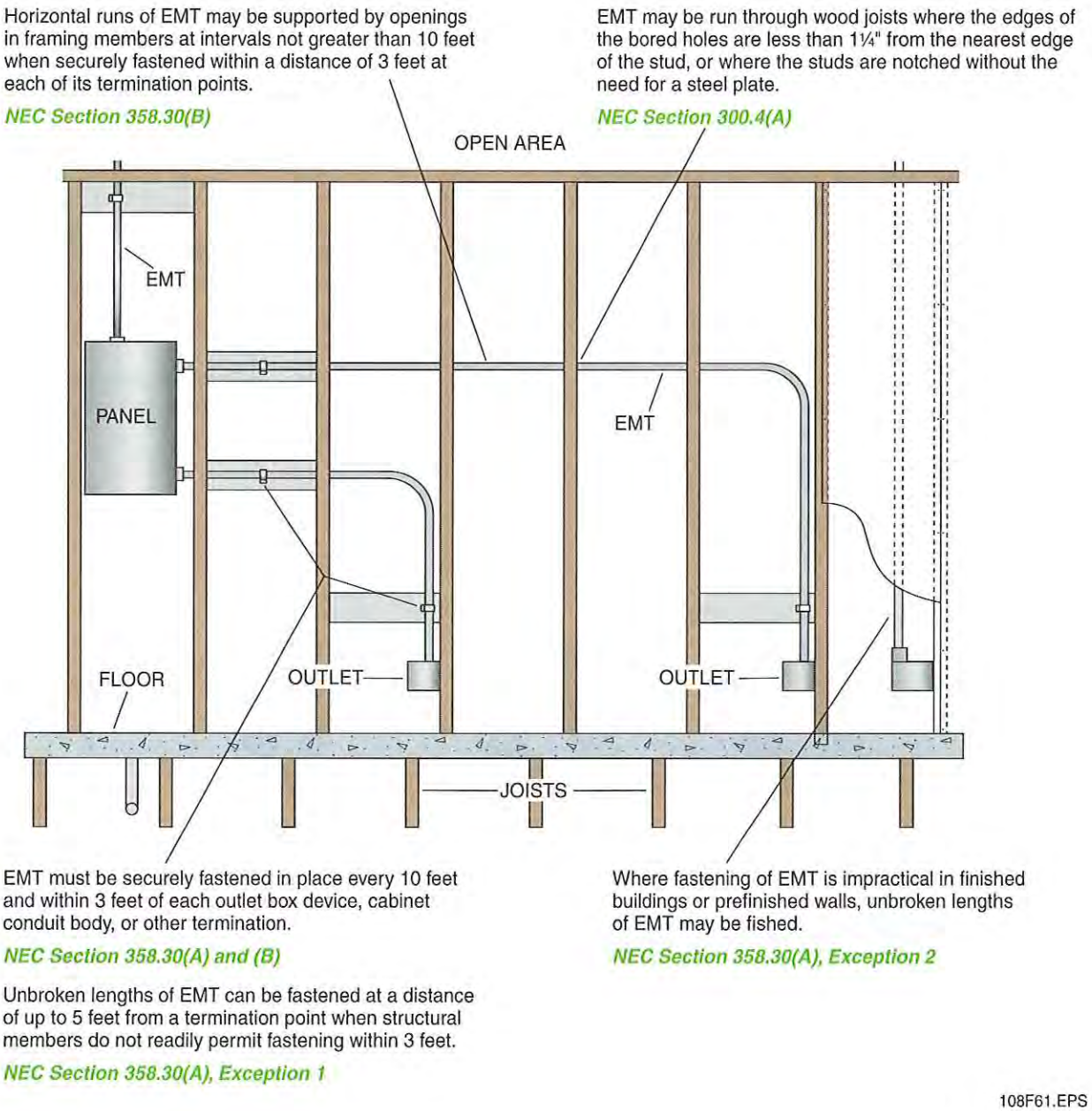

Figure 61 ◆ Installing wire or conduit in a wood-frame building.

The exception in the *NEC*® permits IMC, RMC, RNC, and EMT to be installed through bored holes or laid in notches less than 1¼ inches from the nearest edge without a steel plate or bushing.

Because of its weakening effect upon the structure, notching should be resorted to only where absolutely necessary. Notches should be as narrow as possible and in no case deeper than ⅛ the stock of a bearing timber. A bearing timber supports floor joists or other weight. An additional requirement is for the notch to be covered with a steel reinforcement bracket. This bracket aids in retaining the original strength of the timber.

NOTE

Always check with the architect before notching.

16.4.0 Steel Environment

Electrical installations in buildings where steel beams are the structural framework are most often industrial buildings and warehouses. This type of construction is typical of the pre-engineered building where beams and other supports are pre-cut and pre-drilled so that erection of the building is fast and simple.

The interior of the building in most cases will be unfinished, and the wiring will be supported by the metal beams and purlings. Beams and purlings should not be drilled through; consequently, the conduit is supported from the metal beams by anchoring devices designed especially for that purpose. The supports attach to the beams or supports and have clamps to secure the conduit to the structure. All conduit runs should be plumb since they are exposed. Bends should be correct and have a neat and orderly appearance.

Since steel construction usually takes place in buildings where load handling and moving large and heavy items is common, rigid metal conduit is often required. If a large number of conduits are run along the same path, strut-type systems are used. These systems are sometimes referred to as Unistrut® systems (Unistrut® is a manufacturer of these systems). Another manufacturer of strut systems is B-Line systems. Both are very similar. These systems use a channel-type member that can support conduits from the ceiling by using threaded rod supports for the channel, as shown in *Figure 62*. Strut channel can also be secured to masonry walls to support vertical runs of conduit, wireways, and various types of boxes.

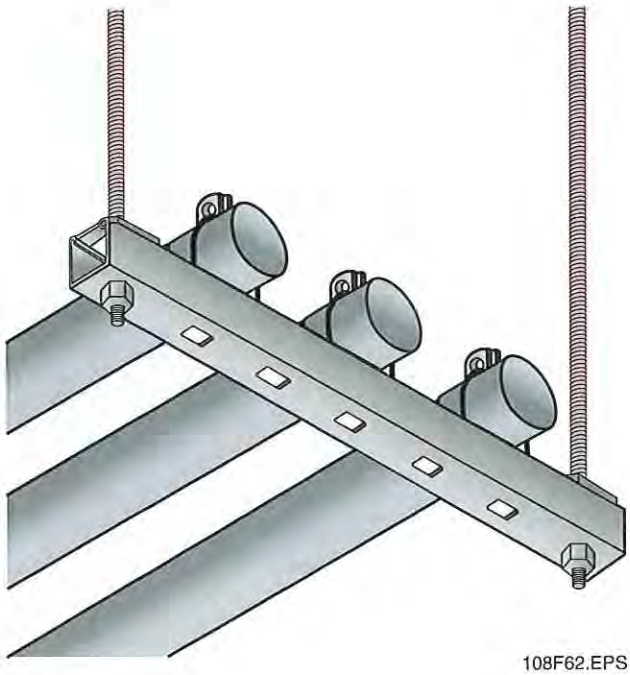

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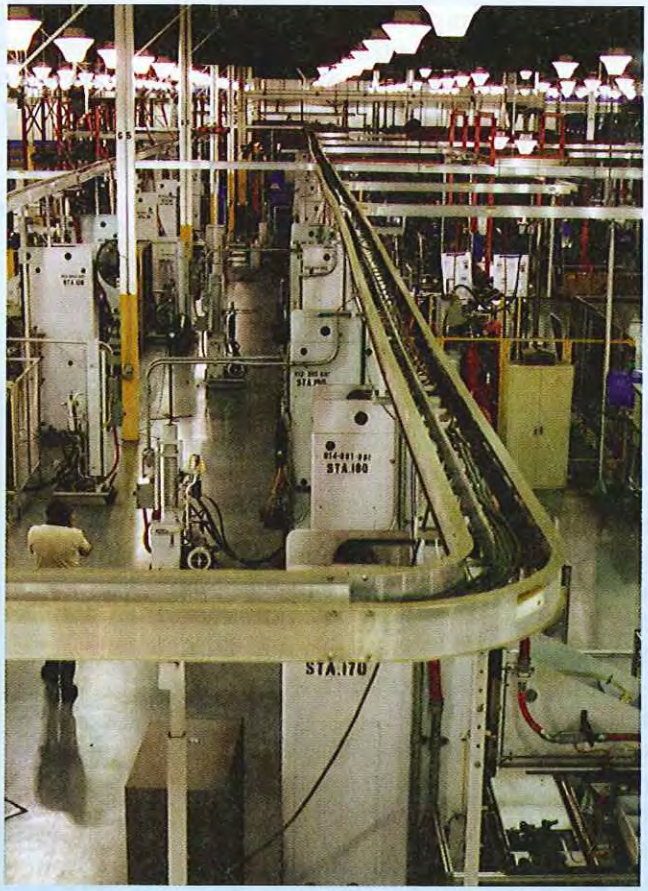
Figure 62 ◆ Steel strut system.

Putting It All Together

THINK ABOUT IT

Think about the effort that goes into the design of a large industrial installation. If you were to design a large complex, such as the one shown here, where would you start and why?



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Review Questions

1. _____ is the lightest duty and most widely used non-flexible metal conduit available for enclosing and protecting electrical wiring.
   a. Electrical metallic tubing
   b. Rigid metal conduit
   c. Aluminum conduit
   d. Plastic-coated rigid metal conduit

2. Because the wall thickness of _____ is much less than that of rigid conduit, it is often referred to as thinwall conduit.
   a. intermediate metal conduit
   b. electrical metallic tubing
   c. rigid nonmetallic conduit
   d. galvanized rigid steel conduit

3. The type of conduit that provides the best physical protection for the wire inside is _____.
   a. flexible metal conduit
   b. rigid metal conduit
   c. electrical metallic tubing
   d. intermediate metal conduit

4. Bending intermediate metal conduit is often easier than bending the same size and quantity of rigid metal conduit because intermediate metal conduit has a slightly _____.
   a. larger outside diameter
   b. larger internal diameter
   c. smaller outside diameter
   d. smaller internal diameter

5. Flexible metal conduit _____.
   a. is made from a single strip of steel or aluminum
   b. can be used in wet locations if lead-covered conductors are installed
   c. can be used in underground locations
   d. is available in sizes up to six inches in diameter

6. Flexible metal conduit cannot be used in _____ locations.
   a. dry
   b. wet
   c. underground
   d. outdoor

7. The requirements for boxes and fittings are found in _____.
   a. *NEC Section 300.15*
   b. *NEC Section 348.10*
   c. *NEC Section 370.6*
   d. *NEC Section 390.14*

8. A Type LB conduit body has the cover on _____.
   a. the left
   b. the right
   c. the back
   d. both sides

9. When conduit is joined to metal boxes, _____ protect the wires from the sharp edges of the conduit.
   a. washers
   b. locknuts
   c. bushings
   d. couplings

10. _____ are rigid rectangular raceways used for housing electric wires and cables.
    a. Troughs
    b. Gutters
    c. Pull boxes
    d. Conduits

11. Wireways must not be installed where they are subject to _____.
    a. physical damage
    b. corrosion and sunlight
    c. hazardous locations
    d. physical damage, corrosive vapors, and hazardous locations

12. Pancake raceways are a type of _____.
    a. rigid tubing
    b. flexible metal conduit
    c. surface metal raceway
    d. surface nonmetallic raceway

13. Surface metal raceways are designed primarily to protect conductors that run to devices _____ in a room.
    a. located near the walls and outlets
    b. located on the surface of the walls and ceilings
    c. not located near the walls and outlets
    d. not located near the walls and ceiling

Review Questions

14. When storing raceway, it is best to _____.
    a. lay it on the floor so that there is no chance that it will fall and injure someone
    b. store all raceway together regardless of the type of raceway material
    c. stand it on end so that it does not collect moisture
    d. cover it with a tarpaulin or other suitable covering to prevent contamination and corrosion

15. When transporting threaded metal conduit, it is best to _____.
    a. remove your gloves so that you do not contaminate the conduit
    b. remove the thread protection caps so that they do not get lost
    c. place the metal conduit inside a larger raceway to keep it from bending
    d. keep the thread protection caps on to prevent damage to the threads

Summary

This module discussed the various types of raceways, boxes, and fittings, including their uses and procedures for installation. The primary purpose of raceways is to house electric wire used for power distribution, communication, or electronic signal transmission. Raceways provide protection to the wiring and even a means of identifying one type of wire from another when run adjacent to each other. This process requires proper planning to allow for current needs, future expansion, and a neat and orderly appearance.

Notes

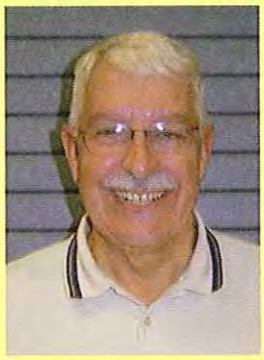
Trade Terms Quiz

1. A(n) _____ area is one that can be reached for service or repair.
2. When something is in a(n) _____, it is not permanently closed in by the structure or finish of a building.
3. When materials meet a regulatory agency's requirements, the material is then said to be _____.
4. The _____ is a regulatory agency that evaluates and approves electrical components and equipment.
5. A(n) _____ is used to make a continuous grounding path between equipment and ground.
6. Any wire or cable that is used to carry electrical current is called a(n) _____.
7. _____ are rigid structures, either suspended or mounted, that are used to support electrical conductors.
8. Similar to pipe, _____ is a round raceway that houses conductors.
9. _____ are bends made in a piece of conduit to alter its course around obstacles.
10. _____ are enclosed channels that are used to house wires and cables.
11. _____ are steel troughs designed to carry electrical wire and cable.
12. A(n) _____ is the connection of two or more conductors.
13. An intermediate point on a main circuit where another wire is connected to supply electrical current to another circuit is called a(n) _____.
14. Electrical connectors that could be exposed to the environment are housed in long, narrow boxes, or _____.

Trade Terms

Accessible
Approved
Bonding wire
Cable trays
Conductors
Conduit
Exposed location
Kick
Raceways
Splice
Tap
Trough
Underwriters Laboratories, Inc. (UL)
Wireways

Profile in Success



Leonard "Skip" Layne

Rust Constructors, Inc.

How did you choose a career in the electrical field?
I think the electrical field chose me. My father was a contractor for several years before closing shop and accepting a job as an electrical superintendent with the Rust Engineering Company. That happened when I was nine years old. After being moved around the country for the next several years and working as an apprentice on Dad's projects during my college summers, I couldn't think of anything that I would rather do.

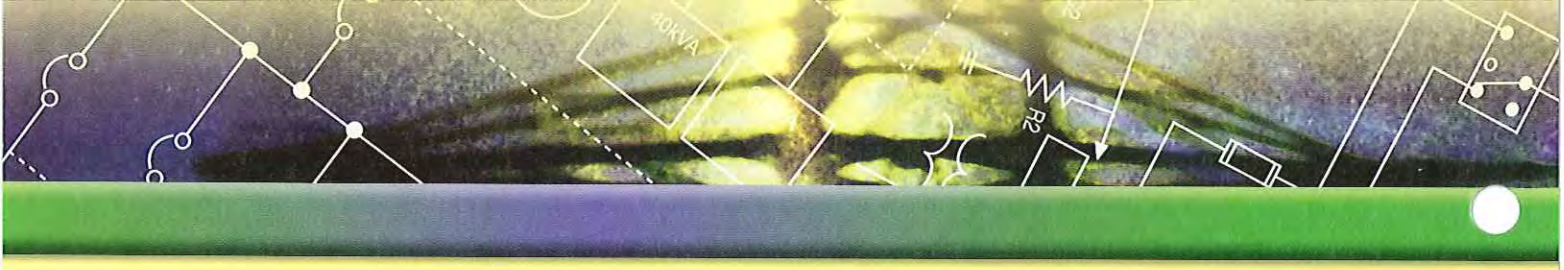
Tell us about your apprenticeship experience.
I've never attended a formal apprenticeship school. There are probably several in our group who might say that they suspected this. My electrical education came from field work exposure and several electrical and engineering courses and seminars I've attended over the years.

I'm happy to say that I'm still learning and I've learned a great deal while working on the NCCER Electrical Committee and from my association with the other subject matter experts.

What positions have you held in the industry?
I started as a field apprentice on a tire plant in Madison, Tennessee, in 1959. I've held field positions as an apprentice, journeyman, field engineer, start-up manager, and superintendent. I spent a number of years estimating work, and I established the material control department for another major open-shop contractor several years ago. I managed the project controls group on a nuclear project for another open-shop contractor. I even spent a few years as vice president with an operations underground utility and treatment plant contractor.

What would you say is the primary factor in achieving success?
Keep learning. Work hard. I've had to work sixteen-hour days on the job site and in the office in order to meet the schedule and incorporate changes. Do what is asked of you and do it well.

What does your current job involve?
My job title says that I'm the Construction Engineering Manager for Rust, but the lack of a definitive job title means that I do whatever the company needs me to do at the time. I direct the company's craft and professional training. I serve on the Birmingham City Schools Career/Technical Advisory Committee. The construction members of the committee helped them select the *Contren® Construction Technology* Curriculum for use in their program. As an NCCER Master Trainer, I taught the Certified Craft Instructor class for the city. I also work with the technical staff at Wallace Community College



in Selma, Alabama. They have adopted the *Contren®* curricula for their welding, electrical, and masonry programs. Rust serves as their training sponsor and I have certified the craft instructors. I still get called to job sites to help with construction completion and start-up. Recent field assignments have required me to spend from three weeks to three months on the job. I hold most of the company's master electrician and/or electrical contractor's licenses.

Do you have any advice for someone just entering the trade?

Get all of the classroom learning you can. Go through all four levels of the *Contren®* Electrical Program while working in the field. Ask questions and try to get assigned to as many new and different tasks as you can. All of our larger ABC contractors have excellent supervisory training programs and you need to get into those after your craft training. Be adaptable and keep learning.

Trade Terms Introduced in This Module

Accessible: Able to be reached, as for service or repair.

Approved: Meeting the requirements of an appropriate regulatory agency.

Bonding wire: A wire used to make a continuous grounding path between equipment and ground.

Cable trays: Rigid structures used to support electrical conductors.

Conductors: Wires or cables used to carry electrical current.

Conduit: A round raceway, similar to pipe, that houses conductors.

Exposed location: Not permanently closed in by the structure or finish of a building; able to be installed or removed without damage to the structure.

Kick: A bend in a piece of conduit, usually less than 45°, made to change the direction of the conduit.

Raceways: Enclosed channels designed expressly for holding wires, cables, or busbars, with additional functions as permitted in the *NEC®*.

Splice: Connection of two or more conductors.

Tap: Intermediate point on a main circuit where another wire is connected to supply electrical current to another circuit.

Trough: A long, narrow box used to house electrical connections that could be exposed to the environment.

Underwriters Laboratories, Inc. (UL): An agency that evaluates and approves electrical components and equipment.

Wireways: Steel troughs designed to carry electrical wire and cable.

Additional Resources

This module is intended to present thorough resources for task training. The following reference works are suggested for further study. These are optional materials for continued education rather than for task training.

Benfield Conduit Bending Manual, 2nd Edition. Overland Park, KS: EC&M Books.

National Electrical Code® Handbook, Latest Edition. Quincy, MA: National Fire Protection Association.

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