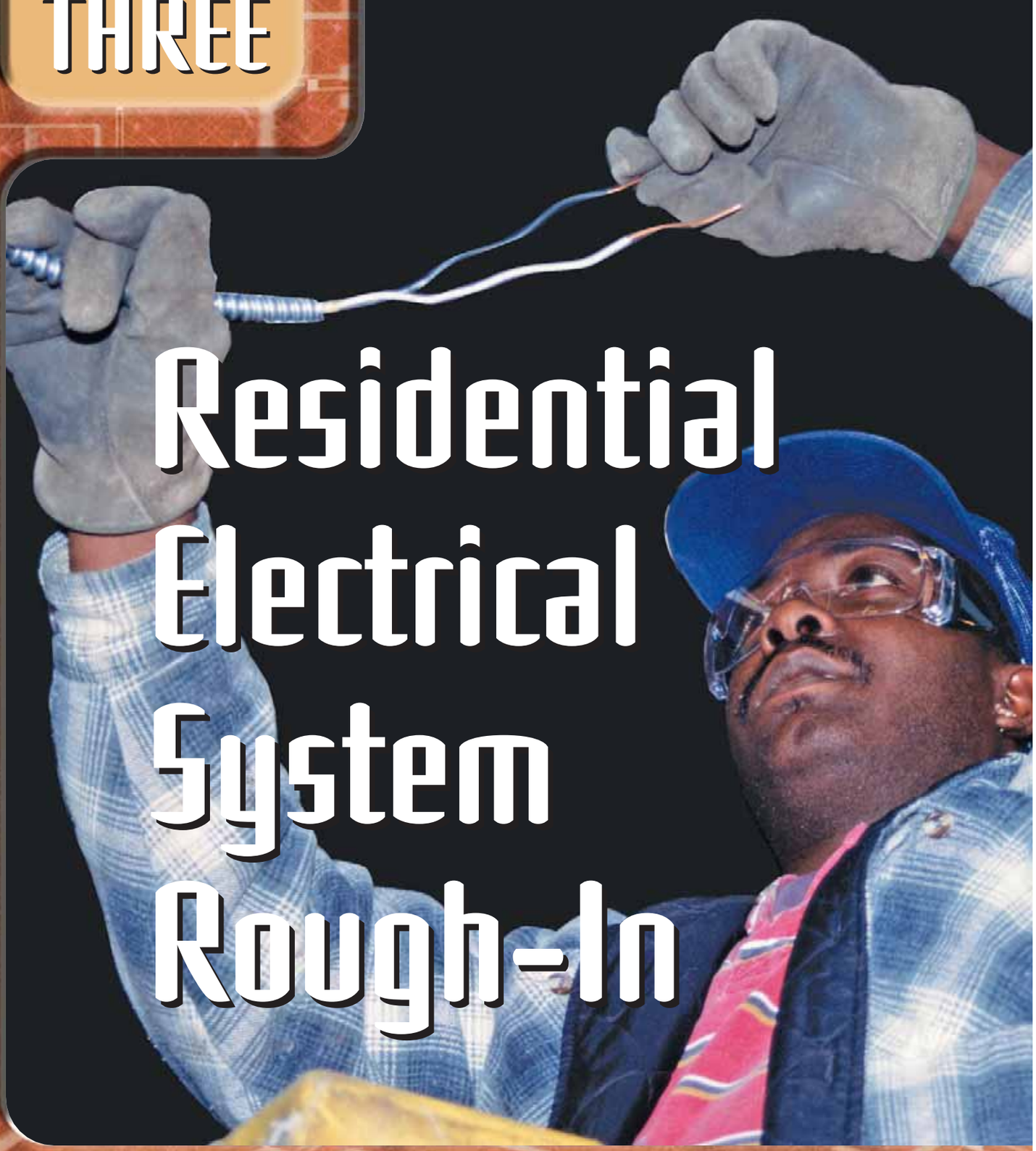
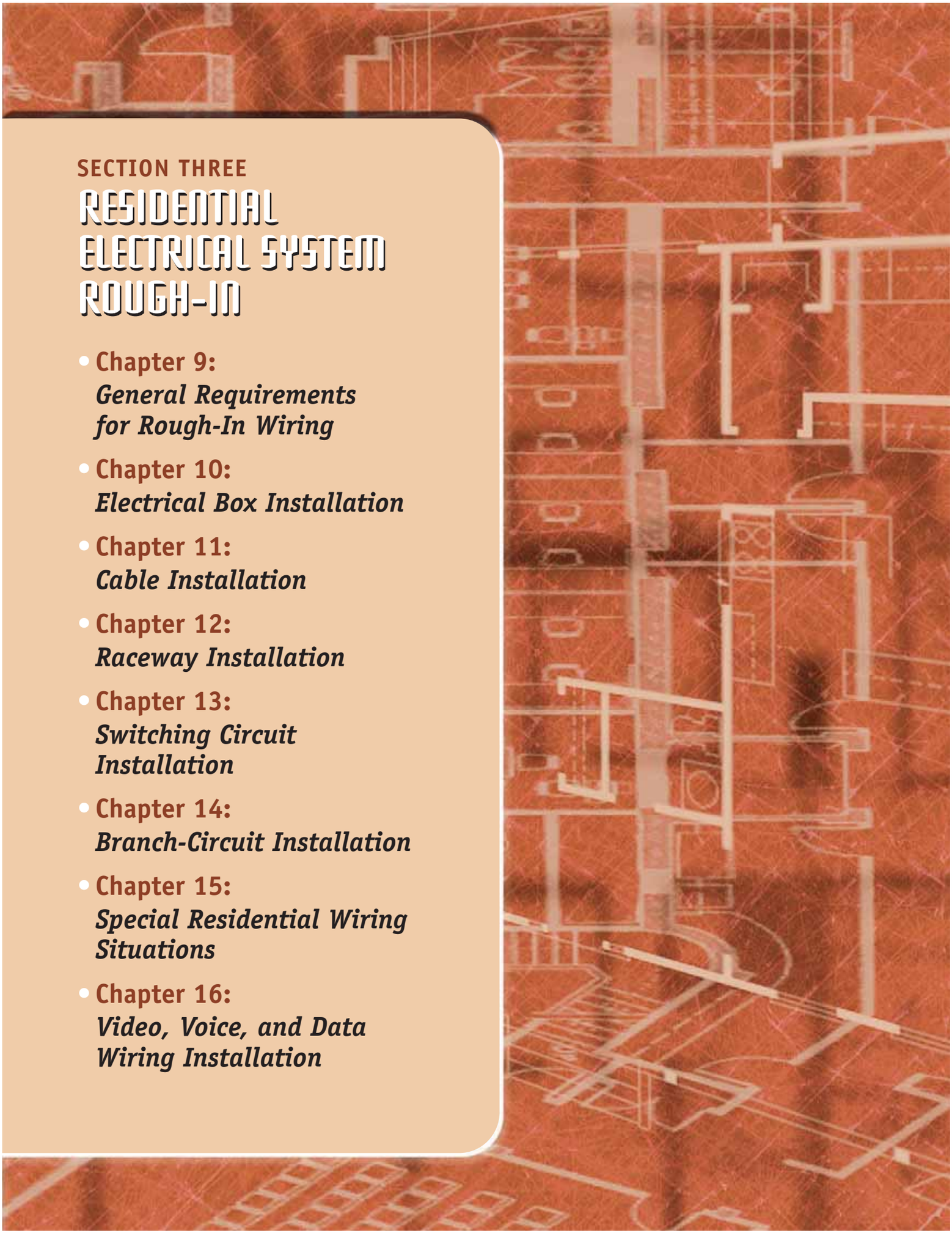
SECTION THREE

Residential Electrical System Rough-In





SECTION THREE

RESIDENTIAL ELECTRICAL SYSTEM ROUGH-IN

Chapter 9 General Requirements for Rough-In Wiring

Wiring is a term that electricians use to describe the process of installing an electrical system. The **rough-in** *stage of wiring a residential electrical system involves mounting boxes and installing the circuit conductors using an appropriate wiring method. There are many* National Electrical Code® *(NEC®) requirements that need to be followed during the rough-in stage. This chapter looks at several general requirements that an electrician must consider when installing the rough-in wiring.*

OBJECTIVES

Upon completion of this chapter, the student should be able to:

- **discuss the selection of appropriate wiring methods, conductor types, and electrical boxes for a residential electrical system rough-in.**
- **demonstrate an understanding of general requirements for wiring as they apply to residential rough-in wiring.**
- **demonstrate an understanding of general requirements for conductors as they apply to residential rough-in wiring.**
- **demonstrate an understanding of general requirements for electrical box installation as they apply to residential rough-in wiring.**
- **list several general requirements that pertain to wiring methods, conductors, and electrical boxes installed during the rough-in stage of a residential wiring system.**

Glossary of Terms

deteriorating agents a gas, fume, vapor, liquid, or any other item that can cause damage to electrical equipment

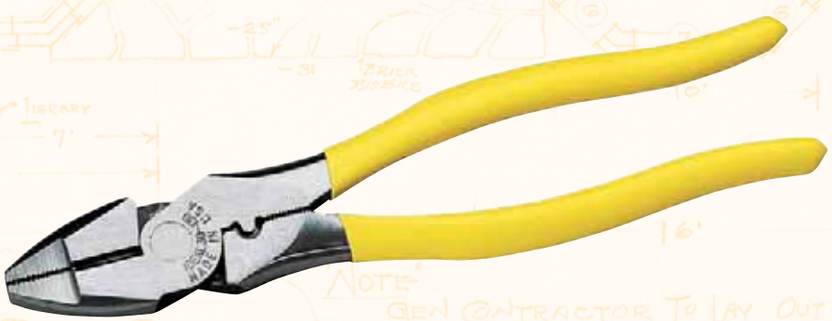
inductive heating the heating of a conducting material in an expanding and collapsing magnetic field; inductive heating will occur when current-carrying conductors of a circuit are brought through separate holes in a metal electrical box or enclosure

knockout plug a piece of electrical equipment used to fill unused openings in boxes, cabinets, or other electrical equipment

rough-in the stage in an electrical installation when the raceways, cable, boxes, and other electrical equipment are installed; this electrical work must be completed before any construction work can be done that covers wall and ceiling surfaces

sheetrock a popular building material used to finish off walls and ceilings in residential and commercial construction; it is available in standard sizes, such as 4 by 8 feet, and is constructed of gypsum sandwiched between a paper front and back

wiring a term used by electricians to describe the process of installing a residential electrical system



General Wiring Requirements

Chapter 2 covered many of the types of equipment and material used to install a residential electrical system. It included an introduction to the different cable and raceway types used in residential wiring. Conductor types and sizes were also presented. Based on the *NEC*® and local electrical code requirements, an electrician must determine an appropriate wiring method and conductor type to be used for installing the residential electrical system. Residential wiring systems are usually installed using a cable-type wiring method. In most areas of the country, electricians use nonmetallic sheathed cable (Type NM), commonly called Romex™, to install residential electrical systems. In certain areas of the country, the authority having jurisdiction does not allow Type NM cable to be used in residential construction. If this is the case, armored-clad cable (Type AC) or metal-clad cable (Type MC) are great alternative wiring methods to Romex™. Rarely are residential electrical systems installed using a raceway wiring method. However, some local electrical codes require dwelling units to be wired using a raceway like electrical metallic tubing (EMT). We discuss raceway installation in a later chapter. In an effort to keep this book easier to understand for the new electrician, and because the vast majority of residential electrical system wiring is done using nonmetallic sheathed cable (NMSC), this chapter and subsequent chapters assume the use of NMSC as further discussion of the rough-in stage is presented.

Requirements for Electrical Installations

Article 110 of the *NEC*® includes several requirements that apply to rough-in wiring. These requirements will need to be followed by electricians during the rough-in stage of a residential wiring job. The following paragraphs discuss in detail the Article 110 sections that must be considered.

Section 110.3(B) states that listed or labeled equipment must be installed and used in accordance with any instructions included in the listing or labeling. Manufacturers usually supply installation instructions with equipment for use by electrical contractors, electrical inspectors, and others concerned with an installation. It is important to follow the listing or labeling installation instructions when installing electrical equipment in the rough-in stage.

CAUTION

CAUTION: Never throw away the instructions that come with any piece of electrical equipment. According to Section 110.3(B), all electrical equipment must be installed according to the instructions that are included by the manufacturer of the equipment.

Section 110.7 addresses insulation integrity. It states that completed wiring installations must be free from short circuits and ground faults. Insulation is the material that prevents the short circuits and faults to ground. Failure of the insulation system is one of the most common causes of problems in residential electrical systems. The installing electrician must take care not to damage the conductor insulation in any way during the rough-in stage.

Section 110.11 covers **deteriorating agents** and states that, unless identified for use in the operating environment, no conductors or equipment can be located in damp or wet locations; be exposed to gases, fumes, vapors, liquids, or other agents that have a deteriorating effect on the conductors or equipment; or be exposed to excessive temperatures. When choosing a cable or conductor type, an electrical box style, or any other piece of electrical equipment used in a residential electrical system, an electrician must make sure that it is suitable for the location where you wish to install it. Otherwise, damage to the electrical equipment can occur that will cause problems—if not immediately, then down the road. Fine-Print Note 2 of Section 110.11 tells us that some cleaning and lubricating compounds can cause severe deterioration of plastic materials used for insulating and structural applications in electrical equipment. Equipment identified as "dry locations," "NEMA Type 1," or "indoor use only" must be protected against permanent damage from the weather during building construction. This last sentence requires electricians to cover and protect any electrical equipment that is being used during the rough-in stage and that might be subject to rain or snow damage. This is especially true when electricians start to install the rough-in wiring and the doors and windows (and sometimes even the roof!) have not been installed yet.

Section 110.12 states that all electrical equipment must be installed in a neat and workmanlike manner. The "neat and workmanlike" installation requirement has appeared in the *NEC*® for more than 50 years. It stands as a basis for pride in one's work and helps make electrical work a profession and not just a "job." Electrical inspectors have cited many *NEC*® violations based on their interpretation of "neat and workmanlike manner." Many electrical inspectors use their own experience or common wiring practice in their local areas as the basis for their judgments. Examples of installations that do not qualify as "neat and workmanlike" include exposed runs of cables or raceways that are not properly supported and result in sagging between supports; field-bent and kinked, flattened, or poorly measured electrical conduit; or electrical boxes and enclosures that are not level or not properly secured.

Section 110.12(A) covers unused openings and states that any unused opening other than those for the operation of equipment or for mounting purposes must be closed. The material being used to cover the opening must be at least as strong as the material the electrical box is made of. A common piece of equipment used to meet this requirement is called a **knockout plug** and is inserted into any knockout opening that is open and not used (Figure 9–1).

Figure 9–1 Section 110.12(A) requires unused cable or raceway openings in electrical boxes to be effectively closed.

Section 110.12(C) requires that any internal parts of electrical equipment not be damaged or contaminated by foreign materials such as paint, plaster, cleaners, abrasives, or corrosive residues. There must be no damaged parts that may adversely affect safe operation or mechanical strength of the equipment, such as parts that are broken, bent, cut, or deteriorated by corrosion, chemical action, or overheating. This rule will mean that after the rough-in wiring has been done, an electrician must look at the installed electrical equipment and determine if any of the equipment may have to be covered so that when the house finish work begins, no paint, plaster, or anything else could contaminate the insides of the electrical equipment. For example, a flush-mounted service panel located in an area of the house that will be finished off may require covering the enclosure so that contamination of the inside of the panel cannot take place by paint that is being applied to the walls with a spray gun.

Wiring Methods

Article 300 of the *NEC*® contains several requirements for the wiring methods used by an electrician when installing a residential electrical system. Several of the more important requirements that electricians need to be aware of are covered in the following paragraphs.

Section 300.3(A) states that single conductors with an insulation type that is listed in *NEC*® Table 310.13(A) can be installed only as part of an *NEC*®-recognized wiring method. In other words, individual insulated conductors with, for example, a THHN insulation cannot be used in a wiring method that is not listed in the *NEC*®. Here is an example where an electrician probably wishes this rule was not in the *NEC*®. An electrician installs a switching circuit in a house and, after everything is installed, discovers that a two-wire cable was installed instead of the required three-wire cable. Some electricians believe that they are allowed to simply run one more individual insulated conductor in this situation to fix the problem. They are wrong! Section 300.3(A) does not allow one individual conductor to be run unless it is part of a recognized wiring method, like a Romex™ cable. In this case, a new three-wire cable would have to be installed.

Section 300.3(B) states that all conductors of the same circuit and, where used, the grounded conductor and all equipment-grounding conductors and bonding conductors must be contained within the same raceway, trench, cable, or cord. This is designed to eliminate **inductive heating.** By keeping all circuit conductors of an individual circuit grouped together, the magnetic fields around the conductors cancel each other out. This means that an expanding and collapsing magnetic field will not be present and will not cause the molecules in the metal enclosure to move around and produce heat, which could damage the conductor insulation (Figure 9–2).

Section 300.4 states that where a wiring method is subject to physical damage, conductors must be adequately protected. If a cable or raceway is going to be installed through a wood framing member, the following rules must be followed (Figure 9–3):

- Bored holes: Section 300.4(A)(1) states that in both exposed (like exposed studs in a garage) and concealed (wall studs inside with **sheetrock** on them) locations, where a cable or raceway type wiring method is installed through bored holes in joists, rafters, or wood members, holes must be bored so that the edge of the hole is not less than 1¼ inches (32 mm) from the nearest edge of the wood member. Where this distance cannot be maintained, the cable or raceway must be protected from penetration by screws or nails by a steel plate or bushing, at least 1/16 inch (1.6 mm) thick, and of appropriate length and width installed to cover the area of the wiring. *Exception No. 1* states that steel plates are not required to protect rigid metal conduit (RMC), intermediate metal conduit (IMC), rigid nonmetallic pvc

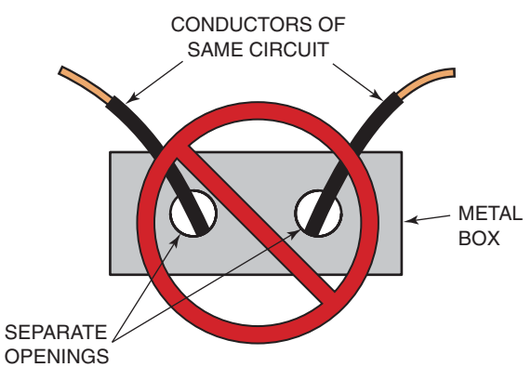


Figure 9–2 Section 300.3(B) requires all circuit conductors of an individual circuit to be grouped together and run through the same box opening to reduce inductive heating and to avoid increases in overall circuit impedance.

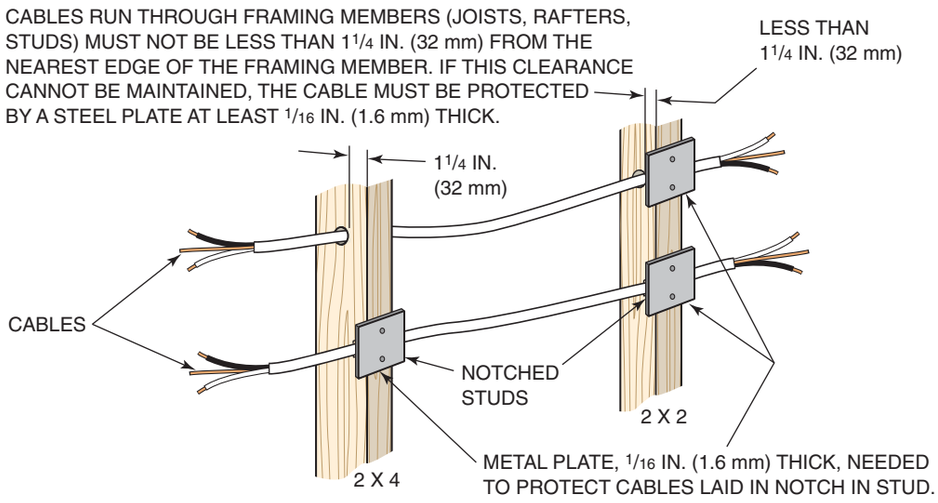


Figure 9–3 **Cables or raceways installed through a wood framing member must be protected according to Section 300.4(A)(1) and (2). The intent of this section is to prevent nails and screws from being driven into cables and raceways. An *Exception* to this section permits RMC, IMC, (PVC) or EMT to be installed in wood framing members without additional protection.**

conduit (PVC), or EMT, that is installed through a wood framing member. *Exception No. 2* to Section 300.4(A)(1) allows a listed and marked steel plate to be less than 1/16 inch (1.6 mm) thick if it still provides equal or greater protection against nail or screw penetration.

- Notches in wood: Section 300.4(A)(2) states that where there is no objection because of weakening the building structure, in both exposed and concealed locations, cables or raceways are permitted to be laid in notches in wood studs, joists, rafters, or other wood members where the cable or raceway at those points is protected against nails or screws by a steel plate at least 1/16 inch (1.6 mm) thick installed before the building finish is applied. *Exception No. 1* states that steel plates are not required to protect RMC, IMC, PVC, or EMT when these raceways are installed in a notch. *Exception No. 2* to Section 300.4(A)(2) allows a listed and marked steel plate to be less than 1/16 inch (1.6 mm) thick if it still provides equal or greater protection against nail or screw penetration.

The intent of Section 300.4(A)(1) is to prevent nails and screws from being driven into cables and raceways. Keeping the edge of a drilled hole 1¼ inches (32 mm) from the nearest edge of a stud should prevent nails from penetrating the wooden framing member far enough to injure a cable. Building codes limit the maximum size of bored or notched holes in studs, and Section 300.4(A)(2) indicates that consideration should be given to the size of notches in studs so they do not affect the strength of the structure. Most electricians will bore a hole in the framing member rather than notch it.

Sometimes, metal framing members are encountered in residential construction. Section 300.4(B) covers the use of NMSC and electrical nonmetallic tubing (ENT) through metal framing members. If a Type NM cable or ENT raceway is going to be installed through a metal framing member, the following rules must be followed (Figure 9–4):

- NMSC: Section 300.4(B)(1) states that in both exposed and concealed locations where NMSC pass through either factory- or field-punched, -cut, or -drilled slots or holes in metal members, the cable must be protected by listed bushings or listed grommets covering all metal edges that are securely fastened in the opening prior to installation of the cable. The listed grommets or listed bushings must completely encircle Type NM cables as they pass through holes in metal studs. This requirement affords physical protection for NMSC as the cables are "pulled" through the openings in metal studs. Fastening the listed grommet or listed bushing in place prior to installing cable is mandatory.

FROM EXPERIENCE

Many building contractors in charge of the actual framing of a house will not want an electrician to "notch" framing members. They are concerned that the studs, joists, or rafters may not have the required strength after a notch has been cut into it. Always check with the building contractor to see if "notching" of building framing members is allowed in the house you are wiring. It is a good idea to also check local building codes to find out what the maximum hole size is that you can bore in a building framing member. Be aware that some premanufactured roof truss systems are designed and engineered so that drilling them for cable runs is not allowed.

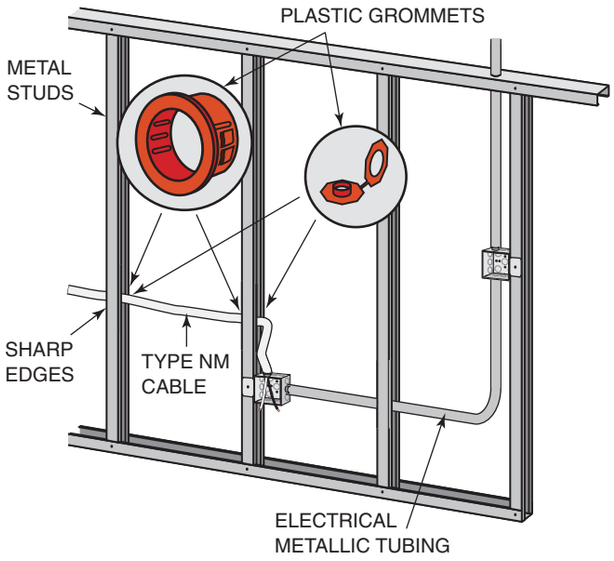


Figure 9–4 Where metal framing members are encountered, *NEC*® Sections 300.4(B) and 334.17 require protection for NMSC when it is run through holes in the metal framing members. This protection is provided by using listed bushings, or grommets, in the holes that are field punched or drilled by an electrician or holes that are provided by the manufacturer. The grommet must cover all metal edges of the hole.

- NMSC and ENT: Section 300.4(B)(2) states that where nails or screws are likely to penetrate NMSC or ENT, a steel sleeve, steel plate, or steel clip not less than 1/16 inch (1.6 mm) in thickness shall be used to protect the cable or tubing. An *Exception* to Section 300.4(B)(2) allows a listed and marked steel plate to be less than 1/16 inch (1.6 mm) thick if it still provides equal or greater protection against nail or screw penetration.

Section 300.4(C) addresses the installation of cables or raceways in spaces behind panels. It states that cables or raceway-type wiring methods, installed behind panels designed to allow access, must be supported according to their applicable articles. Sometimes you will find yourself installing wiring above a suspended ceiling. This ceiling type is sometimes called a "dropped ceiling." Any cable- or raceway-type wiring methods installed above suspended ceilings with lift-up panels must not be allowed to lay on the suspended ceiling panels or grid system. They are required to be supported according to Sections 300.11(A) and 300.23 and the requirements of the article applicable to the wiring method involved. This also applies to the installation of low-voltage cable for chime or thermostat wiring, telephone wiring, cable television wiring, or home computer network wiring. They are not permitted to block access to equipment above the suspended ceiling.

Section 300.4(D) covers the requirements for installing cables and raceways parallel to framing members and furring strips. In both exposed and concealed locations, where a cable- or raceway-type wiring method is installed along framing members (such as joists, rafters, studs, or furring strips), the cable or raceway must be installed and supported so that the nearest outside edge of the cable or raceway is not less than 1¼ inches (32 mm) from the nearest edge of the framing member or furring strip where nails or screws are likely to penetrate. Where this distance cannot be maintained, the cable or raceway shall be protected from penetration by nails or screws by a steel plate, sleeve, or equivalent at least 1/16 inch (1.6 mm) thick (Figure 9–5). *Exception No. 1* states that steel plates or sleeves are not required to protect RMC, IMC, PVC, or EMT where they have an edge that is less than 1¼ inches (32 mm) to the edge of the framing member. The intent of Section 300.4(D) is to prevent mechanical damage to cables and raceways from nails and screws. One way to do this is to fasten the cable or raceway so that it is 1¼ inches (32 mm) from the edge of the framing member, as illustrated in Figure 9–6. This requirement generally applies to exposed and concealed work. *Exception No. 1* permits the cable or raceway to be installed closer than 1¼ inches (32 mm) from the edge of the framing member if physical protection, such as a steel plate or a sleeve, is provided (a steel plate is illustrated in Figure 9–7). *Exception No. 2* states that for concealed work in a finished

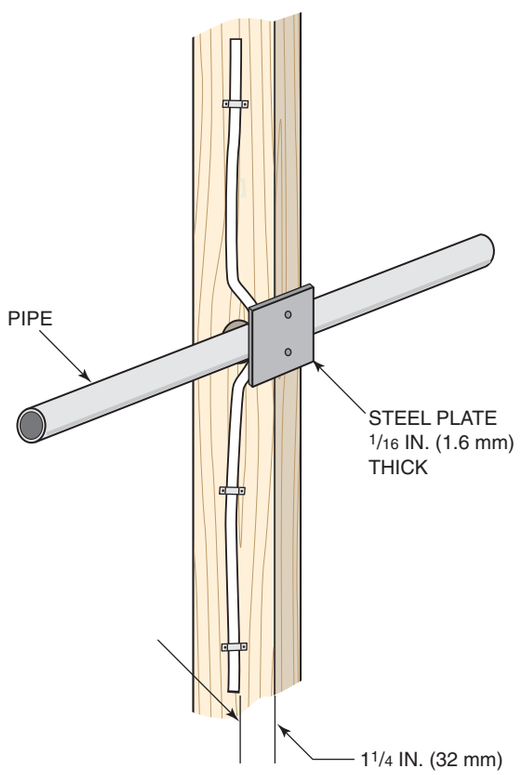


Figure 9–5 Cables run parallel to framing members must have a clearance of at least 1¼ inches (32 mm) from the cable to the edge of the framing member. If it is not possible to maintain this clearance, a steel plate at least 1/16 inch (1.6 mm) must be installed.

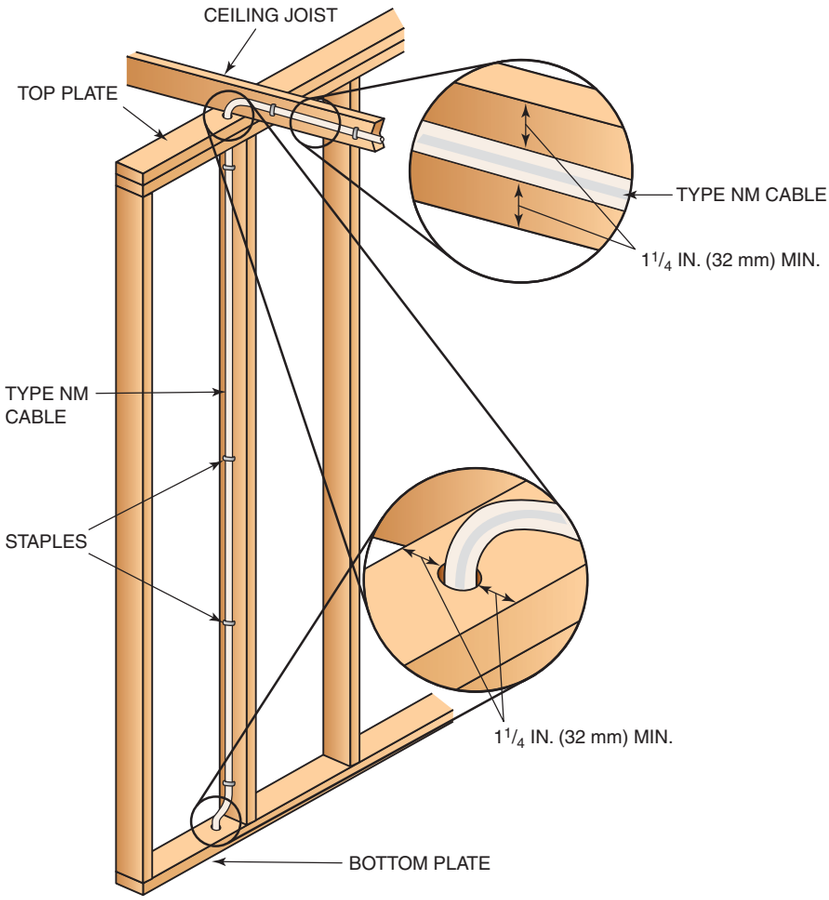


Figure 9–6 **The intent of Section 300.4(D) is to prevent mechanical damage to cables and raceways from nails and screws. Cable is fastened to framing members so that it is at least 1¼ inches (32 mm) from the edge of the framing member. If the cable is installed closer than 1¼ inches (32 mm) from the edge of the framing member, physical protection, such as a steel plate or a sleeve, must be provided. An *Exception* to this section says that this requirement does not apply to RMC, PVC, IMC, or EMT wiring methods because these methods provide physical protection for the conductors.**

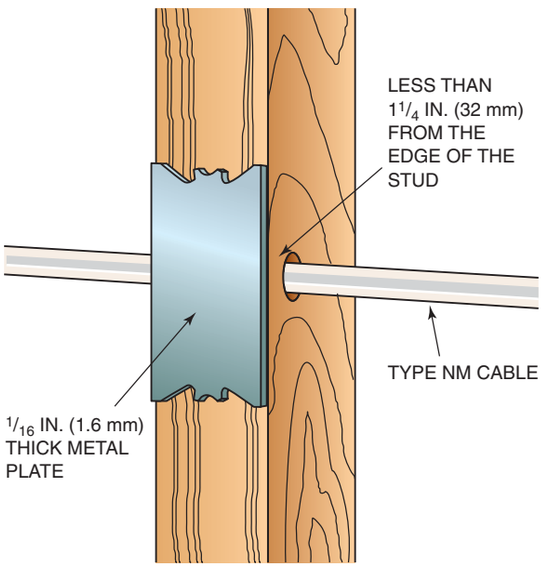


Figure 9–7 **A steel plate used to protect Type NM cable within 1¼ inches (32 mm) of the edge of a wood stud. A listed and marked steel plate less than 1/16 inch (1.6 mm) thick may be used if it still provides equal or better protection against nail or screw penetration.**

existing building, it is permissible to fish the cables between access points and not have the cable or raceway be at least 1¼ inches (32 mm) from the edge of a framing member. *Exception No. 3* to Section 300.4(D) allows a listed and marked steel plate to be less than 1/16 inch (1.6 mm) thick if it still provides equal or greater protection against nail or screw penetration.

Section 300.4(E) covers cables and raceways installed in shallow grooves. Cable- or raceway-type wiring methods installed in a groove and to be covered by wallboard, siding, paneling, carpeting, or similar finish must be protected by a steel plate or sleeve 1/16 inch (1.6 mm) thick or by not less than 1¼ inches (32 mm) free space for the full length of the groove in which the cable or raceway is installed. For example, an installation may require an electrician to groove out a solid wooden beam so that a Romex™ cable can be laid in it and run to a certain location (Figure 9–8). Before a wall covering can be placed over the beam with the cable in the groove, the groove must be covered with a metal plate at least 1/16 inch thick (1.6 mm). If the electrician makes the groove so that the cable sits at least 1¼ inches (32 mm) down into it, no steel plate would have to be used. *Exception No. 1* says that steel plates or sleeves are not required to protect RMC, IMC, PVC, or EMT used in a groove. *Exception No. 2* to

Section 300.4(E) allows a listed and marked steel plate to be less than 1/16 inch (1.6 mm) thick if it still provides equal or greater protection against nail or screw penetration.

Section 300.10 covers the electrical continuity of metal raceways and enclosures. It states that metal raceways, cable armor, and other metal enclosures for conductors must be metallically joined together into a continuous electric conductor and must be connected to all boxes, fittings, and cabinets to provide effective electrical continuity. Unless specifically permitted elsewhere in the *NEC*®, raceways and cable assemblies must be mechanically secured to boxes, fittings, cabinets, and other enclosures. Section 250.4(A) states what must be accomplished by grounding and bonding the metal parts of the electrical system. These metal parts must form an effective low-resistance path to ground in order to safely conduct any fault current and facilitate the operation of overcurrent devices protecting the enclosed circuit conductors. If an electrician is installing metal boxes during the rough-in stage, a wiring method that can provide a way to ground all the metal boxes must be used. Type NM cable with a bare grounding wire connected to each box with a green grounding screw is very common and works well to meet the intent of this section.

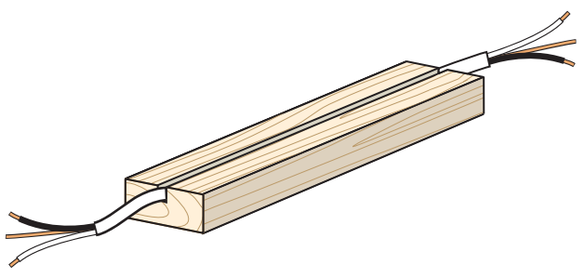


Figure 9–8 **A groove can be cut in a solid wood framing member. After the cable has been laid in the groove, a metal plate not less than 1/16 inch (1.6 mm) thick must be installed over the groove to protect the cable. A listed and marked steel plate less than 1/16 inch (1.6 mm) thick may be used if it still provides equal or better protection against nail or screw penetration.**

Section 300.11(A) states that raceways, cables, boxes, cabinets, and fittings must be securely fastened in place (Figure 9–9). The specific *NEC*® article that covers a raceway or cable type will state the support requirements for that type of wiring method.

Section 300.11(B) states that raceways may be used as a means of support for other raceways, cables, or nonelectric equipment only under the following conditions:

1. Where the raceway or means of support is identified for the purpose
2. Where the raceway contains power supply conductors for electrically controlled equipment and is used to support Class 2 circuit conductors or cables that are solely for the purpose of connection to the equipment control circuits
3. Where the raceway is used to support boxes or conduit bodies in accordance with Section 314.23 or to support luminaires (fixtures) in accordance with Article 410.

The purpose of this section is to prevent cables from being attached to the exterior of a raceway. Electrical, telephone, and computer cables wrapped around a raceway can prevent dissipation of heat from the raceway and affect the temperature of the conductors inside. This section also prohibits the use of a raceway as a means of support for nonelectric equipment, such as suspended ceilings, water pipes, nonelectric signs, and the like, which could cause a mechanical failure of the raceway (Figure 9–9). However, Section 300.11(B)(2) does allow the installation of Class 2 thermostat conductors for a boiler or air-conditioning unit to be supported by the conduit supplying power to the unit, as shown in Figure 9–10.

Section 300.11(C) states that cable wiring methods must not be used as a means of support for other cables, raceways,

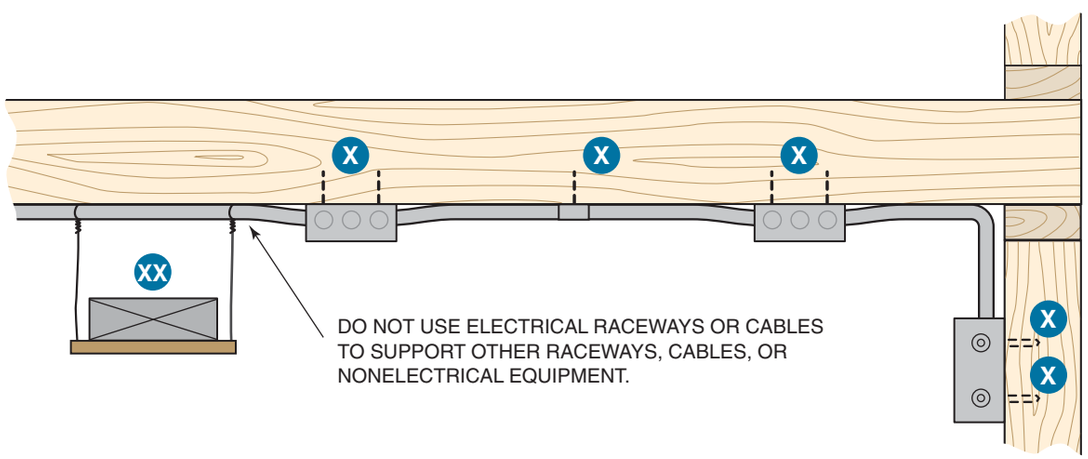


Figure 9–9 **Section 300.11(A) requires all electrical boxes, raceways, and cable assemblies to be securely fastened in place (points X). Section 300.11(B) and (C) do not allow raceways or cables to support other raceways or cables, electrical boxes, or nonelectrical equipment (point XX).**

or nonelectrical equipment. This section prohibits cables from being used as a means of support for other cables, raceways, or nonelectric equipment. Taking the requirements of both Section 300.11(B) and Section 300.11(C) together, the common practice (by some electricians) of using one supported cable or raceway to support other raceways and cables is clearly not allowed.

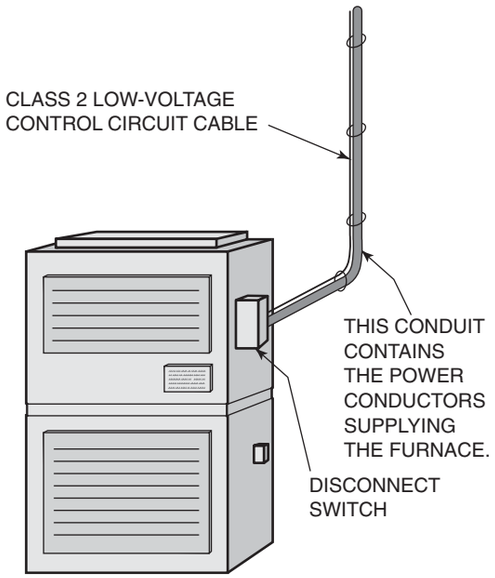


Figure 9–10 **Section 300.11(B)(2) allows Class 2 control wiring to be supported by the raceway that supplies the power to the piece of equipment that the control wiring is associated with. A common residential wiring practice is to use the piece of EMT conduit that supplies a furnace to also provide support to the Class 2 thermostat control cable. The thermostat cable is usually secured to the raceway with electrical tape.**

Section 300.12 requires that all metal or nonmetallic raceways, cable armors, and cable sheaths must be continuous between cabinets, boxes, fittings, or other enclosures or outlets. An electrician must install a complete length of cable or raceway from one box or enclosure to another. An *Exception* allows an electrician to use short sections of raceways to provide support or protection of cable assemblies from physical damage. Used this way, a raceway is not required to be mechanically continuous.

Section 300.14 covers a very important requirement: the length of free conductors at outlets, junctions, and switch points. At least 6 inches (150 mm) of free conductor, measured from the point in the box where it emerges from its raceway or cable sheath, must be left at each outlet, junction, and switch point for splices or the connection of luminaires (fixtures) or devices (Figure 9–11). Where the opening to an outlet, junction, or switch point is less than 8 inches (200 mm) in any dimension, each conductor must be long enough to extend at least 3 inches (75 mm) outside the opening. An *Exception* states that conductors that are not spliced or terminated at the outlet, junction, or switch point are not required to have the minimum 6 inches (150 mm) of conductor. This is the case when conductors installed in a raceway may go straight through one box to get to another box. This section is very specific about the amount of free conductor length required at each splice point or device outlet.

Section 300.15 states that where the wiring method is conduit, tubing, Type AC cable, Type MC cable, or NMSC, a box or conduit body must be installed at each conductor splice point,

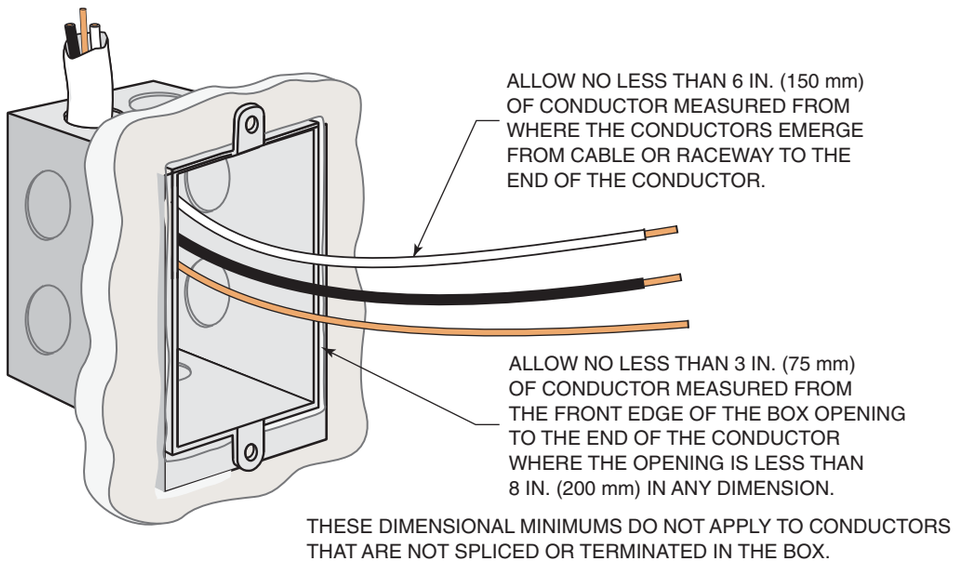


Figure 9–11 **When roughing in the wiring to electrical boxes mounted in walls and ceilings, Section 300.14 requires a minimum of 6 inches (150 mm) of conductor length at each location. No maximum length is stated, but good wiring practice dictates that electricians leave no more than 8 inches (200 mm). Too much conductor left in a box makes it more difficult to place connected receptacles and switches into the box.**

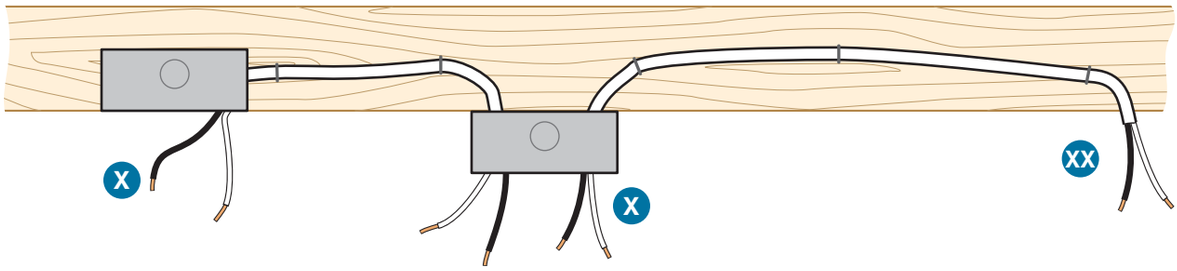


Figure 9–12 **Section 300.15 requires that where the wiring method is conduit or cable, an electrical box must be installed at each conductor splice point, outlet point, switch point, junction point, or termination point as shown at points X. Point XX would be a code violation if no box were used.**

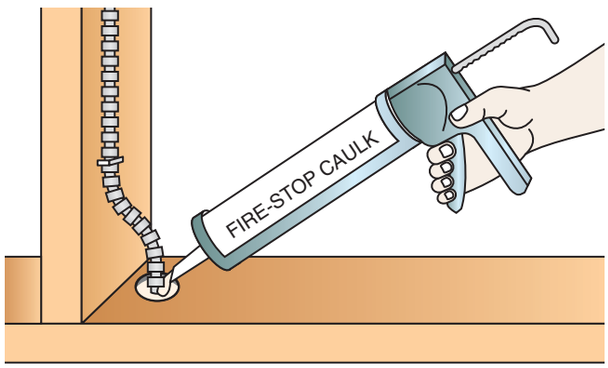


Figure 9–13 **Section 300.21 requires all openings made to route cables or raceways through fire-rated walls and ceilings to be fire-stopped. This is to maintain the proper fire-resistance rating. Some state and local jurisdictions require that fire-rated as well as non-fire-rated penetrations be fire-stopped.**

outlet point, switch point, junction point, termination point, or pull point. There are some wiring methods used where a box is not required because the wiring method provides interior access to the wires by design or a built-in box is provided. For all practical purposes, all receptacle outlets, switch locations, or junction locations in residential wiring will require that an electrical box be installed (Figure 9–12).

Section 300.21 covers the spread of fire or products of combustion. It states that electrical installations in hollow spaces, vertical shafts, and ventilation or air-handling ducts must be made so that the possible spread of fire or products of combustion (i.e., smoke) will not be substantially increased. Openings around electrical penetrations through fire-resistant-rated walls, partitions, floors, or ceilings must be fire-stopped using approved methods to maintain the fire-resistance rating (Figure 9–13). The intent of Section 300.21 is that cables and raceways must be installed through fire-rated walls, floors, or ceilings in such a manner that they do not contribute to the spread of fire or smoke. NFPA 221, Standard for Fire Walls and Fire Barrier Walls, defines fire-resistance rating as "the time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures of NFPA 251, Standard Methods of Tests of Fire Endurance of Building Construction and Materials." The fine print note (FPN) to Section 300.21 points out that directories of electrical construction materials published by qualified testing laboratories contain many listing installation restrictions necessary to maintain the fire-resistive rating of assemblies where penetrations or openings are made. Building codes also contain restrictions on penetrations on opposite sides of a fire-resistant–rated wall assembly. An example is the 24 inches (600 mm) of minimum horizontal separation that applies between boxes installed on opposite sides of the wall (Figure 9–14).

CAUTION

CAUTION: It is a good idea to always check with the authority having jurisdiction to determine which wiring method penetrations you have made will require fire-stopping. Some state and local inspectors will require both non-fire-rated and fire-rated penetrations to be fire-stopped.

Section 300.22 covers wiring in ducts, plenums, and other air-handling spaces. Usually, the information contained in this section is something that electricians doing commercial electrical work are more concerned with. However, Section 300.22(C) addresses wiring in spaces used for environmental air handling, such as those found in dwelling unit forced-hot-air furnace systems. A common practice of heating system installers in a house is to install sheet metal across the bottom of two joists in a basement and use this newly created space as a cold-air return to the furnace. The *Exception* to Section 300.22(C) states that this section does not apply to the joist or stud spaces of dwelling units where the wiring passes through such spaces perpendicular to the long dimension of such spaces. This permits cable to pass through joist or stud spaces of a dwelling unit, as illustrated in Figure 9–15. Equipment such as a junction box or device box is not permitted in this location.

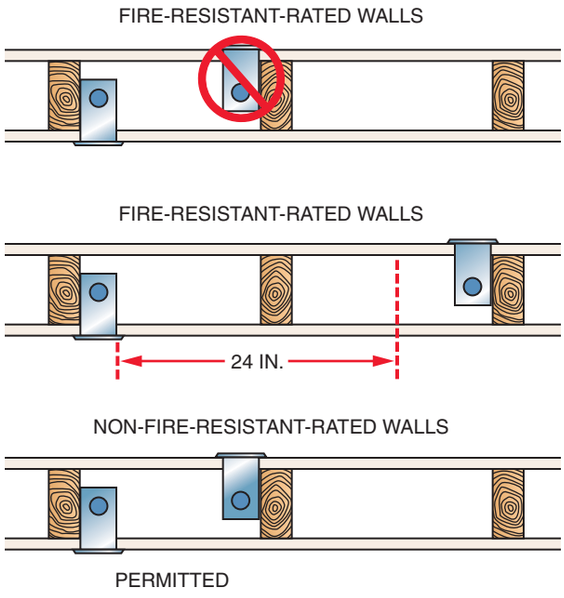


Figure 9–14 **Back-to-back electrical boxes in a fire-resistant wall. Boxes cannot be placed back-to-back in the same stud cavity unless the walls are non-fire-rated. In fire-rated walls, the boxes must be placed a minimum of 24" apart, even when they are in different stud cavities.**

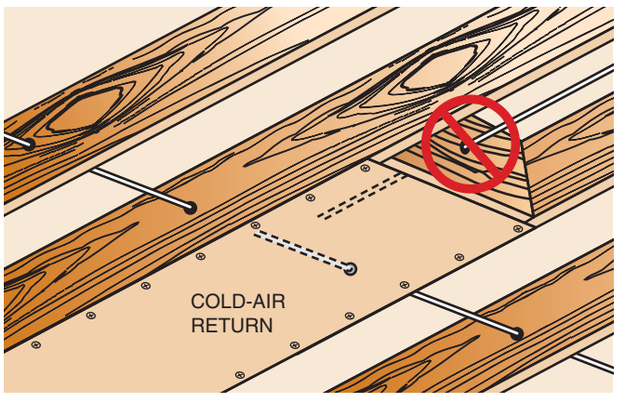


Figure 9–15 **A Section 300.22(C) *Exception* allows wiring to pass through in a direction that is perpendicular to the long dimension of air-handling spaces. This situation could present itself if the space between two joists is used as a cold-air return.**

General Requirements for Conductors

Article 310 of the *NEC*® contains several sections that cover general requirements for the conductors that an electrician will be installing during the rough-in stage. It is essential that a residential electrician understand these requirements. The most important requirements are presented in the following paragraphs.

Section 310.5 addresses the minimum size of conductors. The minimum size of conductors is shown in *NEC*® Table 310.5. This table tells us that in the voltage range of 0 to 2,000 volts, the minimum-size conductor allowed is 14 AWG copper and 12 AWG aluminum. Because dwelling unit voltages (120/240 volts) fall into this range, we can say that the smallest wire size allowed in residential wiring is 14 AWG copper or 12 AWG aluminum. Other sections of the *NEC*® allow the use of 16 or 18 AWG in residential wiring situations for such things as chime circuits, furnace thermostat circuits, lighting fixture wires, and flexible cords.

Section 310.7 states that conductors used for direct burial applications must be of a type identified for such use. If any of your rough-in wiring will involve installing conductors underground, the wiring method must be listed as suitable for use in an underground location. For example, if you are installing wiring for an outside-located pole light, NMSC could not be installed underground to feed the fixture. A wiring method listed for such use would have to be used. Type UF cable would be a good choice.

Section 310.8(D) addresses those locations exposed to direct sunlight. It states that insulated conductors and cables used where exposed to the direct rays of the sun must be of a type listed for sunlight resistance or listed and marked "sunlight resistant." Section 310.8(D)(3) allows tape or sleeving listed or marked as being sunlight resistant to be used on conductors and cables that are not sunlight resistant to make them so. Sometimes an electrician is required to install conductors outside a house where the wiring method is exposed to the direct rays of the sun; NMSC could not be used in this situation since it is not marked as sunlight resistant. Too much exposure to the direct rays of the sun will cause the insulation on Romex™ cable to deteriorate quickly. Again, a Type UF cable marked sunlight resistant would be a good choice in this application.

Section 310.10 covers the temperature limitation of conductors. No conductor can be used in such a manner that its operating temperature exceeds that designated for the type of insulated conductor involved. In no case shall conductors be associated together in such a way with respect to type of circuit, the wiring method employed, or the number of conductors that the limiting temperature of any conductor is exceeded. Residential terminations are normally designed for 60°C or 75°C maximum temperatures. Therefore, the higher-rated ampacities for conductors of 90°C cannot be used unless the terminals at which the conductors terminate have 90°C ratings. Table 310.16 has ampacity correction factors for ambient temperatures greater or less than the ambient temperature identified in the table heading. To assign the proper ampacity to a conductor in an ambient above 30°C (86°F), the appropriate temperature correction factor must be used. This correction factor is applied in addition to any adjustment factor, such as in Section 310.15(B)(2)(a). The information presented in this section was covered in Chapter 7.

FROM EXPERIENCE

An electrician will often use NMSC from a partially used roll. Typically, the package that the cable originally came in, and that has information about the cable written on it, has been discarded. The conductor size, maximum rated voltage, and letter type for the cable will be clearly written on the sheathing.

Section 310.11(A) states that all conductors and cables must be marked to indicate the following information:

- The maximum rated voltage
- The proper type letter or letters for the type of wire or cable
- The manufacturer's name, trademark, or other distinctive marking by which the organization responsible for the product can be readily identified
- The AWG size or circular mil area
- Cable assemblies where the neutral conductor is smaller than the ungrounded conductors

This information is marked on the surface of the following conductors and cables: single-conductor (solid or stranded) insulated wire, NMSC, service entrance cable, and underground feeder and branch-circuit cable. The information is on a printed tag attached to the coil, reel, or carton for the following conductors and cables: Type AC cable and Type MC cable.

Section 310.12(A) states that insulated grounded conductors must be identified in accordance with Section 200.6. Section 200.6(B) permits a grounded conductor of 6 AWG or smaller to be identified by a white or gray color along its entire length. An alternative method of identification is described as "three continuous white stripes on other than green insulation along the conductor's entire length." An insulated grounded conductor larger than 6 AWG must be identified either by a continuous white or gray outer finish, by three continuous white stripes on other than green insulation along its entire length, or, at the time of installation, by a distinctive white marking at its terminations. This marking must encircle the conductor or insulation. The general rule of Section 200.6(B) requires the insulated conductors to be white or gray for their entire length or to be identified by three continuous white stripes along the entire length of the insulated conductor. Another permitted method for these larger conductors is applying a distinctive white marking in the field, such as white electrical tape. The tape is applied at the time of installation at all the grounded conductor termination points. If field-applied, the white marking must completely encircle the conductor in order to be clearly visible. This method of identification is shown in Figure 9–16.

Section 310.12(B) states that equipment-grounding conductor identification must be in accordance with Section 250.119. Equipment-grounding conductors are permitted

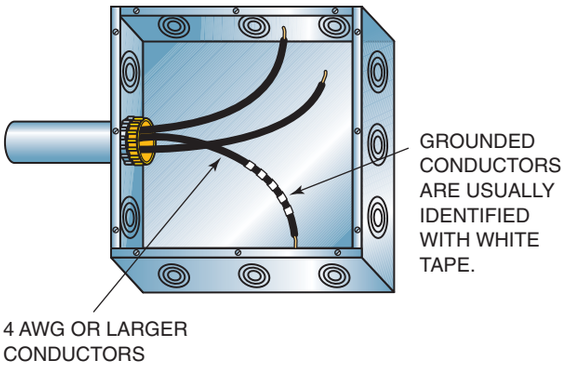


Figure 9–16 The general rule of Section 200.6(B) requires insulated grounded conductors to be white or gray for their entire length or to be identified by three continuous white stripes along the entire length of the insulated conductor. The most often used method to identify grounded conductors larger than 6 AWG having an insulation that is not white or gray in color is to field-apply white marking tape at the time of installation at all the conductor termination points. If field applied, the white marking tape must completely encircle the conductor in order to be clearly visible.

to be bare or insulated. Individually insulated equipment-grounding conductors of 6 AWG or smaller must have a continuous outer finish that is either green or green with one or more yellow stripes. For equipment-grounding conductors larger than 6 AWG, it is permitted, at the time of installation, to be permanently identified as an equipment-grounding conductor at each end and at every point where the conductor is accessible. Identification must encircle the conductor and must be accomplished by one of the following:

- Stripping the insulation or covering from the entire exposed length
- Coloring the exposed insulation or covering green at the termination
- Marking the exposed insulation or covering with green tape at the termination

Conductors that are intended for use as ungrounded or "hot" conductors, whether used as a single insulated conductor or in a multiconductor cable like Romex™, must be

FROM EXPERIENCE

Electricians typically use green marking tape to identify a grounding conductor. Make sure that the entire exposed length of conductor is reidentified with the tape. This requirement is slightly different than the reidentification of a grounded conductor in that as little as one wrap of white tape satisfactorily reidentifies a grounded conductor, while a grounding conductor must have its entire exposed length covered with green tape.

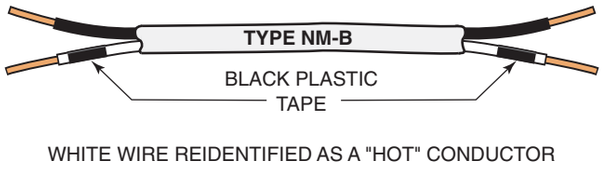


Figure 9–17 A white insulated wire in a cable assembly can be reidentified for use as an ungrounded "hot" conductor by marking it with a piece of black electrical tape.

colored to be clearly distinguishable from grounded and grounding conductors. In other words, the ungrounded conductors can be identified with any color other than white, gray, or green. An *Exception* to Section 310.12 (C) refers you to Section 200.7. Section 200.7(C)(1) states that ungrounded conductors with white or gray insulation in a cable are permitted if the conductors are permanently reidentified at termination points and if the conductor is visible and accessible. The normal method of reidentification is to use black-colored tape (Figure 9–17). Other applications where white conductors are permitted include flexible cords and circuits less than 50 volts. A white conductor used in single-pole, three-way, and four-way switch loops also requires reidentification (a color other than white, gray, or green) if it is used as an ungrounded conductor. Switching circuits are covered in Chapter 13.

Table 310.13(A), Conductor Applications and Insulations, lists and describes the insulation types recognized by the *NEC*®. These conductors are permitted for use in any of the wiring methods recognized in Chapter 3 of the *NEC*®. This table also includes conductor applications and maximum operating temperatures. Some conductors have dual ratings. For example, Type XHHW is rated 90°C for dry and damp locations and 75°C for wet locations; Type THW is rated 75°C for dry and wet locations and 90°C for special applications within electric-discharge (fluorescent) lighting equipment. Types RHW-2, XHHW-2, and other types identified by the suffix "-2" are rated 90°C for wet locations as well as dry and damp locations.

Section 310.15 covers the ampacities for conductors rated 0 to 2,000 volts. Table 310.16 is referenced as the place to look for determining the ampacity of a conductor used in residential wiring. A detailed description of ampacity and how to determine a conductor's ampacity using Table 310.16 was presented in Chapter 7. At this time, you should review the material in Chapter 7 that covers determining the ampacity of a conductor.

General Requirements for Electrical Box Installation

As we discussed earlier, installing electrical boxes is part of the rough-in stage for the wiring of a residential electrical system. Article 314 of the *NEC*® covers several requirements that an electrician must comply with when installing electrical boxes. Article 210 has several requirements for the actual location of receptacle outlets, lighting outlets, and switching locations. It is important for an electrician to understand the following sections that pertain to electrical boxes.

Installation and Use of Boxes Used as Outlet, Device, or Junction Boxes

Section 314.16 of the *NEC*® provides the guidelines for the calculation of the maximum number of conductors in outlet, device, and junction boxes. It states that boxes must be of sufficient size to provide free space for all enclosed conductors. In no case can the volume of the box, as calculated in Section 314.16(A), be less than the fill calculation, as calculated in Section 314.16(B). Calculating the maximum number of conductors in an electrical box is covered in detail in Chapter 10.

Section 314.17 states that any conductors entering electrical boxes must be protected from abrasion. This is true whether the box is metal or made of a nonmetallic material. Protection from abrasion can be accomplished by using bushings on sharp raceway ends, using connectors that are designed and built with a smooth opening for the conductors to go through, or simply by making sure that a short section of cable sheathing extends past the clamping mechanism of a cable clamp.

Section 314.17(B) applies to metal boxes. It states that where a raceway or cable is installed with metal boxes, the raceway or cable must be secured to such boxes. This is accomplished by using the proper cable or raceway connector. The connector may be an internal clamp or an external type of connector. Figure 9–18 shows internal cable clamps in both a metal device box and a metal octagon box.

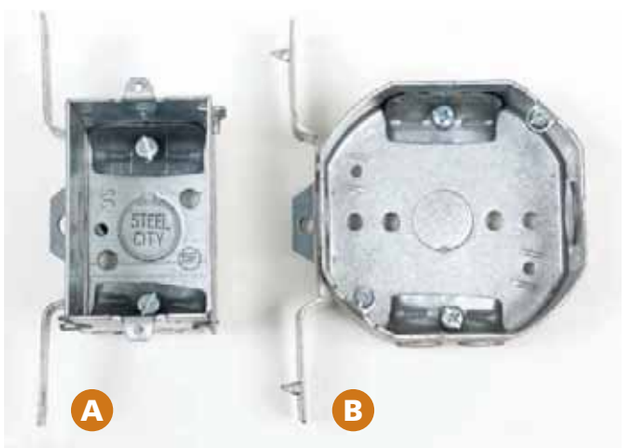


Figure 9–18 (A) A metal device box and (B) octagon box with internal clamps. Section 314.17(B) requires cables and raceways to be attached to all metal electrical boxes. External or internal clamps can be used.

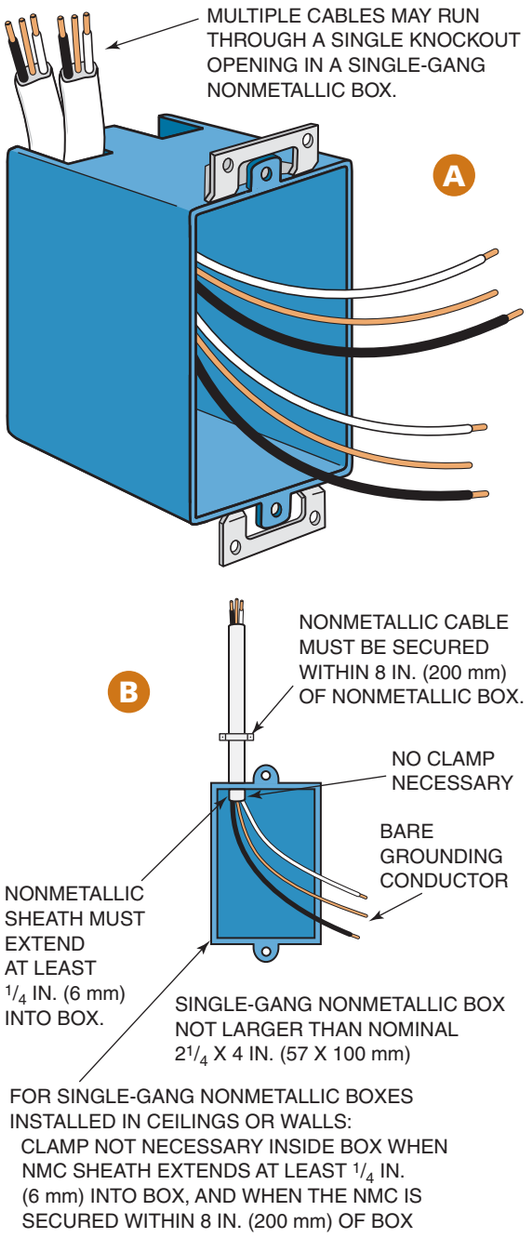


Figure 9–19 (A) A Section 314.17(C) *Exception* allows single-gang nonmetallic electrical boxes to have more than one cable installed in one knockout opening. (B) Nonmetallic sheathed cable must be secured within 8 inches (200 mm) of a single-gang nonmetallic box, and the sheathing must extend into the box at least ¼ inch (6 mm).

CAUTION

CAUTION: Never install a Romex™ cable to a metal box by simply taking out the knockout and pushing the cable through the hole. Remember, there must always be a connector to secure the cable to the box.

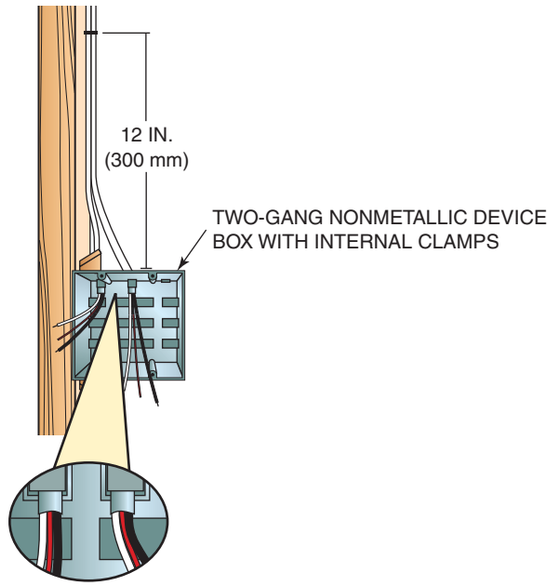


Figure 9–20 Nonmetallic electrical boxes, other than single gang, must have a way to secure a cable to the box. These boxes come from the manufacturer with internal clamps. Nonmetallic sheathed cable must be secured within 12 inches (300 mm) of this box type.

Section 314.17(C) applies to nonmetallic boxes. It says that nonmetallic boxes must be suitable for the lowest-temperature-rated conductor entering the box. Where NMSC or Type UF cable is used, the sheath must extend not less than 1/4 inch (6 mm) inside the box and beyond any cable clamp. In all instances, all permitted wiring methods must be secured to the boxes. The *Exception* to Section 314.17(C) states that where NMSC or Type UF cable is used with single-gang boxes not larger than 2¼ by 4 inches (57 by 100 mm) mounted in walls or ceilings and where the cable is fastened within 8 inches (200 mm) of the box measured along the sheath and where the sheath extends through a cable knockout not less than 1/4 inch (6 mm), securing the cable directly to the box is not required. Multiple cable entries are permitted in a single-cable knockout opening (Figure 9–19). For nonmetallic boxes that are larger than 2¼ by 4 inches (57 by 100 mm), some type of cable-securing means is required (Figure 9–20). The requirement is based on the width of the box and the likelihood that the cable will be pushed back out of the box when the conductors and device, if any, are folded back into the box during installation of receptacles and switches.

Section 314.20 requires boxes that are installed in walls or ceilings with a surface of concrete, tile, gypsum (sheetrock), plaster, or other noncombustible material to be installed so that the front edge of the box will not be set back of the finished surface more than 1/4 inch (6 mm). In walls and ceilings constructed of wood or other combustible surface material, boxes must be installed flush with the finished surface (Figure 9–21). For example, a wall constructed of gypsum board fastened to the face of wood studs is permitted

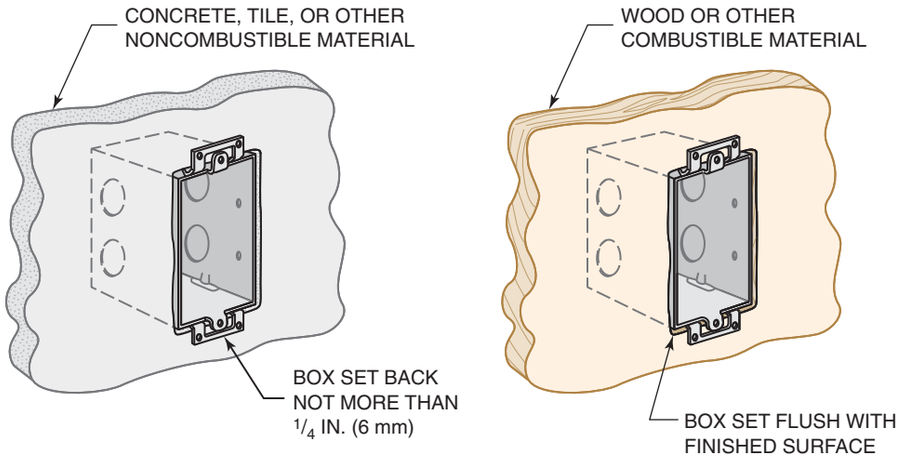


Figure 9–21 **Section 314.20 requires electrical boxes installed in walls or ceilings with a surface of concrete, tile, gypsum, plaster, or other noncombustible material, to be installed so that the front edge of the box will not be set back of the finished surface more than ¼ inch (6 mm). In walls and ceilings constructed of wood or other combustible surface material, boxes must be installed flush with the finished surface.**

to contain boxes set back or recessed not more than 1/4 inch. Another example is a wall constructed of wood paneling fastened to the face of wood (or metal) studs; this requires that installed electrical boxes be mounted flush with the combustible finish.

CAUTION

CAUTION: Electrical inspectors may consider certain sheetrock, such as 3/8 inch and 1/2 inch, to be combustible. Check with the local inspector to make sure that it is okay for you to install electrical boxes that set back 1/4 inch from the finished surface. When in doubt as to whether the wall or ceiling surface is combustible or noncombustible, always mount your boxes flush with the finished surface.

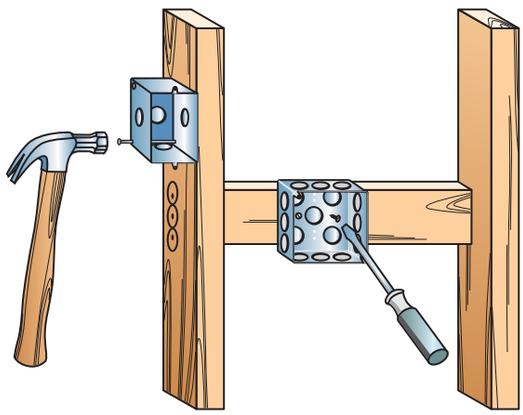


Figure 9–22 **A building structural framing member must support electrical boxes. Attaching the box directly to the framing member or using a brace can accomplish this.**

Section 314.23 addresses support of electrical boxes. 314.23(A) states that an electrical box mounted on a building or other surface must be rigidly and securely fastened in place. If the surface does not provide rigid and secure support, additional support must be provided. Although there is no *NEC*® rule to address it, it is a common wiring practice to use at least two screws, nails, or other fastening means to properly secure a box to any surface.

Section 314.23(B) says that a box supported from a structural member of a building must be rigidly supported either directly or by using a metal, polymeric, or wood brace (Figure 9–22). Section 314.23(B)(1) says that if nails or screws are used as a fastening means, side-mounting brackets on the outside of the electrical box should be used. Some electricians still use nails that are driven through holes inside an electrical box. This practice is allowed as long as the nails are within 1/4 inch (6 mm) of the back, top, or bottom of the box (Figure 9–23). This requirement prevents the nails from interfering with the installation of switches and receptacles. If screws are used and pass through the box, some approved means must be used to cover the screw threads to protect the conductors from abrasion.

Section 314.23(C) allows mounting an electrical box in a finished surface as long as it is rigidly secured by clamps, anchors, or fittings identified for the application. This wiring practice is used in remodel work (old work) where boxes are cut into existing walls. Figure 9–24 shows one example of an acceptable mounting method. More information on old-work wiring is included in later chapters.

Section 314.27 has some requirements that must be observed when installing lighting outlet boxes. Section 314.27(A) states that boxes used at luminaire (lighting fixture) outlets must be designed for the purpose. At every outlet used exclusively for lighting, the box must be designed so that a luminaire weighing a minimum of 50 lbs (23 kg) may be attached. Metal octagon boxes and nonmetallic round

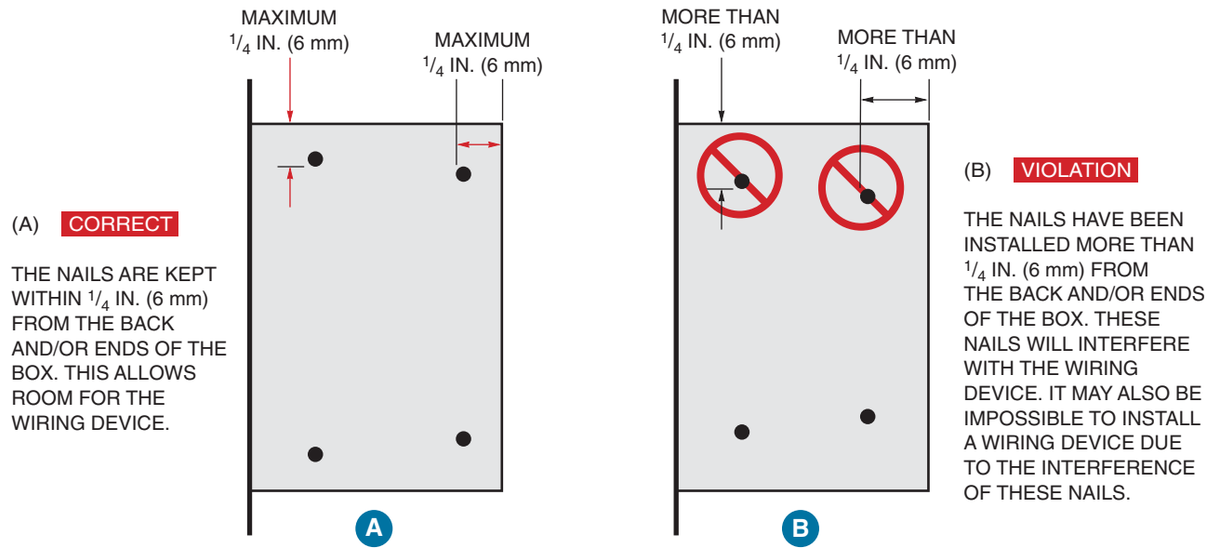


Figure 9–23 **Nails can be used to secure an electrical box to a building framing member. However, care must be taken to follow Section 314.23(B)(1), which requires the nails to be located at least ¼ inch (6 mm) from the back and ends of the box.**

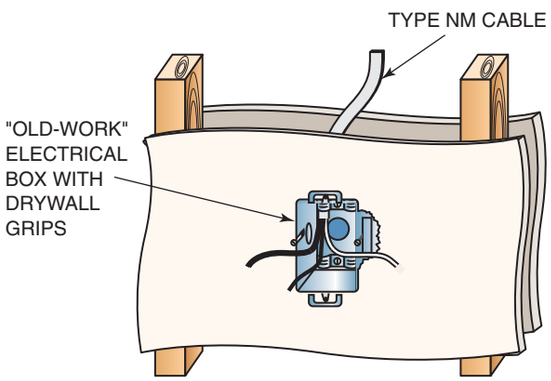


Figure 9–24 **Section 314.23(C) allows an electrical box to be mounted in an existing wall or ceiling by using clamps, anchors, or other fittings identified for the application.**

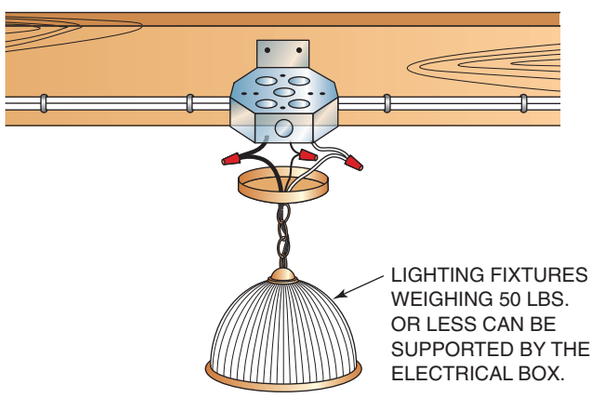


Figure 9–25 **Section 314.27(A) states that electrical boxes used to support a luminaire must be designed specifically for that purpose. Section 314.27(B) states that any lighting fixture that weighs more than 50 pounds (23 kg) cannot rely on just the electrical box for support and must be independently supported.**

nail-on ceiling boxes are used most often in residential wiring at light fixture locations. These boxes are designed so that the 8-32 size screws used with these box types will allow attachment of a light fixture to the box (Figure 9–25). Device boxes, such as a 3- by 2- by 3½-inch metal box or a single-gang plastic nail-on box, are designed to have only devices like switches or receptacles attached to them. However, the *Exception* to Section 314.27(A) allows a wall-mounted luminaire weighing not more than 6 pounds (3 kg) to be permitted to be supported on a device box (Figure 9–26) or on plaster rings that are secured to other boxes (like a 4-inch-square box), provided the luminaire or its supporting yoke is secured to the box with no fewer than two 6-32 or larger screws.

Section 314.27(B) allows outlet boxes to support luminaires weighing no more than 50 pounds (23 kg). In other words, the 8-32 screws can support a lighting fixture to a box as long as the fixture weighs no more than 50 pounds (23 kg). A luminaire that weighs more than 50 pounds (23 kg) must be supported independently of the outlet box unless the outlet box is listed for the weight to be supported. Larger lighting fixtures often weigh over 50 pounds. Make sure to follow the installation instructions that come with the lighting fixture and support the fixture in such a way that the weight of the fixture is not supported by just the 8-32 screws.

Section 314.27(C) states that boxes listed specifically for floor installation must be used for receptacles located in the

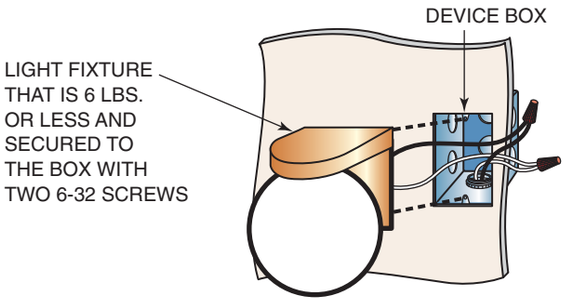


Figure 9–26 **Device boxes are not specifically designed to support luminaires. However, a Section 314.27(A) *Exception* allows a luminaire of no more than 6 pounds (3 kg) to be supported by a device box when at least two 6-32 screws are used.**

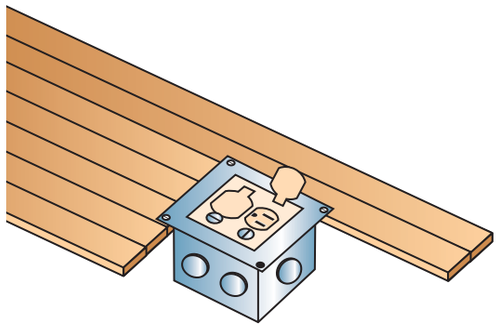


Figure 9–27 **Floor boxes must be designed for the purpose, as required by Section 314.27(C). Regular device boxes, square boxes, or octagon boxes cannot be installed in a floor of a dwelling unit.**

floor. No other box type can be used in a floor installation. Make sure to install only boxes that are specifically designed for floor installation (Figure 9–27).

CAUTION

CAUTION: Regular electrical device boxes are not suitable for installation in a floor. Only boxes that are listed for floor installation can be used. Floor boxes tend to be expensive and harder to install than a "regular" box. Try to avoid installing floor receptacles that require a special box whenever possible. Always try to install the box in a wall.

Section 314.27(D) tells us that where a box is used as the sole support for a ceiling-suspended paddle fan, the box must be listed for the application be marked by the manufacturer as suitable for this purpose, and must not support paddle fans that weigh more than 70 pounds (32 kg). If an outlet box is designed to support a paddle fan that weighs

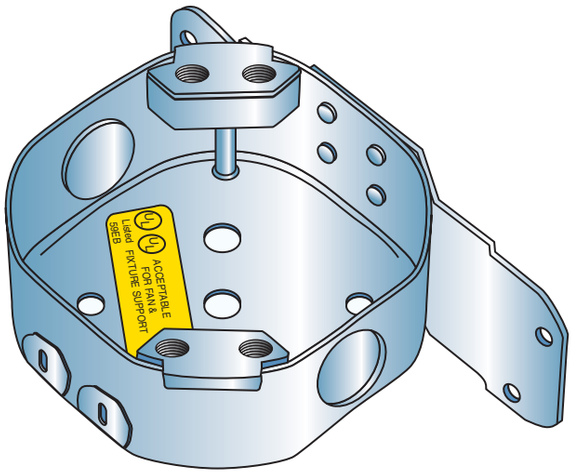


Figure 9–28 **A box that is designed for support of a ceiling-suspended paddle fan. Special "beefed-up" mounting brackets to attach the box to a building framing member and larger tapped holes for attaching a ceiling-suspended paddle fan to the box are included.**

more than 35 pounds (16 kg), the box must have the maximum weight it can support marked on it. Outlet boxes specifically listed to adequately support ceiling-mounted paddle fans are available, as are several alternative and retrofit methods that can provide suitable support for a paddle fan (Figure 9–28). Another thing to consider is that homeowners often replace an existing ceiling lighting fixture with a combination ceiling-suspended paddle fan/lighting fixture. When they do this, separate wall switching of the paddle fan and the lighting fixture is desirable. In anticipation of this happening, many electricians install the necessary wiring for separate switching from a switch box to the paddle fan/lighting fixture box during the rough-in stage. This section requires that whenever wiring is roughed-in to a ceiling lighting outlet box to provide multiple switching in case a ceiling suspended paddle fan/lighting fixture is someday installed at that location, the outlet box must be listed for the sole support of a ceiling-suspended paddle fan, whether a paddle fan is actually installed or not. If a listed ceiling-suspended paddle fan box was not installed and a homeowner attached a ceiling-suspended paddle fan/lighting fixture to a "regular" box, the whole thing could come crashing down and seriously injure someone. Ceiling-suspended paddle fan installation is covered in greater detail later in the text.

The last section covered here is Section 314.29, which states that boxes must be installed so that the wiring contained in them can be rendered accessible without removing any part of the building. A box is permitted to be used at any point for the connection of conduit, tubing, or cable, provided it is not rendered inaccessible. See Article 100 for the definition of "accessible" (as applied to wiring methods).

CAUTION

CAUTION: Never install an electrical box in a location that is accessible during the rough-in stage but is rendered inaccessible once wall and ceiling materials have been installed. Remember, all electrical boxes that contain conductors must be accessible.

Dwelling Unit Required Receptacle Outlets

Section 210.52 of the *NEC*® tells an electrician where receptacle outlets must be installed in a dwelling unit. This information is very important for the electrician to know so that electrical boxes installed during the rough-in stage are located to meet or exceed the requirements of this section. The requirements of Section 210.52 apply to dwelling unit receptacles that are rated 125 volts and 15 or 20 amperes and that are not part of a luminaire or an appliance. These receptacles are normally used to supply lighting and general-purpose electrical equipment and are in addition to the ones that are more than 5½ feet (1.7 m) above the floor, located within cupboards and cabinets, or controlled by a wall switch.

Section 210.52(A) states that in every kitchen, family room, dining room, living room, parlor, library, den, sunroom, bedroom, recreation room, or similar room or area of dwelling units, receptacle outlets must be installed in accordance with the general provisions specified as follows: Receptacles must be installed so that no point measured horizontally along the floor line in any wall space is more than 6 feet (1.8 m) from a receptacle outlet. This means that electrical boxes for receptacles must be installed during the rough-in stage so that no point in any wall space is more than 6 feet (1.8 m) from a receptacle. This rule means that an appliance or lamp with a flexible cord attached may be placed anywhere in the room near a wall and be within 6 feet (1.8 m) of a receptacle (Figure 9–29). This required placement of receptacles will eliminate the need for long extension cords running all over the place.

As used in this section, a wall space includes the following:

- Any space 2 feet (600 mm) or more in width (including space measured around corners) and unbroken along the floor line by doorways, fireplaces, and similar openings (Figure 9–30): Isolated, individual wall spaces 2 feet (600 mm) or more in width are considered usable for the location of a lamp or appliance, and a receptacle outlet is required to be provided.
- The space occupied by fixed panels in exterior walls, excluding sliding panels: Fixed panels in exterior walls, such as the fixed glass section of a sliding glass door, are counted as regular wall space. A floor-type receptacle installed no more than 18 inches (450 mm) from the wall can be used if the spacing requirements might require a receptacle at the location of a glass fixed panel (Figure 9–31).
- The space afforded by fixed room dividers, such as freestanding bar-type counters or railings: Fixed room dividers, such as bar-type counters and railings, are to be included in the 6-foot (1.8 m) measurement (Figure 9–32).

Section 210.52(C) covers the required location of receptacles at countertop locations in a dwelling unit kitchen or dining room. This information is extremely important for the electrician because electrical boxes for the receptacles will have to be installed and wire run to them before any of the kitchen cabinets and countertop have been installed. The correct placement of the electrical boxes during the rough-in stage is imperative so that electrical boxes do not end up hidden behind cabinets or other kitchen equipment. The following requirements must be met when installing

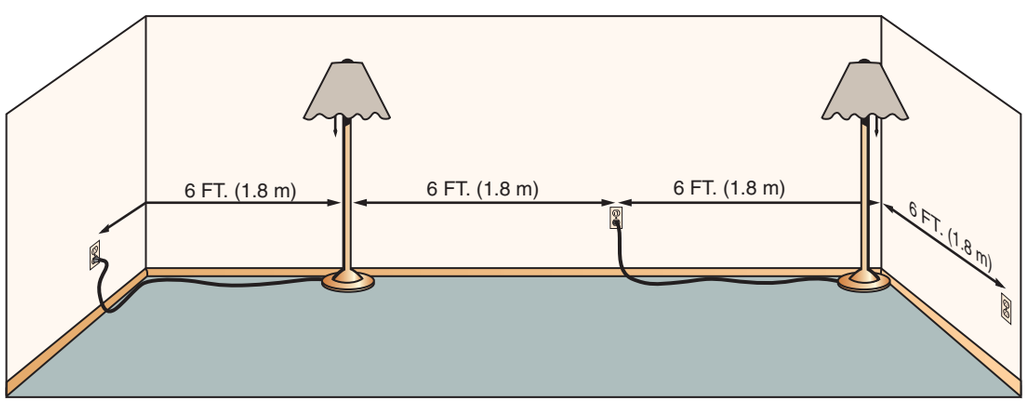


Figure 9–29 **A good way to understand the placement of dwelling unit receptacles along a wall is to make sure that any piece of electrical equipment with a power cord that is 6 feet (1.8 m) long can be placed anywhere in a room and still be able to reach a receptacle.**

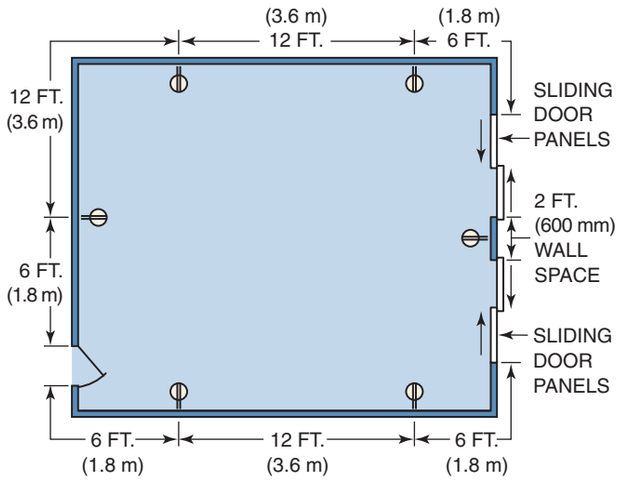


Figure 9–30 **A typical receptacle layout in a dwelling unit room that meets the requirements of Section 210.52(A).**

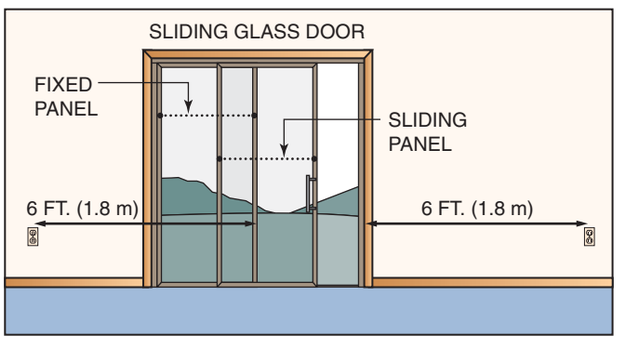


Figure 9–31 **Fixed panels, like the part of a sliding glass door that does not move, are considered wall space.**

boxes for receptacle outlets to serve countertops in a kitchen or dining room (Figure 9–33):

- A receptacle outlet must be installed at each wall counter space that is 12 inches (300 mm) or wider. Receptacle outlets must be installed so that no point along the wall line is more than 24 inches (600 mm) measured horizontally from a receptacle outlet in that space.
- At least one receptacle outlet must be installed at each island counter space with a long dimension of 24 inches (600 mm) or greater and a short dimension of 12 inches (300 mm) or greater.
- At least one receptacle outlet must be installed at each peninsular counter space with a long dimension of 24 inches (600 mm) or greater and a short dimension of 12 inches (300 mm) or greater. A peninsular countertop is measured from the connecting edge.
- Countertop spaces separated by range tops, refrigerators, or sinks are considered as separate countertop spaces.
- Receptacle outlets must be located above, but not more than 20 inches (500 mm) above, the countertop. On island and peninsular countertops where the countertop is flat across its entire surface (no backsplashes, dividers, and so on) and there is no way to mount a receptacle within 20 inches (500 mm) above the countertop, receptacle outlets are permitted to be mounted not more than 12 inches (300 mm) below the countertop. However, receptacles mounted below a countertop cannot be located where the countertop extends more than 6 inches (150 mm) beyond its support base, such as at a bar-type eating area in a kitchen (Figure 9–34).

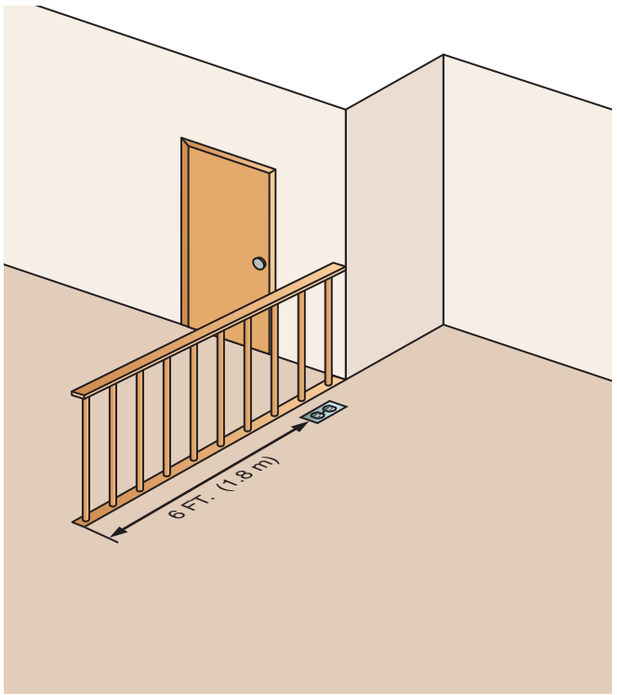


Figure 9–32 **Fixed room dividers, like the railing shown here, are considered to be wall space and must meet the requirements of Section 210.52(A).**

CAUTION

CAUTION: According to Section 406.4(E), receptacles cannot be installed in a face-up position in a countertop. Receptacles installed in a face-up position could collect crumbs, liquids, and other debris, resulting in a potential fire or shock hazard.

Section 210.52(D) requires one wall receptacle in each bathroom of a dwelling unit to be installed adjacent and within 36 inches (900 mm) of the outside edge of the basin (Figure 9–35). This receptacle is required in addition to any receptacle that may be part of any luminaire or medicine

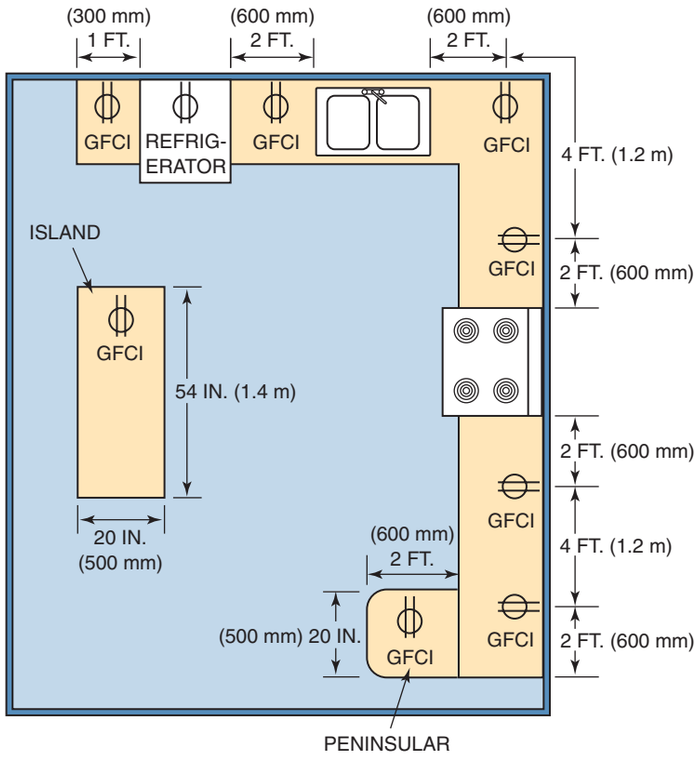


Figure 9–33 **Dwelling unit receptacles serving countertop spaces in a kitchen and installed in accordance with Section 210.52(A).**

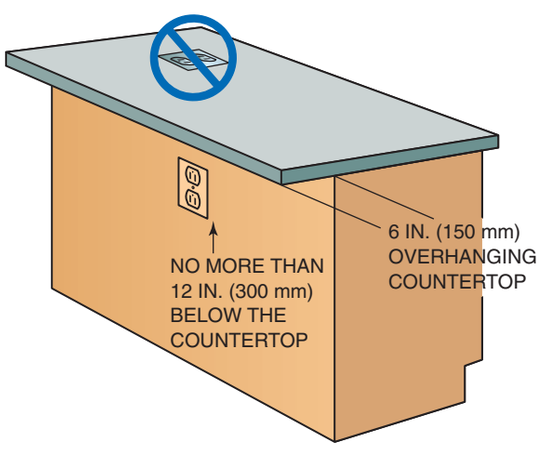


Figure 9–34 **Receptacles cannot be installed face-up in a countertop. However, the receptacles required by Section 210.52(C) can be mounted below countertops as long as they are located no lower than 12 inches (300 mm). If the countertop has an overhanging portion that is more than 6 inches (300 mm), receptacles are not allowed under that area.**

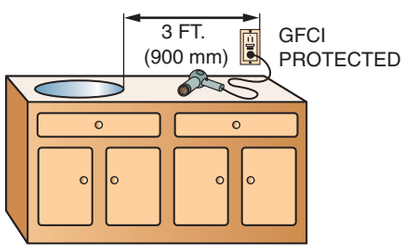


Figure 9–35 **At least one receptacle must be installed within 36 inches (900 mm) of a bathroom basin.**

cabinet. If there is more than one basin, a receptacle outlet is required adjacent to each basin location. If the basins are in close proximity, one duplex receptacle outlet installed between the two basins will satisfy this requirement (Figure 9–36). An *Exception* allows the receptacle to be installed no more than 12 inches (300 mm) below the countertop on the side or face of the basin cabinet instead of on the wall adjacent to the basin.

Section 210.52(E) states that for a one-family dwelling and each unit of a two-family dwelling that is at grade level, at least one receptacle outlet accessible at grade level and not more than 6.5 feet (2.0 m) above grade must be installed at the front and back of the dwelling (Figure 9–37). Balconies, decks, and porches that are attached to a house and are accessible from inside the house need to have at least one receptacle outlet installed that is accessible from the balcony, deck, or porch. This rule helps eliminate the use of extension cords running through doors or windows to provide power to appliances or decorations located on a balcony, deck, or porch.

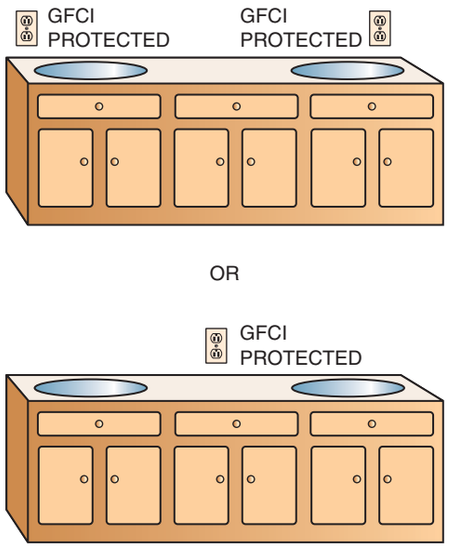


Figure 9–36 **If a bathroom has more than one basin, receptacles can be placed within 36 inches (900 mm) of each basin or one receptacle may be placed so that it is within 36 inches (900 mm) of either basin.**

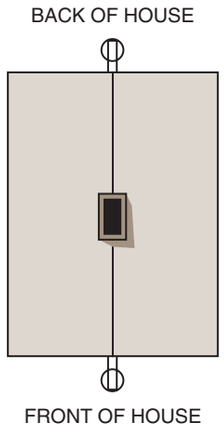


Figure 9–37 **Receptacles are required on the front and back of a one-family dwelling unit as well as each unit of a two-family dwelling. They must be located no more than 6½ feet (2 m) above grade.**

Section 210.52(F) requires at least one receptacle outlet to be installed for the laundry. Remember that a 20-ampere branch circuit, which can have no other outlets on the circuit, supplies the laundry receptacle outlet(s).

Section 210.52(G) states that for a one-family dwelling, at least one receptacle outlet, in addition to any provided for laundry equipment, must be installed in each basement and in each attached garage and in each detached garage with electric power. Where a portion of the basement is finished into one or more habitable rooms, each separate unfinished portion must have a receptacle outlet installed in accordance with this section.

Section 210.52(H) requires that in dwelling units, hallways of 10 feet (3.0 m) or more in length must have at least one receptacle outlet. In determining the hallway length, use the measured length along the centerline of the hall without passing through a doorway.

Dwelling Unit Required Lighting Outlets

During the rough-in stage, electrical boxes will have to be installed for the lighting outlets required in a house. Section 210.70 contains the minimum requirements for providing lighting in a dwelling unit. This information helps the electrician determine where a lighting outlet will have to be located. Some lighting fixtures are attached directly to electrical outlet boxes and will require a box to be mounted at the proper location. Other lighting fixtures are simply mounted to the surface, and electrical wiring is brought into the fixture wiring compartment where connections are made. Either way means that an electrician must install wiring with or without an electrical box at lighting outlet locations. Figure 9–38 shows the location of the required lighting outlets in a typical dwelling unit.

Section 210.70(A)(1) requires at least one wall switch–controlled lighting outlet to be installed in every habitable room and bathroom. *Exception No. 1* to the general rule allows one or more receptacles controlled by a wall switch to be permitted instead of lighting outlets, but only in areas other than kitchens and bathrooms. A wall switch-controlled lighting outlet is required in the kitchen and bathroom. A receptacle outlet controlled by a wall switch is not permitted to serve as a lighting outlet in these rooms. *Exception No. 2* allows lighting outlets to be controlled by occupancy sensors that are (1) in addition to wall switches or (2) located at a customary wall switch location and equipped with a manual override that will allow the sensor to function as a wall switch.

Section 210.70(A)(2) lists three additional locations where lighting outlets need to be installed:

- At least one wall switch–controlled lighting outlet must be installed in hallways, stairways, attached garages, and detached garages with electric power.
- In attached garages and detached garages with electric power, at least one wall switch–controlled lighting outlet must be installed to provide illumination on the exterior side of outdoor entrances or exits with grade-level access. A vehicle door in a garage is not considered as an outdoor entrance or exit.
- Where one or more lighting outlet(s) are installed for interior stairways, there must be a wall switch at each floor level at and each landing level that includes an entryway to control the lighting outlet(s) where the stairway between floor levels has six risers or more.

An *Exception* states that in hallways, stairways, and at outdoor entrances, remote, central, or automatic control of lighting is permitted.

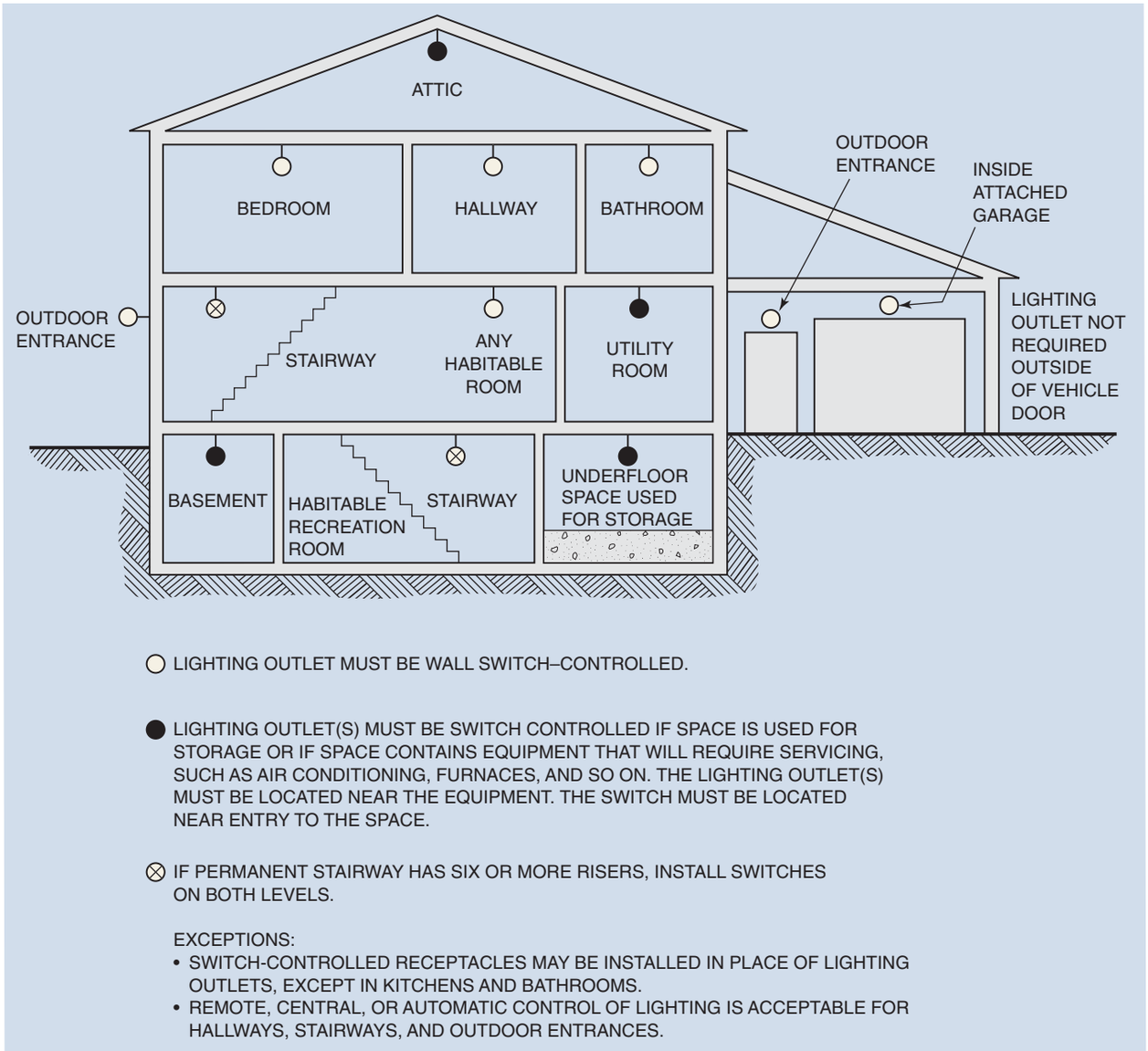


Figure 9–38 **The required lighting outlets in a dwelling unit according to Section 210.70(A).**

Section 210.70(A)(3) addresses storage or equipment spaces. It says that for attics, crawl spaces, utility rooms, and basements, at least one lighting outlet containing a switch or controlled by a wall switch must be installed where these spaces are used for storage or contains equipment requiring servicing. At least one point of control must be at the door to these spaces. The lighting outlet must be provided at or near equipment, like furnaces or other heating, ventilating, and air-conditioning equipment, that requires servicing. Installation of lighting outlets in attics, crawl spaces, utility rooms, and basements is required when these spaces are used for storage of items such as holiday decorations or luggage.

Communications Outlet

Section 800.156 requires a minimum of one communications outlet (Figure 9–39) to be installed in all newly constructed dwellings units. The communication cabling must be run to the location where the telephone company brings in service from the street. This is called the demarcation

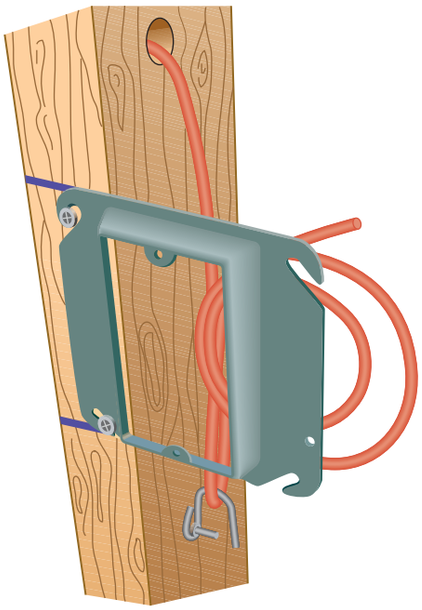


Figure 9–39 **At least one communication outlet is required inside a dwelling unit. A common wiring practice is to secure a raised plaster ring to a framing member and run the communication cable to it. Because of the low amount of electrical power available on a communication circuit, an electrical box is not required but could be used.**

point and is usually at a weatherproof box on the side of the house. Communications wiring is covered in detail in Chapter 16.

Summary

Before an electrician starts the rough-in stage of a residential wiring job, certain *NEC*® requirements must be considered. During the rough-in stage, these requirements are then applied. After completing the rough-in stage, an electrical inspector will determine if you correctly met the *NEC*® requirements with your installation. At this point in the installation of the wiring system, no ceiling or wall coverings have been installed, and the inspector will have easy access to the boxes and wire installed by the electrician. This chapter covered several common *NEC*® general requirements that must be considered when wiring a house. Also discussed and presented were several requirements that pertain to the conductors and electrical boxes installed during the rough-in stage. Understanding and following the *NEC*® requirements presented in this chapter will result in the rough-in stage wiring being free of code violations.

Review Questions

Directions: Answer the following items with clear and complete answers.

1. Define the term "wiring" as it is used by electricians doing residential work.
2. Describe the "rough-in" stage of a residential wiring installation.
3. Name the most common wiring method used in residential wiring and which *NEC*® article covers this wiring method.
4. The *NEC*® requires electricians to install the electrical system in a "neat and workmanlike manner." Describe what this means and give an example of something not installed in a neat and workmanlike manner.
5. Name the table in the *NEC*® that lists the insulation types for conductors used in residential wiring.
6. When boring holes in a wooden framing stud for the installation of Romex™ cable, electricians must make sure that the distance from the edge of the hole to the face of the stud is no less than _____. If this distance cannot be maintained, a metal plate at least _____ thick must be used to protect the cable. Name the *NEC*® section that covers this wiring situation.
7. The minimum amount of free conductor required to be available at an electrical box used in residential wiring for termination purposes is _____. As long as the box has no dimension larger than 8 inches (200 mm), there must be at least _____ of free conductor extending out from the box opening. Name the *NEC*® section that covers this wiring practice.
8. Openings around electrical penetrations through fire-resistant-rated walls, partitions, floors, or ceilings must be fire-stopped using approved methods to maintain the fire-resistance rating. Explain why fire-stopping is required.
9. The minimum size of wire used in residential wiring is _____ AWG. (general rule)
10. The *NEC*® recognizes two wire sizes that are smaller than the answer to question 9. List the two sizes and give an example of where they might be used in a residential wiring system.
11. Name a cable wiring method that would be a good choice for an installation that would result in the cable being located outdoor where the direct rays of the sun could shine on it.
12. Name four items that must be written on the sheathing of a nonmetallic sheathed cable, according to the *NEC*®.
13. Describe how a 6 AWG or smaller insulated grounded conductor must be identified.
14. Describe how an insulated grounded conductor larger than 6 AWG is identified.
15. Describe how a white insulated conductor in a cable assembly is reidentified as a "hot" conductor.
16. Describe how a 6 AWG or smaller grounding conductor is identified.
17. Describe how a conductor that is larger than 6 AWG can be identified as a grounding conductor.
18. Conductors that are intended for use as ungrounded or "hot" conductors, whether used as a single insulated conductor or in a multiconductor cable like Romex™, must be colored to be clearly distinguishable from grounded and grounding conductors. Describe how the identification is accomplished.

19. **Explain what is required by Section 110.3(B) of the *NEC*®.**

20. **Name the common piece of electrical equipment that electricians use to insert into any knockout opening that is open and not used. Name the *NEC*® section that covers this wiring practice.**

21. **In single-gang nonmetallic boxes, the sheathing of a Romex™ cable must extend at least _____ into the box and be visible. Romex™ must also be secured no more than _____ from this same single-gang nonmetallic box.**

22. **A wall constructed of sheetrock fastened to the face of wood studs is permitted to contain boxes set back or recessed not more than _____. Name the *NEC*® section that covers this requirement.**

23. **Some electricians use nails that are driven through holes inside an electrical box to attach the box to a wall stud. This practice is allowed as long as the nails are within _____ of the back, top, or bottom of the box. Name the *NEC*® section that covers this requirement.**

24. **A wall-mounted luminaire (fixture) weighing not more than _____ is permitted to be supported on a device box provided the luminaire or its supporting yoke is secured to the box with no fewer than two 6-32 or larger screws. Name the *NEC*® section that covers this requirement.**

25. **The 8-32 screws used with a lighting outlet box can support a lighting fixture to the box as long as the fixture weighs no more than _____. Name the *NEC*® section that covers this requirement.**

26. **Switch-controlled receptacles, instead of lighting outlets, can be used in all areas of a dwelling unit except _____ and _____.**

27. **Receptacles located more than _____ above the floor are not counted in the required number of receptacles along a wall.**

28. **The maximum distance between wall receptacles in a dwelling unit is _____.**

29. **The maximum distance between countertop receptacles in a dwelling unit kitchen is _____.**

30. **Interior stairway lighting must be controlled by a wall switch placed at the top and bottom of the stairway when the stairway has _____ or more steps.**