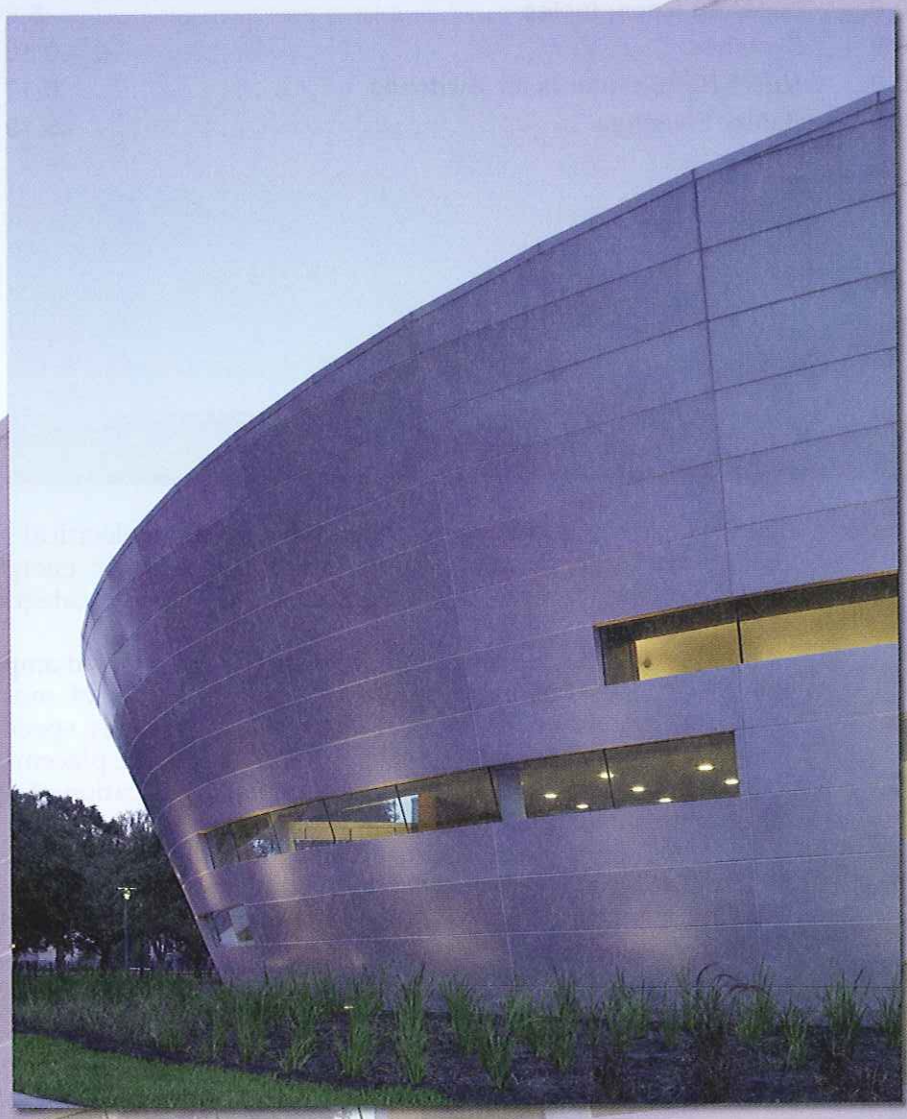
Wiring Devices
26305-05



ExxonMobil URC Training Center
Houston, Texas
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26305-05
Wiring Devices

Topics to be presented in this module include:

Overview

The *NEC*® defines a wiring device as a "unit of an electrical system that is intended to carry or control but not utilize electric energy." Receptacles, switches, relay contacts, and conductors fall into the category of wiring devices.

Most wiring devices are rated according to voltage and amperage. Although the *NEC*® does not regulate the mounting heights of most receptacles or switches, individual electrical floor plans do typically specify the mounting heights for these devices. The *NEC*® does regulate the placement of receptacles and switches, as well as GFCI requirements. The location of receptacles in residential occupancies is regulated by *NEC Section 210.52*.

Switches are devices that are used to open or close an electrical circuit. Switch configurations are described using the terms poles and throws. Poles refer to the number of conductors that the switch can control, while throws refer to the number of internal operations that a switch can perform. Safety switches are knife-type switches usually mounted in either a general-duty or a heavy-duty enclosure.

Objectives

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

1. Select wiring devices according to the National Electrical Manufacturers' Association (NEMA) classifications.
2. Size wiring devices in accordance with *National Electrical Code®* (*NEC®*) requirements.
3. Discuss the NEMA enclosure classifications.
4. Follow *NEC®* regulations governing the installation of wiring devices.
5. Explain the types and purposes of grounding wiring devices.
6. Determine the maximum load allowed on specific wiring devices.

Trade Terms

Attachment plug
Cord
Device
Four-way switch
Gang switch
Receptacle
Switch
Three-way switch

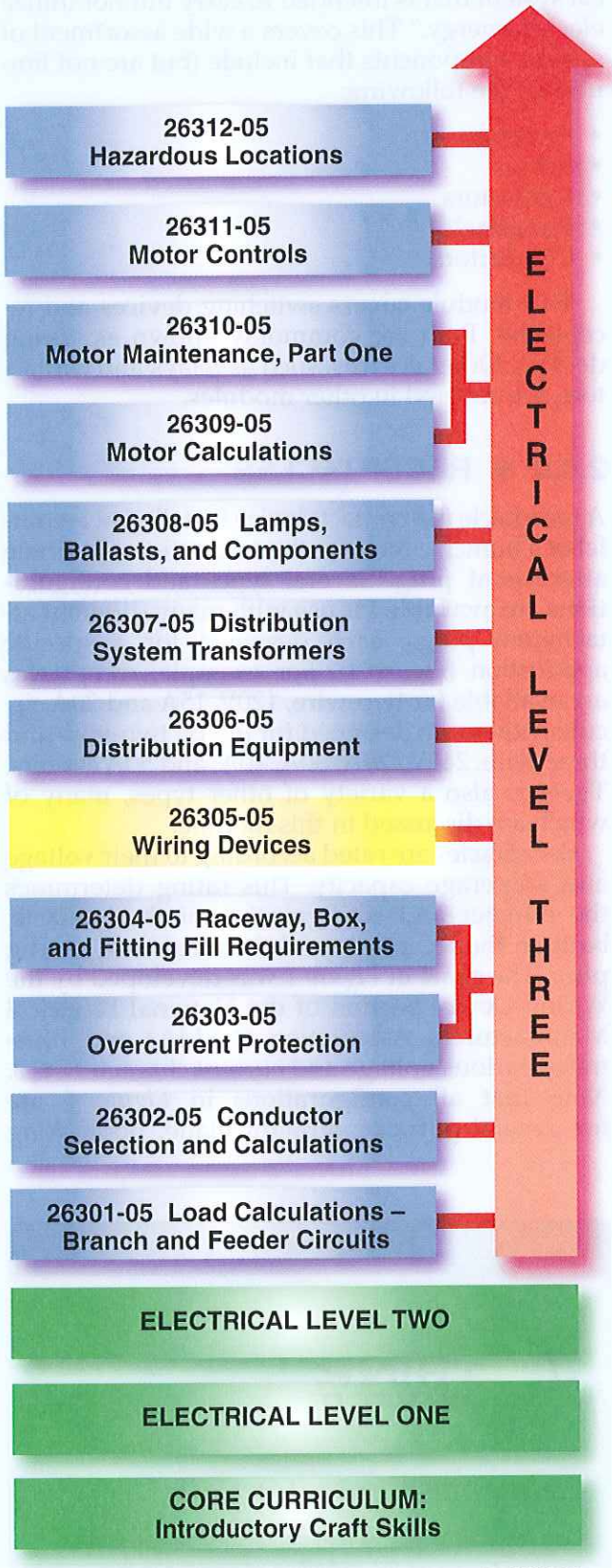
Required Trainee Materials

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

Prerequisites

Before you begin this module, it is recommended that you successfully complete *Core Curriculum; Electrical Level One; Electrical Level Two; Electrical Level Three*, Modules 26301-05 through 26304-05.

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



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1.0.0 ◆ INTRODUCTION

The *NEC*® defines a **device** as "a unit of an electrical system that is intended to carry but not utilize electric energy." This covers a wide assortment of system components that include (but are not limited to) the following:

- **Switches**
- Relays
- Contactors
- **Receptacles**
- Conductors

This module covers switching devices and receptacles. Both are commonly known as wiring devices. Other devices, such as relays and contactors, are covered in other modules.

2.0.0 ◆ RECEPTACLES

A receptacle is a contact device installed at an outlet of a branch circuit for the connection of a single **attachment plug.** Several types and configurations are available for use with many different attachment plugs, each designed for a specific application (*Figure 1*). For example, receptacles are available for two-wire, 120V, 15A and 20A circuits; others are designed for use on two-wire and three-wire, 240V/20A, 30A, 40A, and 50A circuits. There is also a variety of other types, many of which are discussed in this module.

Receptacles are rated according to their voltage and amperage capacity. This rating determines the number and configuration of the contacts, both on the receptacle and the receptacle mating plug. The chart in *Figure 1* was developed by the Wiring Device Section of the National Electrical Manufacturers Association (NEMA) and illustrates various voltage and current characteristics. Note that all configurations in *Figure 1* are for general-purpose, straight blade, nonlocking devices. Locking-type receptacles and plugs are covered later in this module.

Relay and Contactor Coils

Can the coils of relays and contactors be considered devices based on the definition of devices in the *NEC*®?

Factory-Installed Power Cords with Plugs

Never change a factory-installed power cord on an appliance or equipment to make it match a receptacle. Receptacles and branch circuit ratings must be matched to the appliance or equipment.

Unsafe interchangeability has been eliminated by assigning a unique configuration to each voltage and current rating. All dual ratings have been eliminated, and interchangeability exists only where it does not present an unsafe condition.

Each configuration is designated by a number composed of the chart line number, the amperage, and either R for receptacle or P for plug cap. For example, a 5-15R is found on line 5 and represents a 15A receptacle.

A clear distinction is made between system grounds and equipment grounds. System grounds referred to as grounded conductors, normally carry current at ground potential, and terminals for such conductors are marked *W* for white in the chart. Equipment grounds, referred to as grounding conductors, carry current only during ground fault conditions. The terminals for such conductors are marked *G* for grounding or green in the chart. *NEC Article 406* covers the installation of receptacles, cord connectors, and cord caps.

2.1.0 Receptacle Characteristics

Receptacles have various symbols and information inscribed on them that help to determine their proper use and ratings. For example, *Figure 2* shows a standard duplex receptacle and contains the following printed inscriptions:

- Testing laboratory label
- Canadian Standards Association (CSA) label
- Type of conductor for which the terminals are designed
- Current and voltage ratings listed by maximum amperage, maximum voltage, and current restrictions

The testing laboratory label is an indication that the device has undergone extensive testing by a

		15A		20A		30A	
		Receptacle	Plug	Receptacle	Plug	Receptacle	Plug
2-pole, 2-wire	1 125V	1-15R	1-15P				
	2 250V		2-15P	2-20R	2-20P	2-30R	2-30P
2-pole, 3-wire grounding	5 125V	5-15R	5-15P	5-20R	5-20P	5-30R	5-30P
	6 250V	6-15R	6-15P	6-20R	6-20P	6-30R	6-30P
	7 277V	7-15R	7-15P	7-20R	7-20P	7-30R	7-30P
	24 347V	24-15R	24-15P	24-20R	24-20P	24-30R	24-30P
3-pole, 3-wire	10 125/250V			10-20R	10-20P	10-30R	10-30P
	11 3Ø 250V	11-15R	11-15P	11-20R	11-20P	11-30R	11-30P
3-pole, 4-wire grounding	14 125/250V	14-15R	14-15P	14-20R	14-20P	14-30R	14-30P
	15 3Ø 250V	15-15R	15-15P	15-20R	15-20P	15-30R	15-30P
4-pole 4-wire	18 3Ø 208Y/120V	18-15R	18-15P	18-20R	18-20P	18-30R	18-30P

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Figure 1 ◆ Common receptacles and plugs (1 of 2).

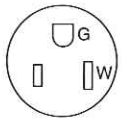
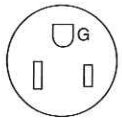
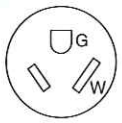
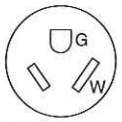
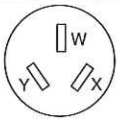
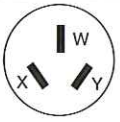
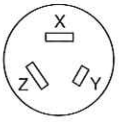
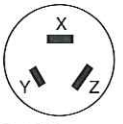
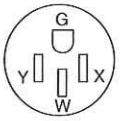
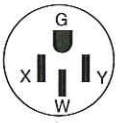
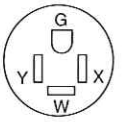
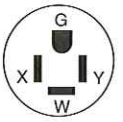
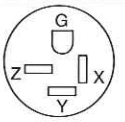
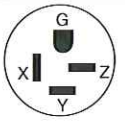
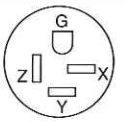
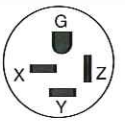
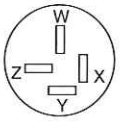
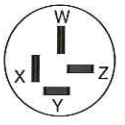
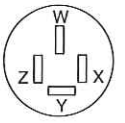
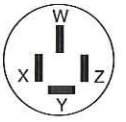
		50A		60A	
		Receptacle	Plug	Receptacle	Plug
2-pole, 3-wire grounding	5 125V	 5-50R	 5-50P		
	6 250V	 6-50R	 6-50P		
	7 277V	 7-50R	 7-50P		
	24 347V	 24-50R	 24-50P		
3-pole, 3-wire	10 125/250V	 10-50R	 10-50P		
	11 3Ø 250V	 11-50R	 11-50P		
3-pole, 4-wire grounding	14 125/250V	 14-50R	 14-50P	 14-60R	 14-60P
	15 3Ø 250V	 15-50R	 15-50P	 15-60R	 15-60P
4-pole 4-wire	18 3Ø 208Y/120V	 18-50R	 18-50P	 18-60R	 18-60P

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Figure 1 ◆ Common receptacles and plugs (2 of 2).

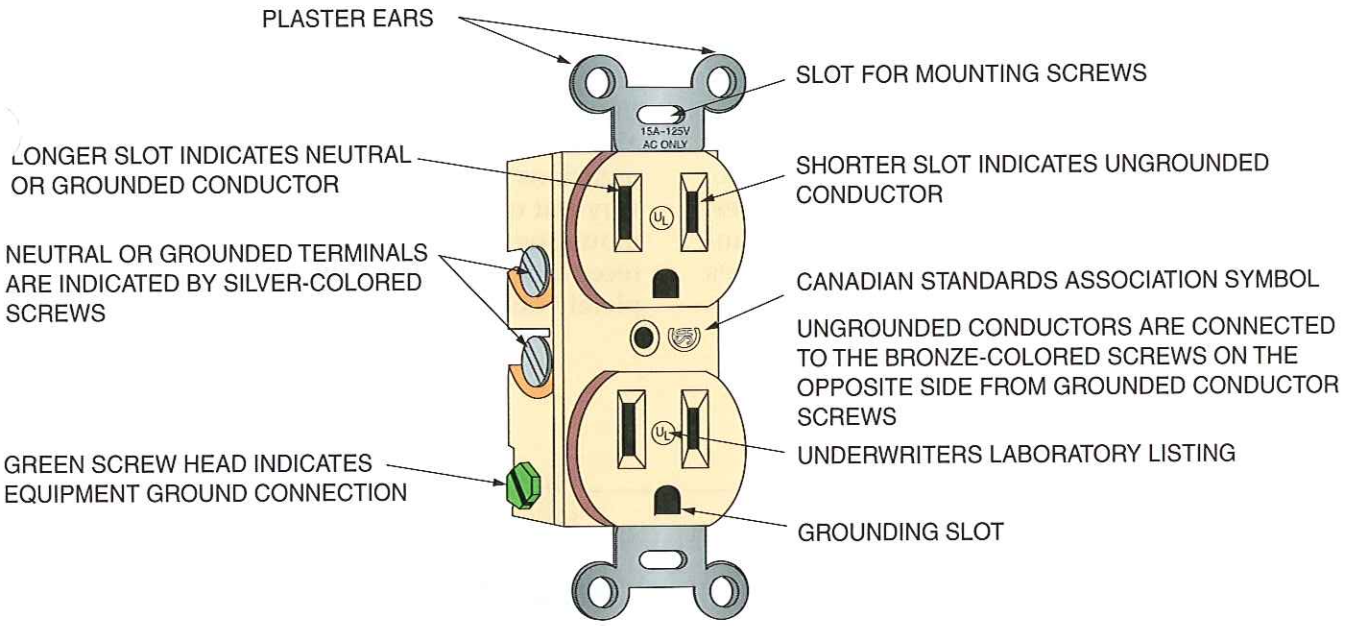

Figure 2 ◆ Typical duplex receptacle.

nationally recognized testing lab and has met certain minimum safety requirements. The label does not indicate quality. The receptacle in *Figure 2* is marked with the UL label, which indicates that the device type was tested by Underwriters Laboratories, Inc. of Northbrook, IL. ETL Testing Laboratories, Inc. of Cortland, NY is another nationally recognized testing laboratory. These laboratories provide labeling, listing, and follow-up service for the safety testing of electrical products to nationally recognized safety standards or specifically designated requirements of jurisdictional authorities. The CSA label is an indication that the material or device has undergone a similar testing procedure by the Canadian Standards Association and is acceptable for use in Canada.

Current and voltage ratings are listed by maximum amperage, maximum voltage, and current restriction. On the device shown in *Figure 2*, the maximum current rating is 15A. The maximum voltage allowed on this device is 125V.

Conductor markings are also usually found on duplex receptacles. Receptacles with quick-connect wire clips will be marked *USE No. 14 SOLID WIRE ONLY*. If the inscription CO/ALR is marked on the receptacle, either copper, aluminum, or copper-clad aluminum wire may be used. The letters ALR stand for aluminum revised. Receptacles marked with the inscription CU/AL should be used for copper only, although they were originally intended for use with aluminum also. However, such devices frequently failed when connected to 15A or 20A circuits. Consequently, devices marked with CU/AL are no longer acceptable for use with aluminum conductors.

The remaining markings on duplex receptacles may include the manufacturer's name or logo, the words *WIRE RELEASE* inscribed under the wire release slots, and the letters GR beneath or beside the green grounding screw.

The screw terminals on receptacles are color-coded. For example, the terminal with the green screw head is the equipment ground connection and is connected to the U-shaped slots on the receptacle. The silver-colored terminal screws are for connecting the grounded or neutral conductors and are associated with the longer of the two vertical slots on the receptacle. The brass-colored terminal screws are for connecting the ungrounded or hot conductors and are associated with the shorter vertical slots on the receptacle.

NOTE

The long vertical slot accepts the grounded or neutral conductor. The shorter vertical slot accepts the ungrounded or hot conductor.

2.2.0 Mounting Receptacles

Although no actual *NEC®* requirements exist for mounting heights and positioning of receptacles, other than the prohibition against mounting receptacles face up on countertops and similar work surfaces, there are certain *NEC®* guidelines

regarding receptacle placement. For example, the *NEC*® states that receptacles shall be not more than 20" above the countertop per *NEC Section 210.52(C)(5).* Also, where allowed, receptacles may not be located more than 12" below the countertop surface. See *NEC Section 210.52(C)(5) Exception.* In addition to these *NEC*® guidelines, certain installation methods have become standard in the electrical industry. *Figure 3* shows common mounting heights of duplex receptacles used on conventional residential and small commercial installations. However, these dimensions are frequently varied to suit the building structure. For example, ceramic tile might be placed above a kitchen or bathroom countertop. If the dimensions in *Figure 3* put the receptacle part of the way out of the tile (i.e., half in and half out), the mounting height should be adjusted to place the receptacle either completely in the tile or completely out of the tile, as shown in *Figure 4.*

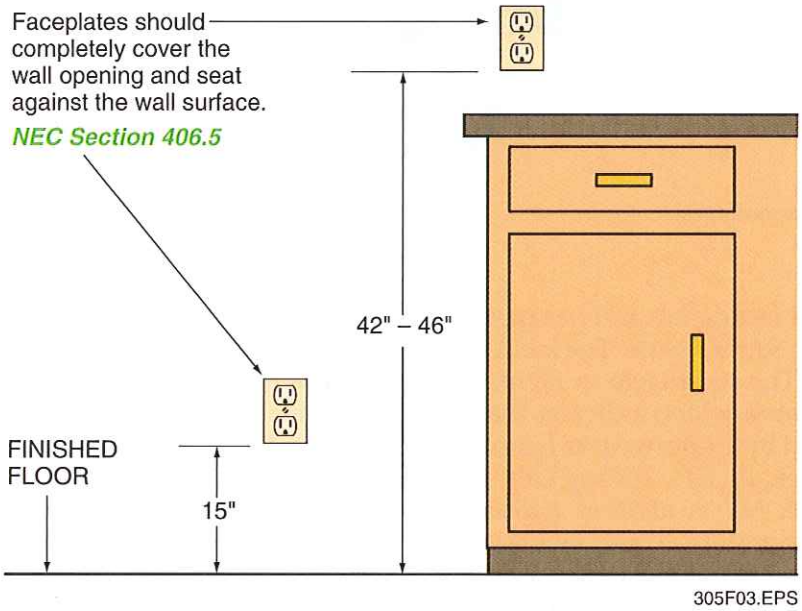

Figure 3 ◆ Mounting heights of duplex receptacles.

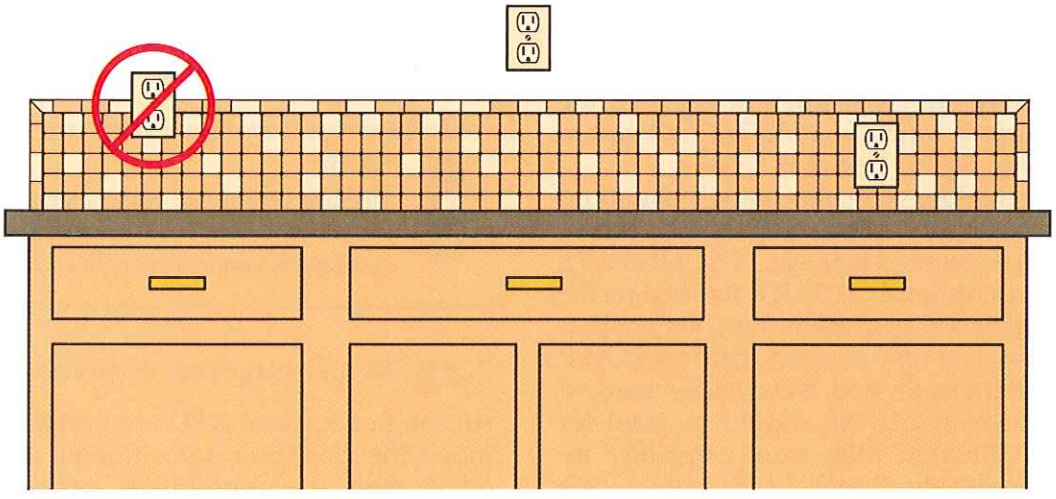

Figure 4 ◆ Adjusting mounting heights.

Refer again to *Figure 3* and note that the mounting heights are given to the bottom of the outlet box. Many dimensions on electrical drawings are given to the center of the outlet box or receptacle. However, during the actual installation, workers installing the outlet boxes can mount them more accurately (and in less time) by lining up the bottom of the box with a chalk mark rather than trying to eyeball this mark to the center of the box.

A decade or so ago, most electricians mounted receptacle outlets 12" from the finished floor to the center of the outlet box. However, a recent survey taken of over 500 homeowners shows that they prefer a mounting height of 15" from the finished floor to the bottom of the outlet box. It is easier to plug and unplug the **cord** assemblies at this height. However, always check the working drawings, written specifications, and details of construction for measurements that may affect the mounting height of a particular receptacle outlet. For example, those confined to wheelchairs may require more specific receptacle height locations to fit their individual needs.

NOTE

Be sure to check local codes as well as the job specifications for specific receptacle mounting requirements.

NEC Section 314.20 requires all outlet boxes installed in walls or ceilings of concrete, tile, or other noncombustible material, such as plaster or drywall, to be installed in such a manner that the front edge of the box or fitting is not set back from the finished surface by more than ¼". Where walls and ceilings are constructed of wood or other combustible materials, outlet boxes and fittings must be flush with the finished surface of the wall. See *Figure 5*.

Wall surfaces such as drywall or plaster that contain wide gaps or are broken, jagged, or otherwise damaged, must be repaired so there will be no gaps or open spaces greater than ⅛" between the outlet box and the wall material. These repairs should be made prior to installing the faceplate. Such repairs are best made using a noncombustible caulking or spackling compound. See *Figure 6*.

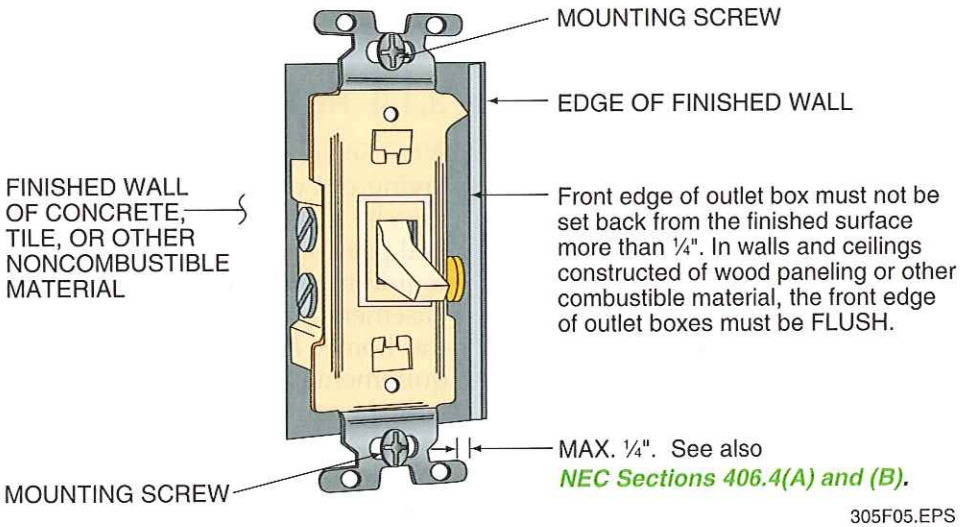

Figure 5 ◆ *NEC*® requirements for mounting outlet boxes in walls or ceilings.

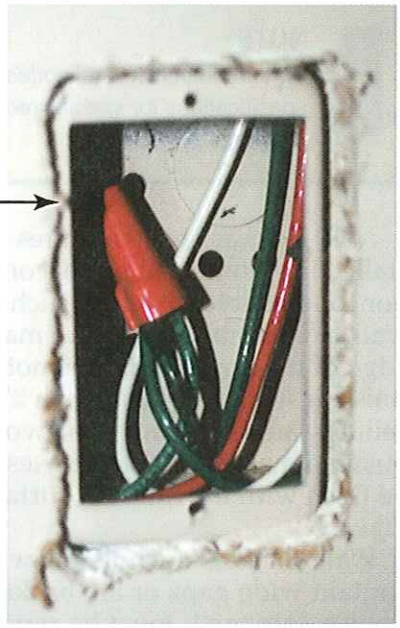

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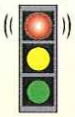
Figure 6 ◆ Gaps or openings around outlet boxes must be repaired.

2.3.0 Types of Receptacles

There are many types of receptacles. For example, the duplex receptacles discussed previously are the straight-blade type, which accepts a straight blade connector or plug. This is the most common type of receptacle in the U.S. and can be found on virtually all electrical projects from residential to large industrial installations.

- *Twist lock receptacles* – Twist lock receptacles are designed to accept a slightly curved blade connector or plug. The plug/connector and the receptacle lock together with a slight twist. This prevents accidental unplugging of the equipment.
- *Pin-and-sleeve receptacles* – Pin-and-sleeve devices have a unique locking feature. These receptacles are made with an extremely heavy-duty plastic housing. They are manufactured with long brass pins for long life and are color-coded according to voltage for easy identification.
- *Low-voltage receptacles* – These receptacles are designed for both AC and DC systems where the maximum potential is 50V. Receptacles used for low-voltage systems must have a minimum current-carrying capacity of 15A.
- *480V receptacles* – Portable electrical equipment operating at 460V to 480V is common on many industrial installations. This includes welders, battery chargers, and other types of portable equipment. Special 480V plugs and receptacles are used to connect and disconnect such equipment from a power source. Equipment grounding is required in all cases.



WARNING!

Make certain that the plug-and-cord assembly is compatible with both the equipment and receptacle before connecting to any receptacle. Polarity and equipment grounding checks on the plug-and-cord assembly should be made on a monthly basis or more often if subjected to hard use.

3.0.0 ◆ LOCATING RECEPTACLES

Several *NEC*® sections specify requirements for locating receptacles in all types of installations. This section presents a summary of these requirements.

3.1.0 Residential Occupancies

NEC Section 210.52 should be referred to when laying out outlets for residential and some commercial installations. This section details the general provisions along with small appliance circuit requirements, laundry requirements, unfinished basements, attached garages, and other areas of the home. *Figure 7* illustrates various *NEC*® requirements for locating receptacles.

In general, every dwelling—regardless of its size—must have receptacles located in each habitable area so that no point along the floor line in any wall space (2' wide or wider) is more than 6' from an outlet in that space. The purpose of this requirement is to prevent the need for extension cords and to minimize the use of cords across doorways, fireplaces, and similar openings.

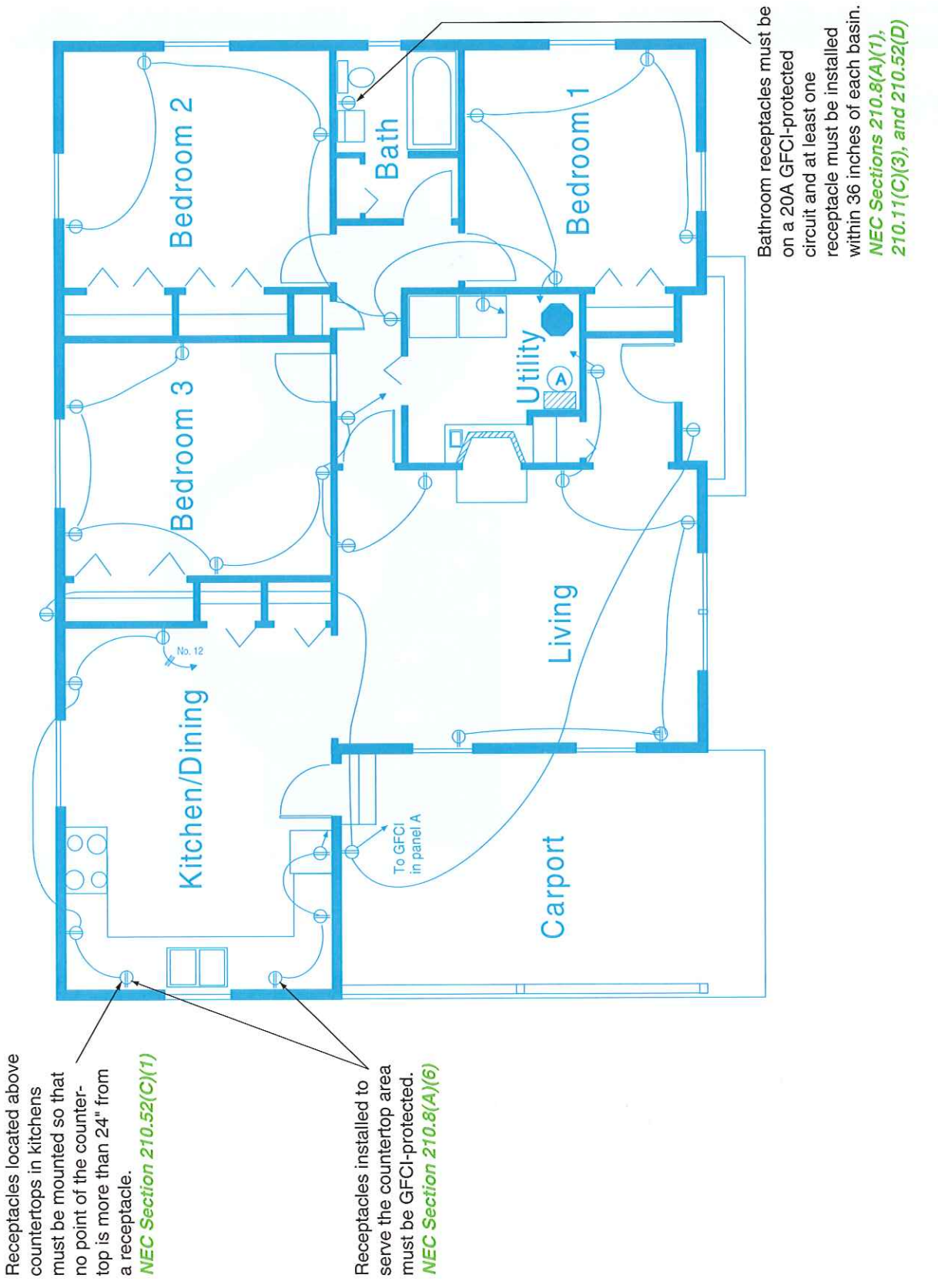


Figure 7 ◆ *NEC*® requirements for locating receptacles.

INSIDE TRACK

Hazardous Location Receptacles

Arc-eliminating receptacles like the one shown here are typically found in petrochemical facilities and other classified locations.

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In addition, a minimum of two 20A small appliance branch circuits are required to serve all receptacle outlets, including refrigeration equipment, in the kitchen, pantry, breakfast room, dining room, or similar area of the dwelling unit. Such circuits, whether two or more are used, must have no other outlets connected to them other than in the rooms listed.

At least one receptacle is required in each laundry area, supplied by a separate 20A circuit, on the outside of the building at the front and back (GFCI protected), in each basement, in each attached and detached garage, in each hallway 10' or more in length, and at an accessible location for servicing any HVAC equipment. *Figures 8 and 9* summarize these and other *NEC®* requirements regarding the installation of receptacles in dwelling units.

When upgrading existing electrical systems, the *NEC®* permits the use of a GFCI receptacle in place of an ungrounded receptacle. With such an arrangement, additional grounded receptacles may be connected on the load side connections of the GFCI, but must be marked *No Equipment Ground* per *NEC Section 406.3(D)(3)(b),* as shown in *Figure 10.*

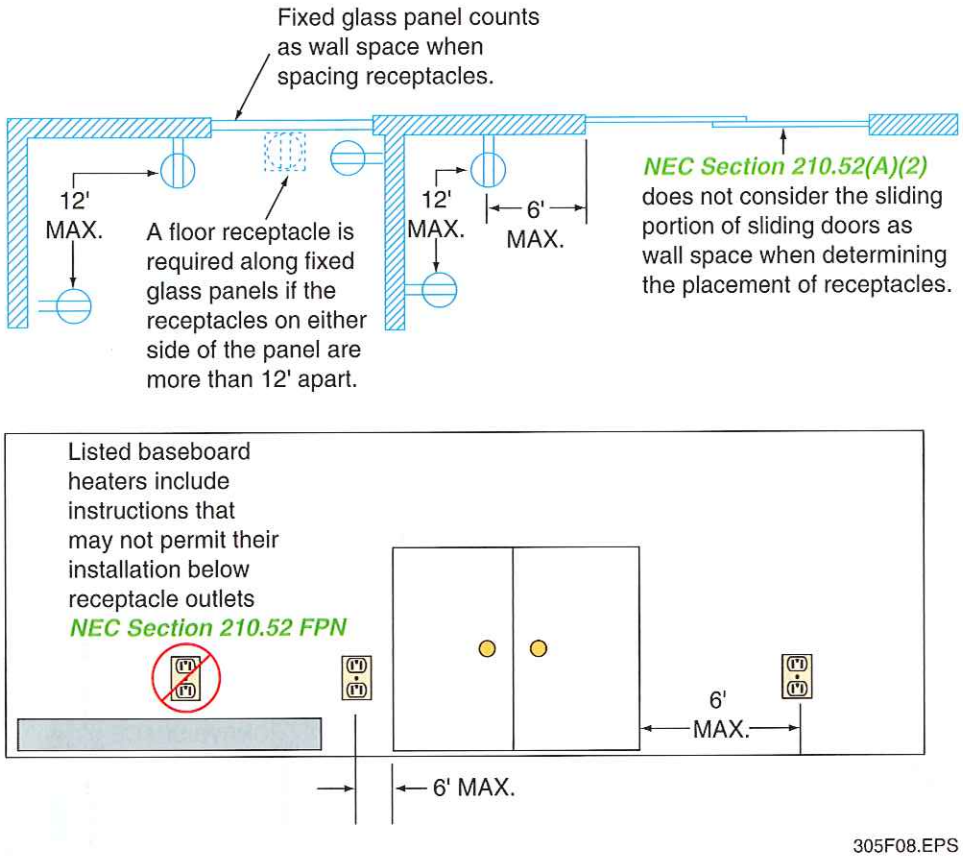


Figure 8 ◆ *NEC®* requirements for dwelling unit receptacles.

Other receptacles and related circuits are provided as needed according to the load to be served. For example, receptacles are normally provided in residential occupancies for electric ranges, clothes dryers, and similar appliances. Most operate on 120/240V branch circuits using 30A to 60A receptacles.

3.2.0 Commercial Applications

Receptacles for commercial installations have only a few code-driven installation requirements. For example, *NEC Section 210.60(A)* states that guest rooms in hotels, motels, and similar occupancies must have receptacle outlets installed in accordance with *NEC Sections 210.52(A) and 210.52(D). NEC Section 210.60(B)* permits receptacle outlets to be located conveniently for permanent furniture layout. At least two receptacles shall be readily accessible.

The only other requirement for commercial installations deals with the placement of receptacle outlets in show windows. *NEC Section 210.62* requires at least one receptacle for each 12 linear feet of show window area measured horizontally at its maximum width. See *Figure 11*. To calculate the number of receptacles required at the top of any show window, measure the total linear feet and then divide this figure by 12. Any remainder or major fraction thereof requires an additional receptacle. For example, the show window in *Figure 11* is 18' in length. Consequently, the number of receptacles required may be calculated as follows:

$$\frac{18'}{12'} = 1.5 \text{ receptacles}$$

To comply with *NEC Section 210.62*, two receptacles are required in this area. Had the calculation resulted in a figure of 1.01, the local inspection authorities would probably require only one receptacle in the show window.

Of course, GFCIs are required on all 15A and 20A receptacles installed in commercial bathrooms, commercial garages, crawlspaces, kitchens, rooftops, boathouses (other than shore-powered outlets), and all receptacles installed outdoors.

Other receptacles and related circuits are provided as needed according to the load to be served.

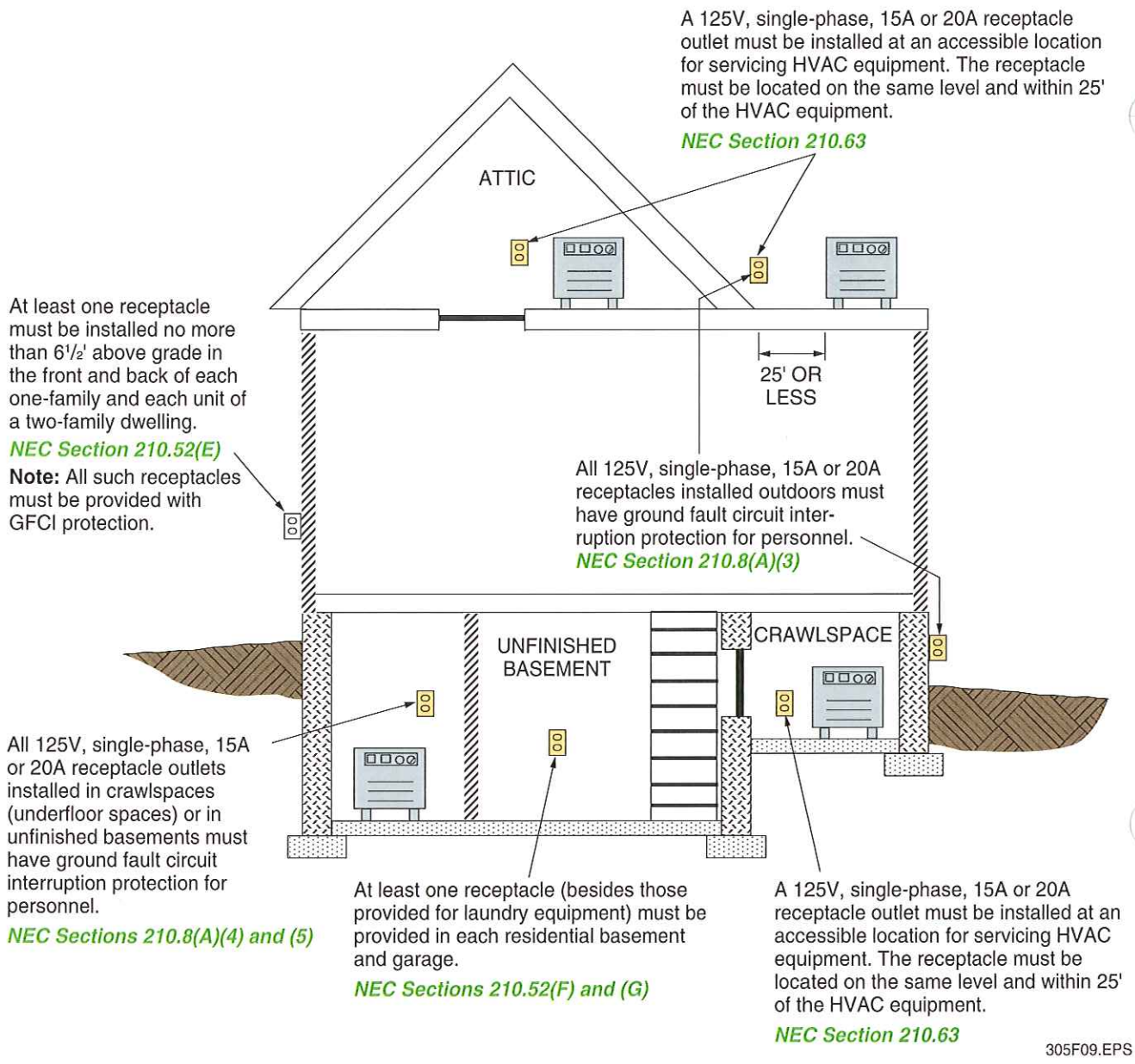


Figure 9 ◆ *NEC*® requirements for placement of dwelling unit receptacles.

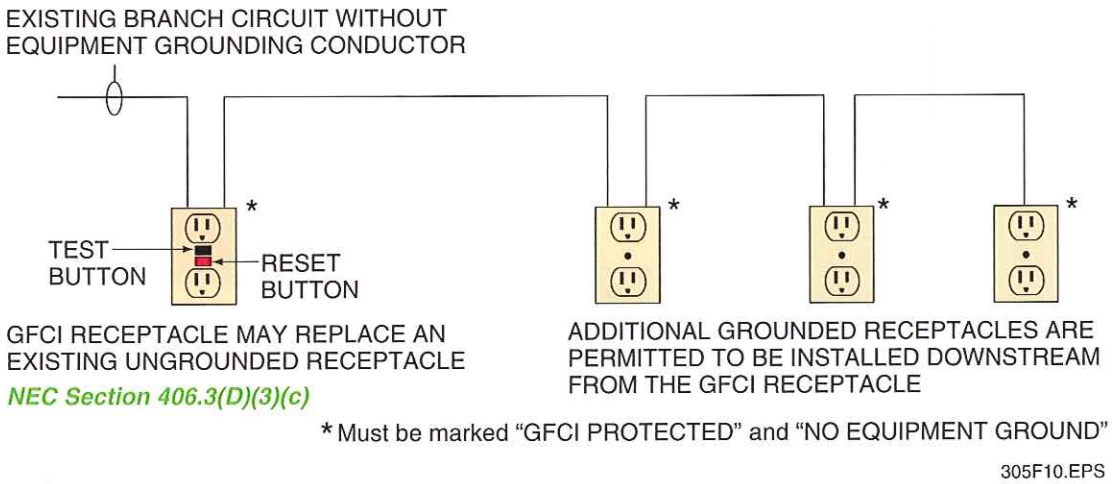


Figure 10 ◆ A GFCI may replace an ungrounded receptacle.

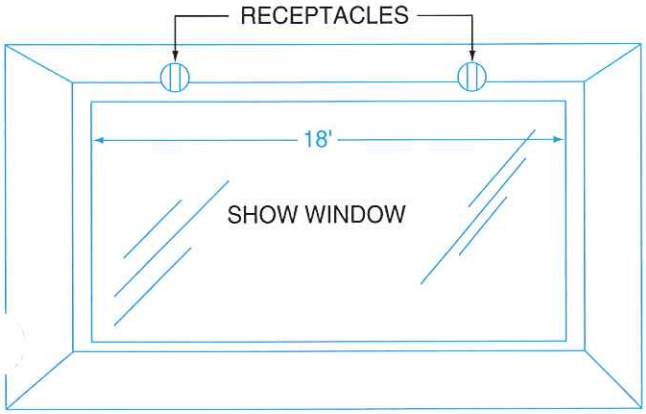


Figure 11 ◆ Commercial show window receptacle placement.

NOTE

Per *NEC Section 220.14(I),* the number of general-purpose receptacles permitted on a branch circuit is calculated at not less than 180VA for each receptacle on a yoke. This is not applicable to dwelling occupancies per *NEC Section 220.14(J).*

4.0.0 ◆ SWITCHES

The purpose of a switch is to make and break an electrical circuit in a safe and convenient manner. In doing so, a switch may be used to manually control lighting, motors, fans, and various other items connected to an electrical circuit. Switches may also be activated by light, heat, chemicals, motion, and electric energy for automatic operation. *NEC Article 404* covers the installation and use of switches.

The *NEC*® switch definitions are as follows:

- *Bypass isolation switch* – This is a manually operated device used in conjunction with a transfer switch to provide a means of directly connecting load conductors to a power source and of disconnecting the transfer switch.
- *General-use switch* – A switch intended for use in general distribution and branch circuits. It is rated in amperes and is capable of interrupting its rated current at its rated voltage.
- *General-use snap switch* – A form of general-use switch that is designed for installation in device boxes or on outlet box covers, or otherwise used in conjunction with wiring systems recognized by the *NEC*®.
- *Isolation switch* – A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating and is intended to be operated only after the circuit has been opened by some other means (see *Figure 12*).

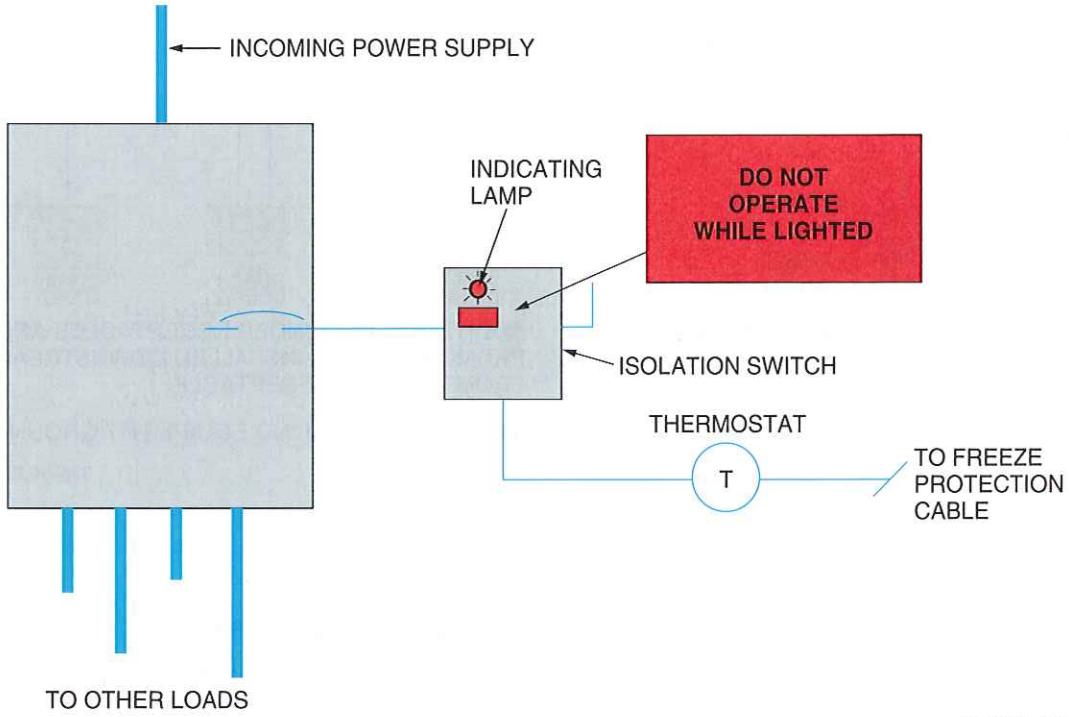


Figure 12 ◆ Isolation switch.

- *Motor circuit switch* – A switch that is rated in horsepower and is capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at its rated voltage.
- *Transfer switch* – A device used to transfer one or more load conductor connections from one power source to another. This type of switch may be either automatic or nonautomatic.

4.1.0 Switch Configurations

Although basic switch terms are covered to some extent in earlier modules, a brief review is warranted here. In general, the major terms used to identify the characteristics of switches are pole and throw.

The term pole refers to the number of conductors that the switch will control in the circuit. For example, a single-pole switch breaks the connection to only one conductor in the circuit. A double-pole switch breaks the connection to two conductors, and so forth.

The term throw refers to the number of internal operations that a switch can perform. *Figure 13* shows common switch configurations. For example, a single-pole, single-throw switch will make one conductor when thrown in one direction (the ON position) and break the circuit when thrown in the opposite direction (the OFF position). The common ON/OFF toggle switch is a single-pole, single-throw (SPST) switch. The single-pole, double-throw (SPDT) switch, also known as the **three-way switch,** is used to control a single load, such as a lamp, from two locations. A double-pole, single-throw (DPST) switch opens or closes two conductors at the same time. Both conductors are either open or closed, that is, in the ON or OFF position. A double-pole, double-throw (DPDT) switch is used to direct a two-wire circuit through one of two different paths. One application of a double-pole, double-throw switch is an electrical transfer switch in which certain circuits may be energized from either the main electric service or from an emergency standby generator. The double-pole, double-throw switch makes the circuit from one or the other and prevents the circuit from being energized from both sources at once.

4.2.0 Switch Identification

Switches vary in grade, capacity, and purpose. It is very important that the proper type of switch be selected for the given application. For example, most single-pole toggle switches used for the control of lighting are restricted to AC use only and are not suitable for use on DC circuits, such as a 32VDC emergency lighting circuit. A switch rated for AC only will not extinguish a DC arc quickly enough. Not only is this a dangerous practice

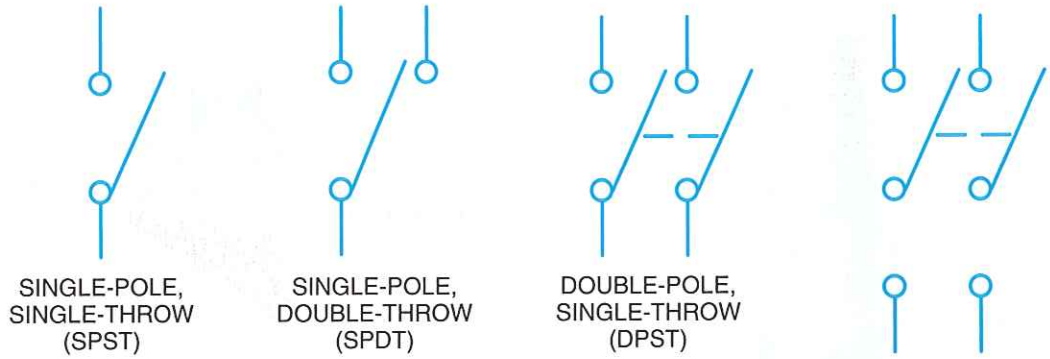
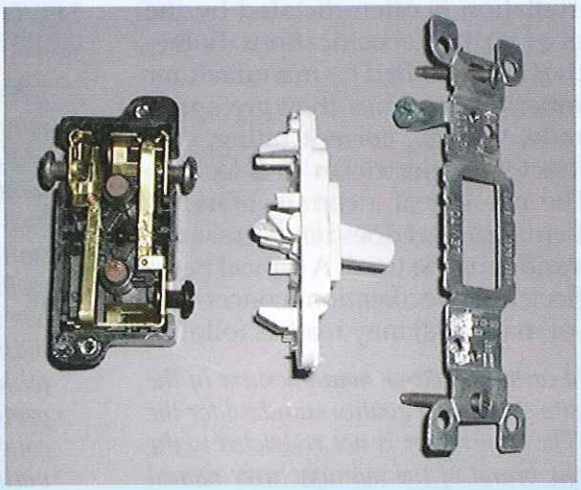


Figure 13 ◆ Common switch configurations.

INSIDE TRACK

Three-Way Switches

This photo shows a three-way switch that has been disassembled. Notice the contact arrangement inside the switch housing. The black-colored screw on the bottom right is permanently and electrically connected to the two brass-colored arms that contact either one of the two upper screw terminals as the white switch handle or toggle is moved from one position to the other.



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(causing arcing and heating of the device), but the switch contacts would probably burn up after only a few operations of the handle, if not the first time.

Figure 14 shows a typical single-pole toggle switch—the type most often used to control AC lighting in all installations. Note the identifying marks. They are similar to those on the duplex receptacle discussed previously.

Screw terminals are also color-coded on conventional toggle switches. Switches are typically constructed with a ground screw attached to the metallic strap of the switch. The ground screw is usually a green-colored hex head screw. This screw is for connecting the equipment grounding conductor to the switch. On three-way switches, the common or pivot terminal usually has a black or bronze screw head.

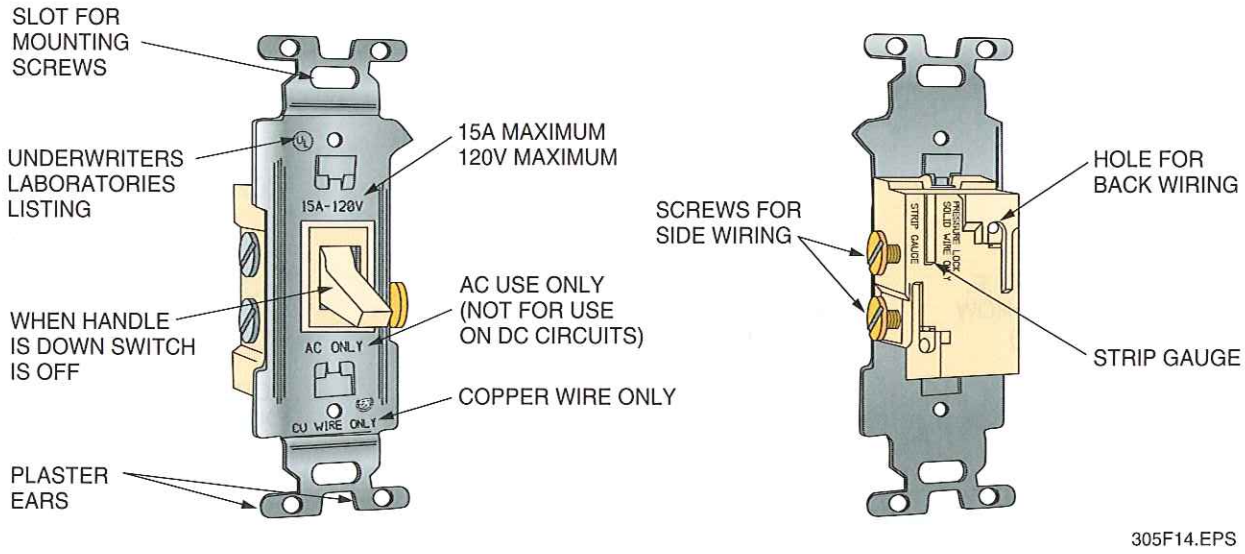

Figure 14 ◆ Identifying marks on a single-pole, single-throw toggle switch.

The switch shown is the type normally used for residential construction. Heavy-duty switches are normally used on commercial wiring. Some heavy-duty switches are rated for use on 277V circuits with current-carrying ratings up to 30A. It is important to check the rating of each switch before it is installed.

The exact type and grade of switch to be used on a specific installation is often dictated by the project drawings or written specifications. Sometimes wall switches are specified by manufacturer and catalog number; other times they are specified by type, grade, voltage, current rating, etc., leaving the contractor or electrician to select the manufacturer. The naming of a certain brand of switch for a particular project does not necessarily mean that this brand must be used. A typical paragraph from an electrical specification (concerning the substitution of materials) may read as follows:

> *The naming of a certain make or manufacturer in the Specifications is to establish a quality standard for the article desired. The Contractor is not restricted to the use of the specific brand of the manufacturer named unless so indicated in the Specifications. However, where a substitution is requested, a substitution will be permitted only with the written approval of the Architect-Engineer. No substitute material or equipment shall be ordered, fabricated, shipped, or processed in any manner prior to the approval of the Architect-Engineer. The Contractor shall assume all responsibility for additional expenses as required in any way to meet changes from the original material or equipment specified. If notice of substitution is not furnished to the Architect-Engineer within ten days after the contract is awarded, the equipment and materials named in the Specifications are to be used.*

Electrical specifications dealing with wall switches are covered in at least two sections of the specifications:

- 16100, *Basic Materials and Methods*
- 16500, *Lighting*

Brief excerpts from these two sections follow.

SECTION 16B—BASIC MATERIALS AND WORKMANSHIP

> *SWITCH OUTLET BOXES: Wall switches shall be mounted approximately 54" above the finished floor (AFF) unless otherwise noted. When the switch is mounted in a masonry wall, the bottom of the outlet box shall be in line with the bottom of a masonry unit. Where more than two switches are located, the switches shall be mounted in a* ***gang switch*** *outlet box with gang cover. Dimmer switches shall be individually mounted unless otherwise noted. Switches with pilot lights, switches with overload motor protection, and other special switches that will not conveniently fit under gang wall plates may be individually mounted.*

EQUIPMENT AND INSTALLATION WORKMANSHIP

> *a. All equipment and material shall be new and shall bear the manufacturer's name and trade name. The equipment and material shall be essentially the standard product of a manufacturer regularly engaged in the production of the required type of equipment and shall be the manufacturer's latest approved design.*
> *b. The Electrical Contractor shall receive and properly store the equipment and material pertaining*

to the electrical work. The equipment shall be tightly covered and protected against dirt, water, chemical or mechanical injury, and theft. The manufacturer's directions shall be followed completely in the delivery, storage, protection, and installation of all equipment and materials.

c. The Electrical Contractor shall provide and install all items necessary for the complete installation of the equipment as recommended or as required by the manufacturer of the equipment or required by code without additional cost to the Owner, regardless of whether the items are shown on the plans or covered in the Specifications.

d. It shall be the responsibility of the Electrical Contractor to clean the electrical equipment, make necessary adjustments, and place the equipment into operation before turning the equipment over to the Owner. Any paint that was scratched during construction shall be touched up with factory color paint to the satisfaction of the Architect. Any items that were damaged during construction shall be replaced.

WIRING DEVICES

a. GENERAL: The wiring devices specified below with Arrow Hart numbers may also be the equivalent wiring device as manufactured by Bryant Electric, Harvey Hubbell, or Pass & Seymour. All other items shall be as specified.
(1) Single Pole AH#1991
(2) Three-Way AH#1993
(3) Four-Way AH#1994
(4) Switch with pilot light AH#2999-R
(5) Motor Switch—Surface AH#6808
(6) Motor Switch—Flush AH#6808-F

b. WALL SWITCHES: Where more than one flush wall switch is indicated in the same location, the switches shall be mounted in gangs under a common plate.

c. WALL PLATE: Stainless steel wall plates with satin finish minimum 0.030 inches shall be provided for all outlets and switches.

In general, the preceding electrical specifications give the grade of materials to be used on the project and the manner in which the electrical system must be installed. Most specification writers use an abbreviated language; although it is relatively difficult for beginners to understand, experience makes possible a proper interpretation with little difficulty. However, electricians involved with any project should make certain that everything is clear. If it is not, contact the architectural or engineering firm and clarify the problem prior to performing the work, not after a system has been completed.

5.0.0 ◆ *NEC*® REQUIREMENTS FOR SWITCHES

There are many *NEC*® requirements for installing light switches (*Figure 15*). For example, wall switch-controlled lighting outlets are required in each habitable room of all residential occupancies. Wall switch-controlled lighting is also required in each bathroom, hallways, stairways, attached garages, and at outdoor entrances. A wall switch-controlled receptacle may be used in place of the lighting outlet in habitable rooms other than the kitchen and bathrooms. Providing a wall switch for room lighting is intended to prevent an occupant's groping in the dark for table lamps or pull chains. In stairways with six or more steps, the stairway lighting must be controlled at two locations—at both the top and bottom of the stairway. This is accomplished by using two three-way switches, as discussed in previous modules.

Lighting outlets are also required in attics, crawlspaces, utility rooms, and basements when these spaces are used for storage or contain equipment requiring servicing, such as HVAC equipment. Again, if the basement or attic stairs have six or more steps, a three-way switch is required at each landing.

At least one wall switch-controlled lighting outlet is required in each guest room in hotels, motels, or similar locations, as shown in *Figure 16*. In areas other than kitchens, bathrooms, and hallways, a wall switch-controlled receptacle is permitted in lieu of the lighting outlet.

In many commercial installations, circuit breakers in panelboards that are listed and marked as such are permitted by *NEC Section 404.11* and *NEC Section 240.83(D)* to control main area lighting where the areas are constantly illuminated during operating hours. Consequently, wall switches are not required in these areas. However, wall switches are normally installed at outdoor entrances, entrances to storerooms, small offices, toilets, and similar locations.

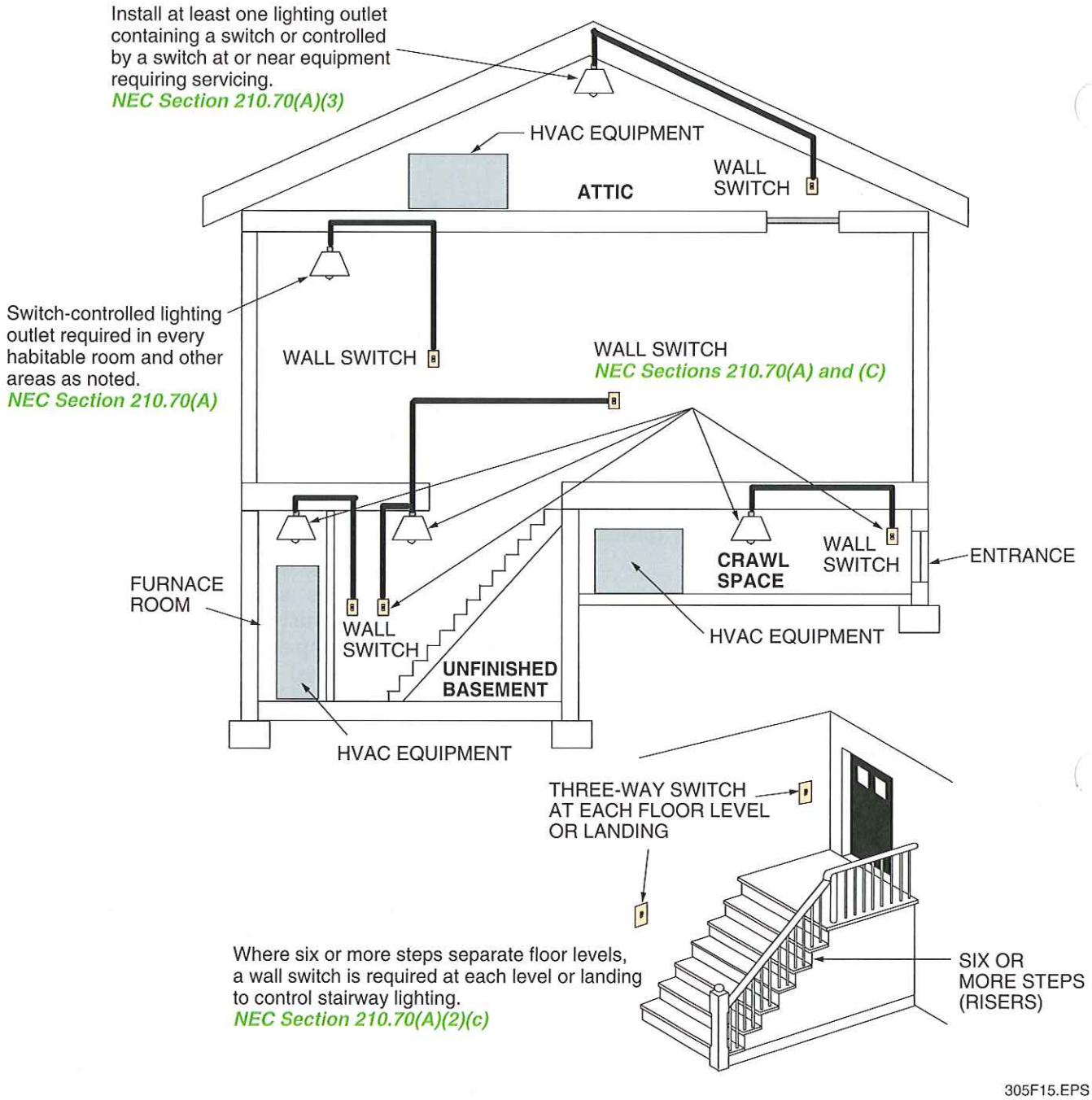

Figure 15 ◆ *NEC®* requirements for residential wall switches.

INSIDE TRACK

Finding Location Requirements for Switched Lighting in the NEC®

Even though *NEC Article 404* covers some of the requirements of switch installations, you must also refer to *NEC Section 210.70* to find the location requirements for switched lighting.

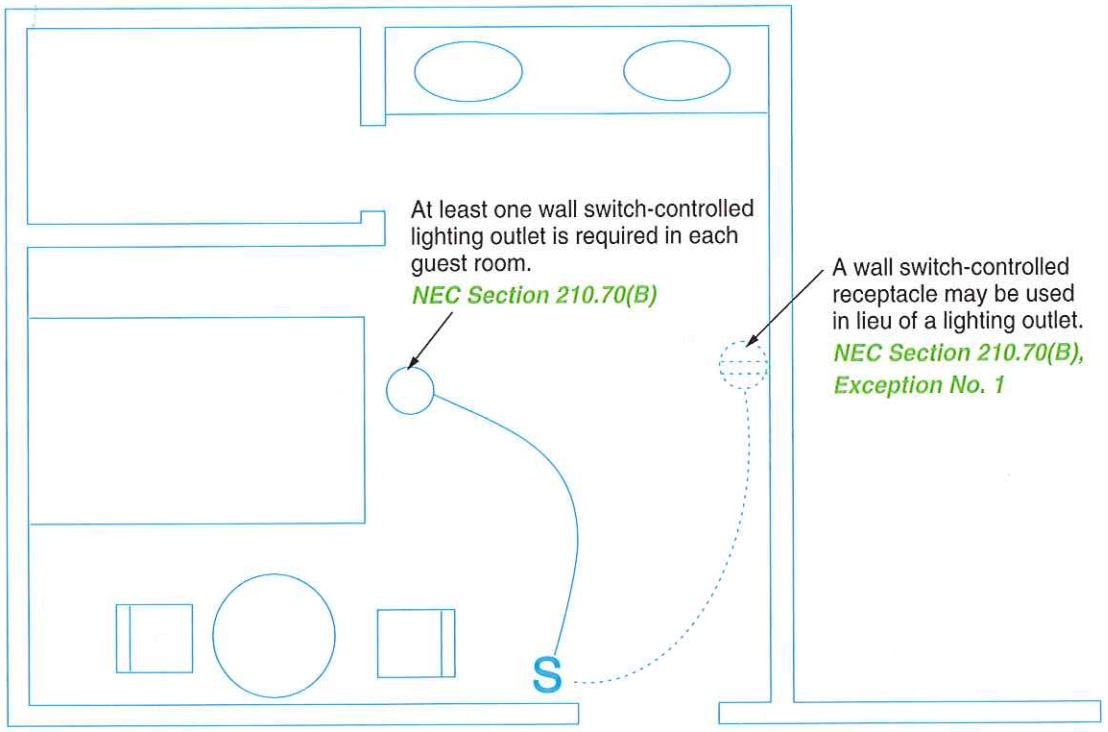

Figure 16 ◆ Wall switch requirements for guest rooms.

Wiring diagrams of switch circuits (single-pole, three-way, and **four-way switches**) were thoroughly discussed in previous modules and these diagrams will not be repeated here. However, it is recommended that the trainee review these diagrams at this time if deemed necessary.

6.0.0 ◆ SAFETY SWITCHES

Enclosed single-throw safety switches are manufactured to meet industrial, commercial, and residential requirements. See *Figure 17*. The two basic types of safety switches are:

- General-duty
- Heavy-duty

Double-throw switches are also manufactured with enclosures and features similar to the general-duty and heavy-duty single-throw designs.

The majority of safety switches have visible blades and safety handles. The switch blades are in full view when the enclosure door is open and there is visually no doubt when the switch is off. The only exceptions are NEMA Type 7 and 9 enclosures; these do not have visible blades. The switch handles on all types of enclosures are an integral part of the box, not the cover, so that the handle is in control of the switch blades under

Figure 17 ◆ Typical safety switches.

normal conditions. *NEC Table 430.91* provides a partial listing of enclosure types and what they provide.

6.1.0 Heavy-Duty Switches

Heavy-duty switches are intended for applications where ease of maintenance, rugged construction, and continued performance are primary concerns. They can be used in atmospheres

where general-duty switches would be unsuitable, and are therefore widely used in industrial applications. Heavy-duty switches are rated 30A through 1,200A and 240V to 600VAC or VDC. Switches with horsepower ratings are capable of opening a circuit up to six times the rated current of the switch. When equipped with Class J or Class R fuses for 30A through 600A switches, or Class L fuses in 800A and 1,200A switches, many heavy-duty safety switches are UL listed for use on systems with up to 200,000 rms symmetrical amperes available fault current. This, however, is about the highest short circuit rating available for any heavy-duty safety switch. Applications include use where the required enclosure is NEMA Type 1, 3R, 4, 4X, 7, 9, 12, or 12K.

6.1.1 Switch Blades and Jaws

Two types of switch contacts are used in today's safety switches: the butt contact and the knife blade and jaw. On switches with knife blade construction, the jaws distribute a uniform clamping pressure on both sides of the blade contact surface. In the event of a high-current fault, the electromagnetic forces that develop squeeze the jaws tightly against the blade. In the butt-type contact, only one side of the blade's contact surface is held in tension against the conducting path. Electromagnetic forces due to high current faults force the contacts apart, causing them to burn severely. Consequently, the knife blade and jaw construction is the preferred type for use on all heavy-duty switches. The action of the blades moving in and out of the jaws aids in cleaning the contact surfaces. All current-carrying parts of these switches are plated to reduce heating by keeping oxidation to a minimum. Switch blades and jaws are made of copper for high conductivity. Spring-clamped blade hinges are another feature that helps ensure clean contact surfaces and cool operation. Visible blades are used to provide visual evidence that the circuit has been opened.

WARNING!

Before changing fuses or performing maintenance on any safety switch, always visually check the switch blades and jaws to ensure that they are in the OFF position, and verify with a voltage tester.

6.1.2 Fuse Clips

Fuse clips are plated to control corrosion and to keep heating to a minimum. All fuse clips on heavy-duty switches have steel reinforcing springs for increased mechanical strength and firmer contact pressure. See *Figure 18*.

6.1.3 Terminal Lugs

Most heavy-duty switches have front removable, screw-type terminal lugs. Most switch lugs are suitable for copper or aluminum wire except NEMA Type 4, 4X, 12, and 12K switches, which have all-copper current-carrying parts and lugs designated for use with copper wire only. Listed equipment with terminal lugs is suitable for the wire sizes and number of wires per terminal as stated in *NEC Tables 312.6(A) and (B)*.

6.1.4 Insulating Material

As the voltage rating of switches is increased, arc suppression becomes more difficult, and the choice of insulation material becomes more critical. Arc suppressors are usually made of insulation material and magnetic suppressor plates when required. All arc suppressor materials must provide proper control and extinguishing of arcs.

6.1.5 Operating Mechanism and Cover Latching

Most heavy-duty safety switches have a spring-driven, quick-make, quick-break mechanism. A quick-break action is necessary to safely switch the mechanism OFF under a heavy load.

The spring action, in addition to making the operation quick-make, quick-break, firmly holds the switch blades in the ON or OFF position. The operating handle is an integral part of the switching mechanism and is in direct control of the switch blades under normal conditions.

The switching mechanism should include a one-piece crossbar connected to all switch blades. This adds to the overall stability and integrity of the switching assembly by promoting proper alignment and uniform switch blade operation.

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Figure 18 ◆ Fuse clip.

Mounting Single-Throw Knife Switches

INSIDE TRACK

Single-throw knife switches should always be mounted so that gravity tends to open the switch and not close it.

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CASE HISTORY

Visually Verifying Disconnection

A near-fatality occurred when an electrician received a 480V electrical shock while replacing damaged fuses in a pump motor switch. Although he placed the switch in the OFF position, the switch failed to disconnect the power to the fuses. It was discovered that the switch failed because of a missing screw in the switching arm linkage. If the switch had operated correctly, the fuse clips would have been de-energized, and the grounding bar would have effectively grounded all three fuses.

The Bottom Line: You must confirm the absence of power before grabbing fuses.

Dual cover interlocks are standard on most heavy-duty switches where the NEMA enclosure permits. However, NEMA Type 7 and 9 enclosures have bolted covers and obviously cannot contain dual cover interlocks. The purpose of a dual cover interlock is to prevent the enclosure door from being opened when the switch handle is in the ON position and to prevent the switch from being turned ON while the door is open. A means of bypassing the interlock is provided to allow an energized switch to be inspected by qualified personnel. However, this practice is extremely dangerous and should be avoided if at all possible. Heavy-duty switches can be padlocked in the OFF position with up to three padlocks.

6.1.6 Enclosures

Heavy-duty switches are available in a variety of enclosures that have been designed to conform to specific industry requirements based upon the intended use. Sheet metal enclosures (NEMA Type 1) are constructed from cold-rolled steel, which is usually phosphatized and finished with an electrode-deposited enamel paint. NEMA Type 3R rainproof and Type 12 and 12K dust-tight enclosures are manufactured from sheet steel and painted to provide better weather protection. NEMA Type 4 or 4X enclosures are made of corrosion-resistant stainless steel or nonmetallic materials. NEMA Type 7 and 9 enclosures are cast from copper-free aluminum and finished with an enamel paint. NEMA Type 1 switches are general-purpose devices designed for use indoors to protect personnel from live parts and the enclosed equipment from dirt. Switches rated through

200A are provided with ample knockouts; 400A through 1,200A switches are provided without knockouts.

The following are the NEMA enclosure types that will be encountered most often. Always make certain that the proper enclosure is chosen for the application.

NEMA Type 3R switches are designated rainproof and are designed for use outdoors. NEMA Type 3R enclosures for switches rated through 200A have provisions for interchangeable bolt-on hubs at the top endwall, as illustrated in *Figure 19*. NEMA Type 3R switches rated higher than 200A have blank top endwalls. Knockouts are provided (below live parts only) on enclosures for 200A and smaller Type 3R switches. Type 3R switches are available in ratings through 1,200A.

NEMA Type 4 and 4X switches are designated dust-tight, watertight, and corrosion-resistant, and are designed for indoor and outdoor use. Common applications include commercial kitchens, dairies, canneries, and other types of food processing facilities, as well as areas where mildly corrosive liquids are present. All NEMA Type 4 and 4X enclosures are provided without knockouts. The use of watertight hubs is required. Available switch ratings are 30A through 600A.

NEMA Type 12 and 12K switches are designated dust-tight (except at knockout locations on Type 12K) and are designed for indoor use. Common applications include heavy industrial use where the switch must be protected from dust, lint, flying material, oil seepage, etc. NEMA 12K switches have knockouts in the bottom and top endwalls only. Available switch ratings are 30A through 600A in Type 12 and 30A through 200A in Type 12K.

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Figure 19 ◆ NEMA Type 3R enclosure.

6.1.7 Interlocked Receptacles

Heavy-duty, 60A NEMA Type 1 and 12 switches with an interlocked receptacle are also available. This receptacle provides a means of connecting and disconnecting loads directly to the switch. A non-defeating interlock prevents the insertion or removal of the receptacle plug while the switch is in the ON position. It also prevents operation of the switch if an incorrect plug is used.

6.1.8 Accessories

Accessories for field installation include Class R fuse kits, fuse pullers, insulated neutrals with grounding provisions, equipment grounding kits, watertight hubs for use with NEMA Type 4 or 4X switches, and interchangeable bolt-on hubs for Type 3R switches.

An electrical interlock consists of auxiliary contacts for use where control or monitoring circuits need to be switched in conjunction with the safety switch operation. Kits can be either factory-installed or field-installed, and they contain either one normally open and one normally closed contact or two normally open and two normally closed contacts. The electrical interlock is actuated by a pivot arm that operates directly from the switch mechanism. The electrical interlock is designed so that its contacts disengage before the blades of the safety switch open and engage after the safety switch blades close.

6.2.0 General-Duty Switches

General-duty switches for residential and light commercial applications are used where operation and handling are moderate and where the available fault current is 10,000 rms symmetrical amperes or less. Some general-duty safety switches, however, exceed this specification in that they are UL listed for use on systems havin

up to 100,000 rms symmetrical amperes of available fault current when Class R fuses and Class R fuse kits are used. Class T fusible switches are also available in 400A, 600A, and 800A ratings. These switches accept 300VAC Class T fuses only. Some examples of general-duty switch applications include residential, farm, and small business service entrances and light-duty branch circuit disconnects.

General-duty switches are rated up to 600A at 240VAC in general-purpose (Type 1) and rainproof (Type 3R) enclosures. Some general-duty switches are horsepower-rated and capable of opening a circuit up to six times the rated current of the switch; others are not. Always check the switch specifications under a horsepower-rated condition before use.

6.2.1 Switch Blades and Jaws

All current-carrying parts of general-duty switches are plated to minimize oxidation and reduce heating. Switch jaws and blades are made of copper for high conductivity. Where required, a steel reinforcing spring increases the mechanical strength of the jaws and contact pressure between the blade and jaw. Good pressure contact maintains the blade-to-jaw resistance at a minimum, which in turn promotes cool operation. All general-duty switch blades feature visible blade construction. With the door open, there is visually no doubt when the switch is OFF. However, you should always verify this with a voltage tester.

6.2.2 Fuse Clips

Fuse clips are normally plated to control corrosion and keep heating to a minimum. Where required, steel reinforcing springs are provided to increase the mechanical strength of the fuse clip. The result is a firmer, cooler connection to the fuses, as well as superior fuse retention.

6.2.3 Terminal Lugs

Most general-duty safety switches are furnished with mechanical set screw lugs that are suitable for aluminum or copper conductors.

6.2.4 Insulating Material

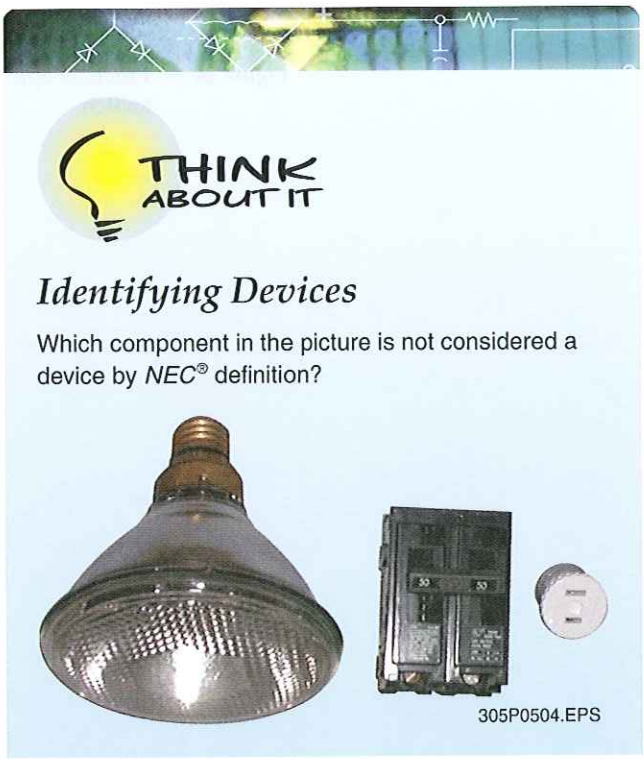
Switch and fuse bases are made of a strong, non-combustible, moisture-resistant material that provides the required phase-to-phase and phase-to-ground insulation.

6.2.5 Operating Mechanism and Cover Latching

Although not required by either the UL or NEMA standards, some general-duty switches have spring-driven, quick-make, quick-break operating mechanisms. Operating handles are an integral part of the operating mechanism and are not mounted on the enclosure cover. The handle provides an indication of the status of the switch. When the handle is up, the switch is ON. When the handle is down, the switch is OFF. A padlocking bracket is provided that allows the switch handle to be locked in the OFF position. Another bracket is provided that allows the enclosure to be padlocked closed.

6.2.6 Enclosures

General-duty safety switches are available in either a NEMA Type 1 enclosure for general-purpose indoor applications or a NEMA Type 3R enclosure for rainproof outdoor applications. Enclosure types were discussed in detail earlier in this module.



6.3.0 Double-Throw Safety Switches

Double-throw safety switches are used as manual transfer switches and are not intended for use as motor circuit switches; thus, horsepower ratings are generally unavailable. Double-throw switches are available as either fused or nonfusible devices. Two general types of switch operation are available:

- Quick-make, quick-break (for use where fast action is the most desirable feature)
- Slow-make, slow-break (for use where the application might expose the switch to voltage fluctuations or current surges on startup)

Figure 20 shows a practical application of a double-throw safety switch used as a transfer switch in conjunction with a standby emergency generator system.

6.4.0 *NEC*® Safety Switch Requirements

Safety switches, in both fusible and nonfusible types, are used as a disconnecting means for services, feeders, and branch circuits. Installation requirements involving safety switches are found in several places throughout the *NEC*®, including:

- *NEC Article 312*
- *NEC Article 404*
- *NEC Article 430, Part IX*
- *NEC Article 440, Part II*
- *NEC Section 450.8(C)*

When used as a service disconnecting means, the major installation requirements are listed in *Table 1.*

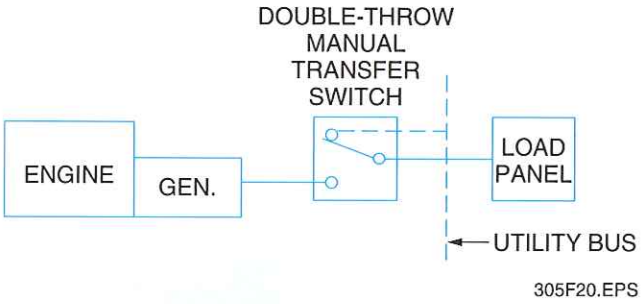


Figure 20 ◆ Practical application of a double-throw safety switch.

Table 1 *NEC*® Installation Requirements Governing Switches Used for Service Disconnects

Application	Installation Requirements	*NEC*® Reference or Comment
General	A means must be provided to disconnect all conductors serving the premises from service-entrance conductors. Each disconnecting means must be permanently identified. Disconnecting means must be installed at a readily accessible location nearest the service-entrance conductors. Service disconnecting means cannot be installed in bathrooms. Each service disconnecting means must be suitable for the prevailing conditions.	*NEC Section 230.70*
Number of disconnects	Service disconnecting means can consist of no more than six switches for each service.	*NEC Section 230.71*
	The two to six disconnects permitted above shall be grouped. Each disconnect shall be identified as to the load served. *Exception:* Disconnect for the water pump of a fire pump protection system.	*NEC Section 230.72*
Service disconnecting means	The service disconnecting means shall not be rated less than the load to be carried: *One circuit*—Not less than 15A *Two circuits*—Not less than 30A *Single-family dwelling*—Not less than three-wire, 100A *All others*—Not less than 60A	*NEC Sections 230.79(A), (B), (C), and (D)*
Working space	Requirements for any electrical equipment apply; that is, the minimum head room of working spaces around service equipment must be 6.5' or more. The dimensions of working space in the direction of access to live parts operating at 600V nominal or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized must not be less than indicated in *NEC Table 110.26(A)(1).*	*NEC Section 110.26*
Type of disconnect	Disconnects may include either a manually operated or power-operated safety switch, provided the switch can be opened by hand in the event of a power supply failure.	*NEC Section 230.76*
Disconnection of grounded conductor	Where the service disconnecting means does not disconnect the grounded conductor from the premises wiring, other means shall be provided for this purpose in the service equipment.	*NEC Section 230.75*
Connections to terminals	Service conductors must be connected to the disconnecting means by pressure connectors, clamps, or other approved means. Soldered connections are forbidden.	*NEC Section 230.81*
More than one building on the same premises	In industrial establishments under single management, the disconnecting means for several buildings may be conveniently located if *NEC*® conditions are met.	*NEC Section 225.32, Exception 1*
Service disconnecting means with more than one switch or circuit breaker	Where service disconnecting means consist of more than one switch or circuit breaker, the combined ratings of all the circuit breakers or switches shall not be rated at less than the load to be carried.	*NEC Section 230.80*

Summary

The *NEC*® defines a device as a unit of an electrical system that is intended to carry or help carry but not utilize electric energy. This covers a wide assortment of system components that include, but are not limited to, the following:

- Switches
- Relays
- Contactors
- Receptacles
- Conductors

The purpose of a switch is to make and break an electrical circuit in a safe and convenient manner. *NEC Article 404* covers most of the installation requirements for switches.

A receptacle is a contact device installed at the outlet of a circuit for the connection of a single attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is a single device containing two or more receptacles, with the most common being the duplex receptacle. *NEC Sections 210.50, 210.52, 210.60, 210.62, 220.14(I), and 220.14(J)* cover many of the requirements for receptacles.

Notes

Trade Terms Introduced in This Module

Attachment plug: The male connector for electrical cords.

Cord: A small, flexible conductor assembly, usually jacketed.

Device: An item intended to carry or help carry but not utilize electric energy.

Four-way switch: A device that, when used in conjunction with two three-way switches, offers control of an electrical outlet (usually lighting) at three or more locations.

Gang switch: A unit of two or more switches that allows control of two or more circuits from one location. The entire mechanism is mounted in one box under one cover.

Receptacle: A contact device installed at an outlet for the connection of an attachment plug and flexible cord to supply portable equipment.

Switch: A device used to open, close, or change the connection of a circuit.

Three-way switch: A switch used to control a light or set of lights from two different locations.

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.

American Electrician's Handbook. Terrell Croft and Wilfred I. Summers. New York, NY: McGraw-Hill, 1996.

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