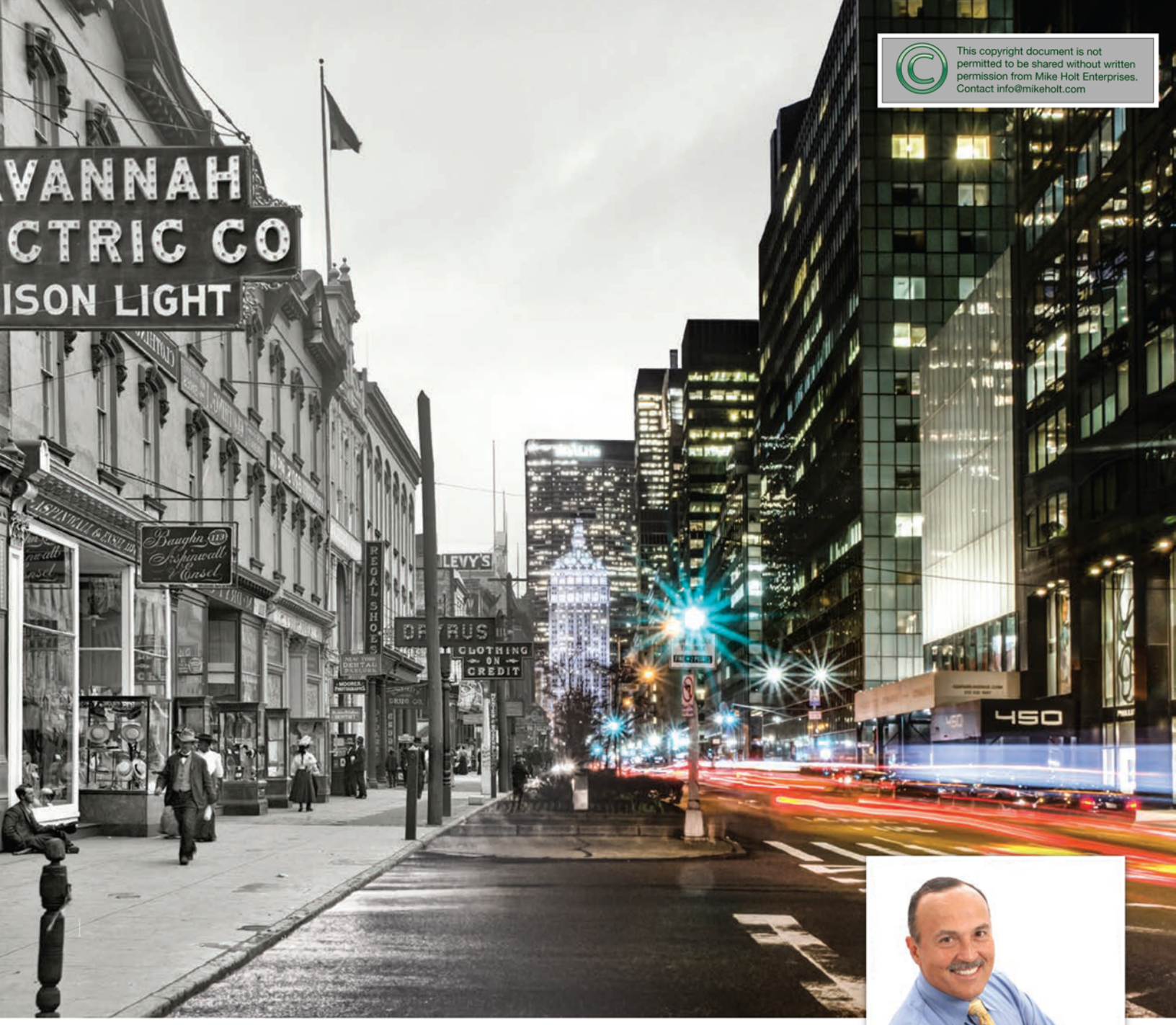

Mike Holt's Illustrated Guide to

TOP 10 CHANGES TO THE 2017 NATIONAL ELECTRICAL CODE®

Extracted from Mike Holt's Changes to the National Electrical Code®- Based on the 2017 NEC®

Rules 110.14, 110.16, 210.8, 210.12, 240.21, 250.24, 250.122, 404.2, 406.12, 680.26

January 31, 2019

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ABOUT THE AUTHOR

Mike Holt worked his way up through the electrical trade. He began as an apprentice electrician and became one of the most recognized experts in the world as it relates to electrical power installations. He's worked as a journeyman electrician, master electrician, and electrical contractor. Mike's experience in the real world gives him a unique understanding of how the *NEC* relates to electrical installations from a practical standpoint. You'll find his writing style to be direct, nontechnical, and powerful.

Did you know Mike didn't finish high school? So if you struggled in high school or didn't finish at all, don't let it get you down. However, realizing that success depends on one's continuing pursuit of education, Mike immediately attained his GED, and ultimately attended the University of Miami's Graduate School for a Master's degree in Business Administration.

Mike resides in Central Florida, is the father of seven children, has five grandchildren, and enjoys many outside interests and activities. He's a nine-time National Barefoot Water-Ski Champion (1988, 1999, 2005–2009, 2012–2013). He's set many national records and continues to train year-round at a World competition level (www.barefootwaterskier.com).

What sets him apart from some is his commitment to living a balanced lifestyle; placing God first, family, career, then self.

I dedicate this book to the
Lord Jesus Christ,
my mentor and teacher.
Proverbs 16:3

TABLE OF CONTENTS

HOW TO USE THE *NATIONAL ELECTRICAL CODE*

The original *NEC* document was developed in 1897 as a result of the united efforts of various insurance, electrical, architectural, and other allied interests. The National Fire Protection Association (NFPA) has sponsored the *National Electrical Code* since 1911.

The purpose of the *Code* is the practical safeguarding of persons and property from hazards arising from the use of electricity. It isn't intended as a design specification or an instruction manual for untrained persons. It is, in fact, a standard that contains the minimum requirements for electrical installations. Learning to understand and use the *Code* is critical to you working safely, whether you're training to become an electrician, or are already an electrician, electrical contractor, inspector, engineer, designer, or instructor.

The *NEC* was written for those who understand electrical terms, theory, safety procedures, and electrical trade practices. Learning to use the *Code* is a lengthy process and can be frustrating if you don't approach it the right way. First of all, you'll need to understand electrical theory and if you don't have theory as a background when you get into the *NEC*, you're going to be struggling—so take one step back if you need to, and learn electrical theory. You must also understand the concepts and terms, and know grammar and punctuation in order to understand the complex structure of the rules and their intended purpose(s). Our goal for the next few pages is to give you some guidelines and suggestions on using your *Code* book to help you understand what you're trying to accomplish, and how to get there.

Language Considerations for the *NEC*

Terms and Concepts

The *NEC* contains many technical terms, so it's crucial for *Code* users to understand their meanings and applications. If you don't understand a term used in a rule, it will be impossible to properly apply the *NEC* requirement. Article 100 defines the terms that are used in two or more *Code* articles; for example, the term "Dwelling Unit" is found in many articles. If you don't know the *NEC* definition for a "dwelling unit" you can't properly identify the *Code* requirements for it.

Many articles have terms unique to that specific article, and the definitions of those terms are only applicable to that given article. These definitions are usually found in the beginning of the article. For example, Section 250.2 contains the definitions of terms that only apply to Article 250—Grounding and Bonding.

Small Words, Grammar, and Punctuation

It's not only the technical words that require close attention since simple words can make a big difference to the application of a rule. Was there a comma; was it "or," "and," "other than," "greater than," or smaller than"? The word "or" can imply alternate choices for wiring methods. A word like "or" gives us choices while the word "and" can mean an additional requirement must be met.

An example of these words being used in the *NEC* is found in 110.26(C)(2), where it says equipment containing overcurrent, switching, "or" control devices that are 1,200A or more "and" over 6 ft wide that require a means of egress at each end of the working space. In this section, the word "or" clarifies that equipment containing any of the three types of devices listed must follow this rule. The word "and" clarifies that 110.26(C)(2) only applies if the equipment is both 1,200A or more and over 6 ft wide.

Grammar and punctuation play an important role in establishing the meaning of a rule. The location of a comma can dramatically change the requirement of a rule such as in 250.28(A), where it says a main bonding jumper

must be a wire, bus, screw, or similar suitable conductor. If the comma between "bus" and "screw" was removed, only a "bus screw" could be used. That comma makes a big change in the requirements of the rule.

Slang Terms or Technical Jargon

Trade-related professionals in different areas of the country often use local "slang" terms that aren't shared by all. This can make it difficult to communicate if it isn't clear what the meaning of those slang terms are. Use the proper terms by finding out what their definitions and applications are before you use them. For example, the term "pigtail" is often used to describe the short piece of conductor used to connect a device to a splice, but a "pigtail" is also a term used for a rubberized light socket with pre-terminated conductors. Although the term is the same, the meaning is very different and could cause confusion.

NEC Style and Layout

It's important to understand the structure and writing style of the *Code* if you want to use it effectively. The *National Electrical Code* is organized using eleven major components.

1. Table of Contents
2. Chapters—Chapters 1 through 9 (major categories)
3. Articles—Chapter subdivisions that cover specific subjects
4. Parts—Divisions used to organize article subject matter
5. Sections—Divisions used to further organize article subject matter
6. Tables and Figures—Represent the mandatory requirements of a rule
7. Exceptions—Alternatives to the main *Code* rule
8. Informational Notes—explanatory material for a specific rule (not a requirement)
9. Tables—Applicable as referenced in the *NEC*
10. Annexes—Additional explanatory information such as tables and references (not a requirement)
11. Index

1. Table of Contents. The Table of Contents displays the layout of the chapters, articles, and parts as well as the page numbers. It's an excellent resource and should be referred to periodically to observe the interrelationship of the various *NEC* components. When attempting to locate the rules for a particular situation, knowledgeable *Code* users often go first to the Table of Contents to quickly find the specific *NEC* rule that applies.

2. Chapters. There are nine chapters, each of which is divided into articles. The articles fall into one of four groupings: General Requirements (Chapters 1 through 4), Specific Requirements (Chapters 5 through 7), Communications Systems (Chapter 8), and Tables (Chapter 9).

Chapter 1—General
Chapter 2—Wiring and Protection
Chapter 3—Wiring Methods and Materials
Chapter 4—Equipment for General Use
Chapter 5—Special Occupancies
Chapter 6—Special Equipment
Chapter 7—Special Conditions
Chapter 8—Communications Systems (Telephone, Data, Satellite, Cable TV, and Broadband)
Chapter 9—Tables–Conductor and Raceway Specifications

3. Articles. The *NEC* contains approximately 140 articles, each of which covers a specific subject. It begins with Article 90, the introduction to the *Code*, and contains the purpose of the *NEC*, what's covered and what isn't covered, along with how the *Code* is arranged. It also gives information on enforcement and how mandatory and permissive rules are written and how explanatory material is included. Article 90 also includes information on formal interpretations, examination of equipment for safety, wiring planning, and information about formatting units of measurement. Here are some other examples of articles you'll find in the *NEC*:

Article 110—Requirements for Electrical Installations
Article 250—Grounding and Bonding
Article 300—General Requirements for Wiring Methods and Materials
Article 430—Motors and Motor Controllers
Article 500—Hazardous (Classified) Locations
Article 680—Swimming Pools, Fountains, and Similar Installations
Article 725—Remote-Control, Signaling, and Power-Limited Circuits
Article 800—Communications Circuits

4. Parts. Larger articles are subdivided into parts. Because the parts of a *Code* article aren't included in the section numbers, we have a tendency to forget what "part" an *NEC* ru20le is relating to. For example, Table 110.34(A) contains working space clearances for electrical equipment. If we aren't careful, we might think this table applies to all electrical installations, but Table 110.34(A) is located in Part III, which only contains requirements for "Over 1,000 Volts, Nominal" installations. The rules for working clearances for electrical equipment for systems 1,000V, nominal, or less are contained in Table 110.26(A)(1), which is located in Part II—1,000 Volts, Nominal, or Less.

5. Sections. Each *NEC* rule is called a "*Code* Section." A *Code* section may be broken down into subsections by letters in parentheses like (A), numbers in parentheses like (1), and lowercase letters like (a), (b), and so on, to further break the rule down to the second and third level. For example, the rule requiring all receptacles in a dwelling unit bathroom to be GFCI protected is contained in Section 210.8(A)(1) which is located in Chapter 2, Article 210, Section 8, Subsection (A), Sub-subsection (1).

Many in the industry incorrectly use the term "Article" when referring to a *Code* section. For example, they say "Article 210.8," when they should say "Section 210.8." Section numbers in this textbook are shown without the word "Section," unless they begin a sentence. For example, Section 210.8(A) is shown as simply 210.8(A).

6. Tables and Figures. Many *NEC* requirements are contained within tables, which are lists of *Code* rules placed in a systematic arrangement. The titles of the tables are extremely important; you must read them carefully in order to understand the contents, applications and limitations of each table. Many times notes are provided in or below a table; be sure to read them as well since they're also part of the requirement. For example, Note 1 for Table 300.5 explains how to measure the cover when burying cables and raceways, and Note 5 explains what to do if solid rock is encountered.

7. Exceptions. Exceptions are *Code* requirements or permissions that provide an alternative method to a specific rule. There are two types of exceptions—mandatory and permissive. When a rule has several exceptions, those exceptions with mandatory requirements are listed before the permissive exceptions.

Mandatory Exceptions. A mandatory exception uses the words "shall" or "shall not." The word "shall" in an exception means that if you're using the exception, you're required to do it in a particular way. The phrase "shall not" means it isn't permitted.

Permissive Exceptions. A permissive exception uses words such as "shall be permitted," which means it's acceptable (but not mandatory) to do it in this way.

8. Informational Notes. An Informational Note contains explanatory material intended to clarify a rule or give assistance, but it isn't a *Code* requirement.

9. Tables. Chapter 9 consists of tables applicable as referenced in the *NEC*. The tables are used to calculate raceway sizing, conductor fill, the radius of raceway bends, and conductor voltage drop.

10. Annexes. Annexes aren't a part of the *NEC* requirements, and are included in the *Code* for informational purposes only.

Annex A. Product Safety Standards
Annex B. Application Information for Ampacity Calculation
Annex C. Raceway Fill Tables for Conductors and Fixture Wires of the Same Size
Annex D. Examples
Annex E. Types of Construction
Annex F. Critical Operations Power Systems (COPS)
Annex G. Supervisory Control and Data Acquisition (SCADA)
Annex H. Administration and Enforcement
Annex I. Recommended Tightening Torques
Annex J. ADA Standards for Accessible Design

11. Index. The Index at the back of the *Code* book is helpful in locating a specific rule.

Author's Comment:

- Changes in the 2017 *Code* book are indicated as follows:
  - Changed rules are identified by shading the text that was changed since the previous edition.
  - New rules aren't shaded like a change, instead they have a shaded "N" in the margin to the left of the section number.
  - Relocated rules are treated like new rules with a shaded "N" in the left margin by the section number.
  - Deleted rules are indicated by a bullet symbol "•" located in the left margin where the rule was in the previous edition.

How to Locate a Specific Requirement

How to go about finding what you're looking for in the *Code* book depends, to some degree, on your experience with the *NEC*. Experts typically know the requirements so well that they just go to the correct rule. Very experienced people might only need the Table of Contents to locate the requirement they're looking for. On the other hand, average users should use all of the tools at their disposal, including the Table of Contents, the Index, and the search feature on electronic versions of the *Code* book.

Let's work through a simple example: What *NEC* rule specifies the maximum number of disconnects permitted for a service?

Table of Contents. If you're an experienced *Code* user, you might use the Table of Contents. You'll know Article 230 applies to "Services," and because this article is so large, it's divided up into multiple parts (actually

eight parts). With this knowledge, you can quickly go to the Table of Contents and see it lists the Service Equipment Disconnecting Means requirements in Part VI.

Author's Comment:

- The number 70 precedes all page numbers because the *NEC* is NFPA Standard Number 70.

Index. If you use the Index, which lists subjects in alphabetical order, to look up the term "service disconnect," you'll see there's no listing. If you try "disconnecting means," then "services," you'll find that the Index indicates the rule is located in Article 230, Part VI. Because the *NEC* doesn't give a page number in the Index, you'll need to use the Table of Contents to find it, or flip through the *Code* book to Article 230, then continue to flip through pages until you find Part VI.

Many people complain that the *NEC* only confuses them by taking them in circles. Once you gain experience in using the *Code* and deepen your understanding of words, terms, principles, and practices, you'll find the *NEC* much easier to understand and use than you originally thought.

Customizing Your *Code* Book

One way to increase your comfort level with the *Code* book is to customize it to meet your needs. You can do this by highlighting and underlining important *NEC* requirements. Preprinted adhesive tabs are also an excellent aid to quickly find important articles and sections that are regularly referenced. Be aware that if you're using your *Code* book to prepare to take an exam, some exam centers don't allow markings of any type. Visit www.MikeHolt.com/tabs for more information.

Highlighting. As you read through textbooks or find answers to your questions, be sure you highlight those requirements in the *NEC* that are the most important or relevant to you. Use one color, like yellow, for general interest and a different one for important requirements you want to find quickly. Be sure to highlight terms in the Index and the Table of Contents as you use them.

Underlining. Underline or circle key words and phrases in the *Code* with a red or blue pen (not a lead pencil) using a short ruler or other straightedge to keep lines straight and neat. This is a very handy way to make important requirements stand out. A short ruler or other straightedge also comes in handy for locating the correct information in a table.

Different Interpretations

Industry professionals often enjoy the challenge of discussing the *NEC* requirements. This discussion is important to the process of better understanding the *Code* requirements and application(s). If you decide you're going to participate in one of these discussions, don't spout out what you think without having the actual *NEC* book in your hand. The professional way of discussing a *Code* requirement is by referring to a specific section, rather than talking in vague generalities. This will help everyone involved clearly understand the point and become better educated.

Become Involved in the *NEC* Process

The actual process of changing the *Code* takes about two years and involves hundreds of individuals making an effort to have the *NEC* as current and accurate as possible. As you study and learn how to use it, you'll find it very interesting, enjoy it more, and realize that you can also be a part of the process. Rather than sitting back and just reading it and learning it, you can participate by making proposals and being a part of its development. For the 2017 *Code*, there were 4,000 public inputs and 1,500 comments. Hundreds of updates and five new articles were added to keep the *NEC* up to date with new technologies, and pave the way to a safer and more efficient electrical future.

Let's review how this process works:

STEP 1—Public Input Stage

Public Input. The revision cycle begins with the acceptance of Public Input (PI): the public notice asking for anyone interested to submit input on an existing standard or a committee-approved new draft standard. Following the closing date, the Committee conducts a First Draft Meeting to respond to all public inputs.

First Draft Meeting. At the First Draft (FD) Meeting, the Technical Committee considers and provides a response to all Public Input. The Technical Committee may use the input to develop First Revisions to the standard. The First Draft documents consist of the initial meeting consensus of the committee by simple majority. However, the final position of the Technical Committee must be established by a ballot which follows.

Committee Ballot on First Draft. The First Draft developed at the First Draft Meeting is balloted: to appear in the First Draft, a revision must be approved by at least two-thirds of the Technical Committee.

First Draft Report Posted. First revisions which pass ballot are ultimately compiled and published as the First Draft Report on the document's NFPA web page. This report serves as documentation for the Input Stage and is published for review and comment. The public may review the First Draft Report to determine whether to submit Public Comments on the First Draft.

STEP 2—Public Comment Stage

Public Comment. Once the First Draft Report becomes available, there's a public comment period during which anyone can submit a Public Comment on the First Draft. After the Public Comment closing date, the Technical Committee conducts/holds their Second Draft Meeting.

Second Draft Meeting. After the Public Comment closing date, if Public Comments are received or the committee has additional proposed revisions, a Second Draft Meeting is held. At the Second Draft Meeting, the Technical Committee reviews the First Draft and may make additional revisions to the draft Standard. All Public Comments are considered, and the Technical Committee provides an action and response to each Public Comment. These actions result in the Second Draft.

Committee Ballot on Second Draft. The Second Revisions developed at the Second Draft Meeting are balloted. To appear in the Second Draft, a revision must be approved by at least two-thirds of the Technical Committee.

Second Draft Report Posted. Second Revisions which pass ballot are ultimately compiled and published as the Second Draft Report on the document's NFPA website. This report serves as documentation of the Comment Stage and is published for public review.

Once published, the public can review the Second Draft Report to decide whether to submit a Notice of Intent to Make a Motion (NITMAM) for further consideration.

STEP 3—NFPA Technical Meeting (Tech Session)

Following completion of the Public Input and Public Comment stages, there's further opportunity for debate and discussion of issues through the NFPA Technical Meeting that takes place at the NFPA Conference & Expo®. These motions are attempts to change the resulting final Standard from the committee's recommendations published as the Second Draft.

STEP 4—Council Appeals and Issuance of Standard

Issuance of Standards. When the Standards Council convenes to issue an NFPA standard, it also hears any related appeals. Appeals are an important part of assuring that all NFPA rules have been followed and that due process and fairness have continued throughout the standards development process. The Standards Council considers appeals based on the written record and by conducting live hearings during which all interested parties can participate. Appeals are decided on the entire record of the process, as well as all submissions and statements presented.

After deciding all appeals related to a standard, the Standards Council, if appropriate, proceeds to issue the Standard as an official NFPA Standard. The decision of the Standards Council is final subject only to limited review by the NFPA Board of Directors. The new NFPA standard becomes effective twenty days following the Standards Council's action of issuance.

Author's Comment:

- Proposals and comments can be submitted online at the NFPA website at www.nfpa.org/doc# (for NFPA 70, go to www.nfpa.org/70 for example). From the homepage, look for "Codes & Standards," then find "How the Process Works." If you'd like to see something changed in the *Code*, you're encouraged to participate in the process.

ARTICLE 110 REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

Introduction to Article 110—Requirements for Electrical Installations

Article 110 sets the stage for how you'll implement the rest of the *NEC*. This article contains a few of the most important and yet neglected parts of the *Code*. For example:

- How should conductors be terminated?
- What kinds of warnings, markings, and identification does a given installation require?
- What's the right working clearance for a given installation?
- What do the temperature limitations at terminals mean?
- What are the *NEC* requirements for dealing with flash protection?

It's critical that you master Article 110; as you read this article, you're building your foundation for correctly applying the *NEC*. In fact, this article itself is a foundation for much of the *Code*. The purpose for the *National Electrical Code* is to provide a safe installation, but Article 110 is perhaps focused a little more on providing an installation that's safe for the installer and maintenance electrician, so time spent in this article is time well spent.

Top Ten Changes to the *NEC* #1

110.14 Conductor Termination and Splicing

A properly calibrated tool must be used when torquing terminal connections.

Analysis

NEW

When electrical fires or failures occur, they usually do so at terminations, not in the middle of a cable or conductor. With that said, the rules in 110.14 are some of the most important in the entire *Code*.

Studies have found that approximately 75 to 80 percent of conductor terminations aren't installed correctly unless a torque measuring device, such as a torque wrench or screwdriver, is used. Approximately 60 percent of conductor terminations aren't tight enough and 20 percent are too tight, leaving about only 20 percent meeting the manufacturer's torquing requirements.

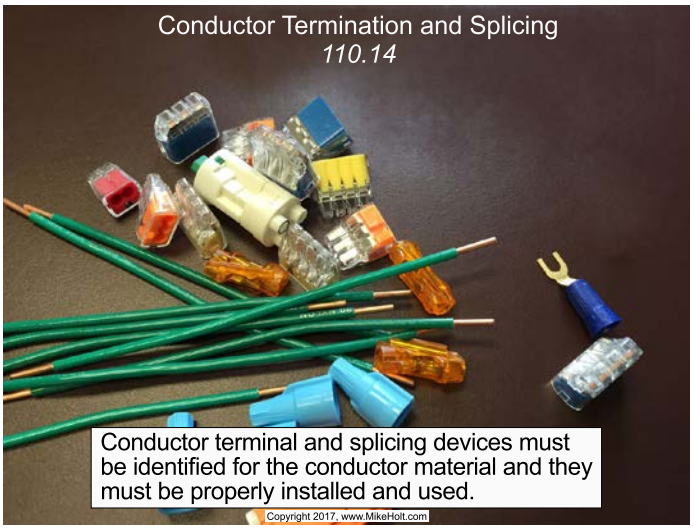
This new rule requires the installer to use a properly calibrated tool for conductor terminations when a tightening torque is specified by the manufacturer for the terminal.

Enforcement of this new rule will prove challenging. Does the electrical inspector need to be on site when the terminations are made so he or she can verify the tool being used? How will he or she know the tool is calibrated corrected? Has the tool been dropped since being calibrated and is now therefore inaccurate? Should the inspectors carry their own tools?

As with any new *Code* rule, this one might create growing pains, but we can all certainly agree on one thing; this rule is intended to increase safety by ensuring proper terminations. Let's not lose sight of the big picture—electrical safety.

110.14 Conductor Termination and Splicing

Conductor terminal and splicing devices must be identified for the conductor material and they must be properly installed and used. ▶Figure 110–23

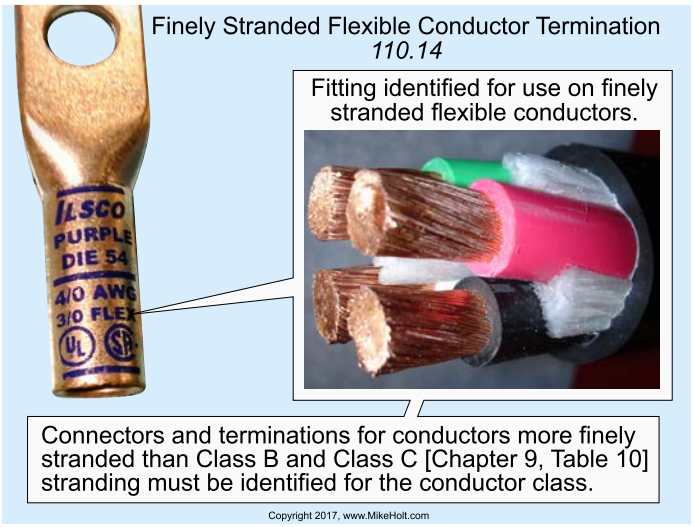


▶Figure 110–23

Author's Comment:

- Switches and receptacles marked "CO/ALR" are designed to ensure a good connection through the use of a larger contact area and compatible materials. The terminal screws are plated with the element called "Indium." Indium is an extremely soft metal that forms a gas-sealed connection with the aluminum conductor.

Connectors and terminals for conductors more finely stranded than Class B and Class C, as shown in Table 10 of Chapter 9, must be identified for the use of finely stranded conductors. ▶Figure 110–24

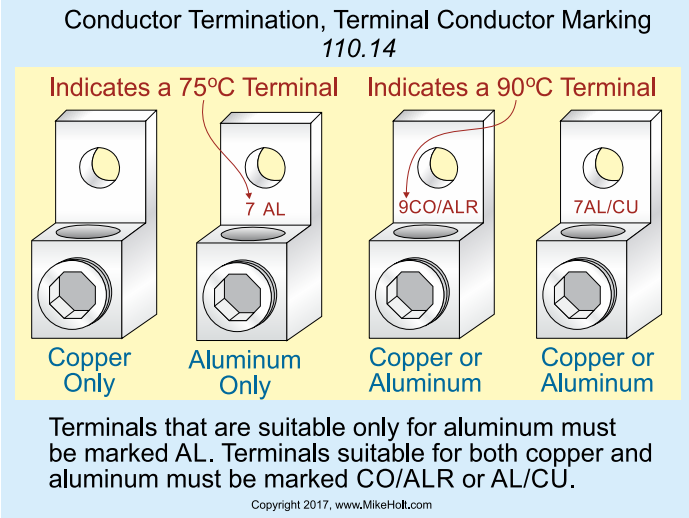


▶Figure 110–24

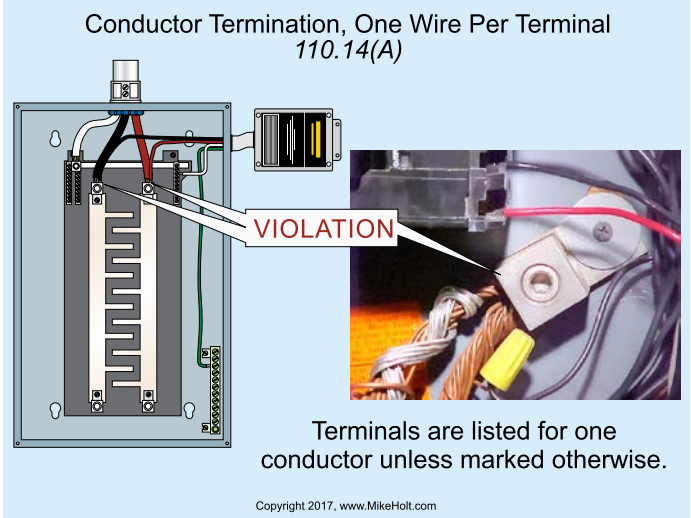
Author's Comment:

- According to UL Standard 486 A-B, a terminal/lug/connector must be listed and marked for use with other than Class B stranded conductors. With no marking or factory literature/instructions to the contrary, terminals may only be used with Class B stranded conductors.
- See the definition of "Identified" in Article 100.
- Conductor terminations must comply with the manufacturer's instructions as required by 110.3(B). For example, if the instructions for the device state "Suitable for 18-12 AWG Stranded," then only stranded conductors can be used with the terminating device. If the instructions state "Suitable for 18-12 AWG Solid," then only solid conductors are permitted, and if the instructions state "Suitable for 18-12 AWG," then either solid or stranded conductors can be used with the terminating device.

Copper and Aluminum Mixed. Copper and aluminum conductors must not make contact with each other in a device unless the device is listed and identified for this purpose. ▶Figure 110–25



▶Figure 110–25



▶Figure 110–26

Author's Comment:

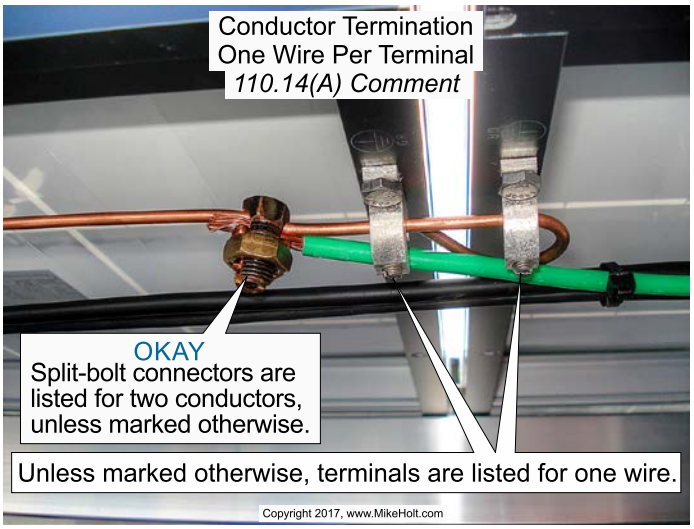
- Few terminations are listed for the mixing of aluminum and copper conductors, but if they are, that will be marked on the product package or terminal device. The reason copper and aluminum shouldn't be in contact with each other is because corrosion develops between the two different metals due to galvanic action, resulting in increased contact resistance at the splicing device. This increased resistance can cause the splice to overheat and cause a fire.

(A) Terminations. Conductor terminals must ensure a good connection without damaging the conductors.

Terminals for more than one conductor and terminals used for aluminum conductors must be identified for this purpose, either within the equipment instructions or on the terminal itself. ▶Figure 110–26

Author's Comment:

- Split-bolt connectors are commonly listed for only two conductors, although some are listed for three conductors. However, it's a common industry practice to terminate as many conductors as possible within a split-bolt connector, even though this violates the *NEC*. ▶Figure 110–27



▶Figure 110–27

(B) Conductor Splices. Conductors must be spliced by a splicing device identified for the purpose or by exothermic welding. ▶Figure 110–28

Author's Comment:

- Conductors aren't required to be twisted together prior to the installation of a twist-on wire connector, unless specifically required in the installation instructions. ▶Figure 110–29

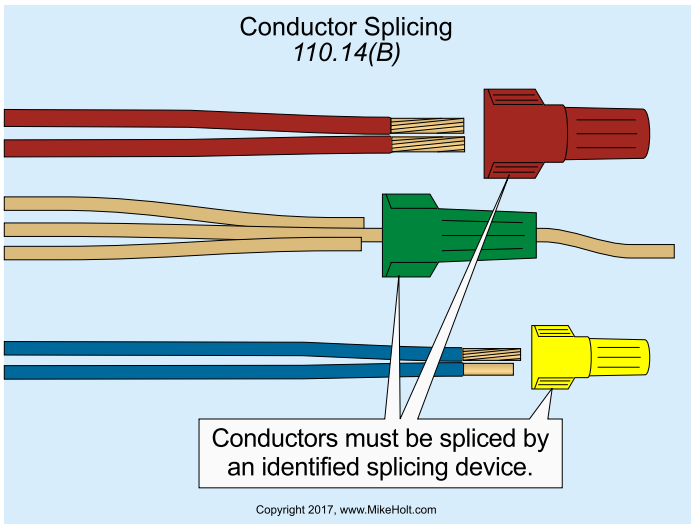


Figure 110–28

Figure 110–29

- Unused circuit conductors aren't required to be removed. However, to prevent an electrical hazard, the free ends of the conductors must be insulated to prevent the exposed end of the conductor from touching energized parts. This requirement can be met by the use of an insulated twist-on or push-on wire connector. Figure 110–30
- See the definition of "Energized" in Article 100.

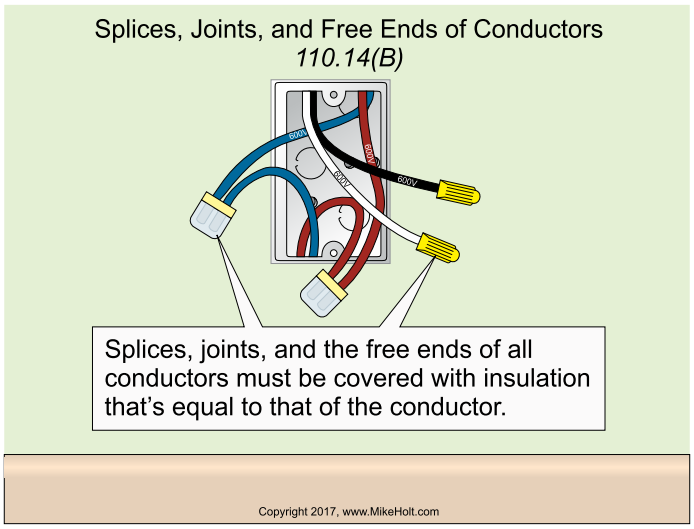


Figure 110–30

Underground Splices, Single Conductors. Single direct burial conductors of types UF or USE can be spliced underground without a junction box, but the conductors must be spliced with a device listed for direct burial [300.5(E) and 300.15(G)]. Figure 110–31

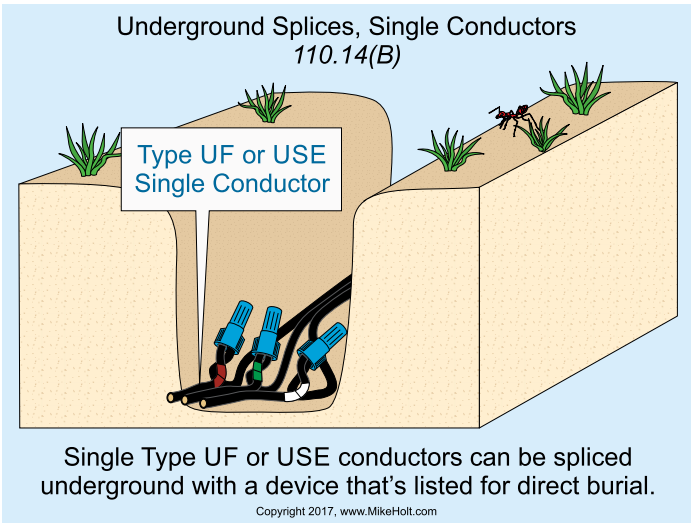
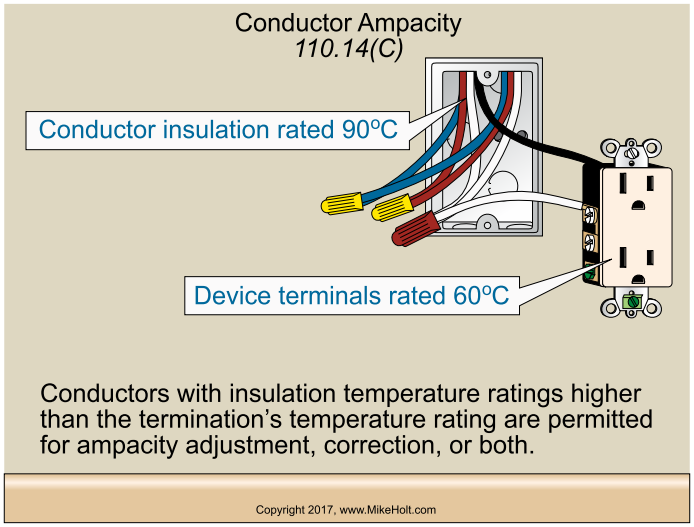


Figure 110–31

Underground Splices, Multiconductor Cable. Multiconductor UF or USE cable can have the individual conductors spliced underground without a junction box as long as a listed splice kit that encapsulates the conductors as well as the cable jacket is used.

(C) Temperature Limitations (Conductor Size). Conductors are to be sized using their ampacity from the insulation temperature rating column of Table 310.15(B)(16) that corresponds to the lowest temperature rating of any terminal, device, or conductor of the circuit.

Conductors with insulation temperature ratings higher than the termination's temperature rating can be used for ampacity adjustment, correction, or both. ▶Figure 110–32

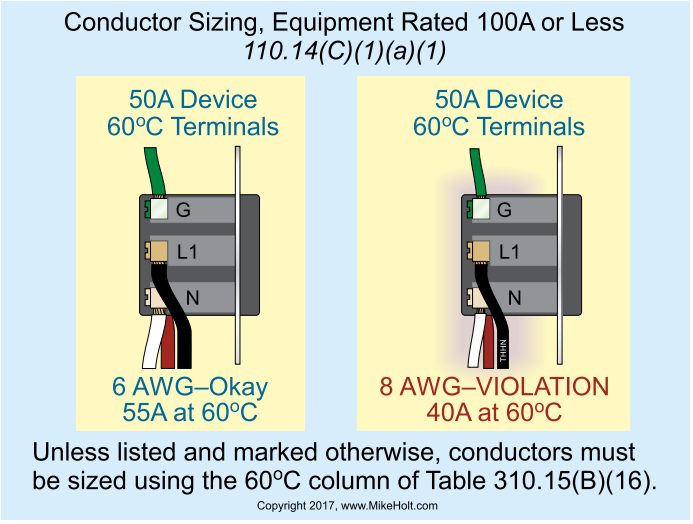


▶Figure 110–32

(1) Equipment Temperature Rating Provisions. Unless the equipment is listed and marked otherwise, conductor sizing for equipment terminations must be based on Table 310.15(B)(16) in accordance with (a) or (b):

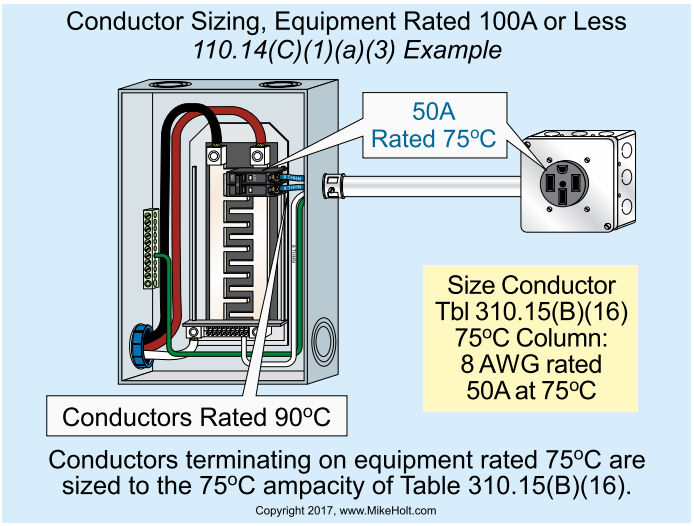
(a) Equipment Rated 100A or Less.

(1) Conductors must be sized using the 60°C temperature column of Table 310.15(B)(16). ▶Figure 110–33



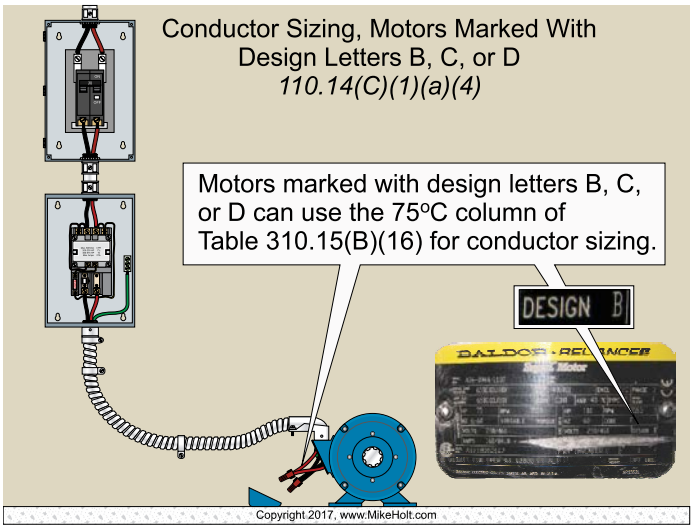
▶Figure 110–33

(3) Conductors terminating on terminals rated 75°C are to be sized in accordance with the ampacities listed in the 75°C temperature column of Table 310.15(B)(16). ▶Figure 110–34



▶Figure 110–34

(4) For motors marked with design letters B, C, or D, conductors having an insulation rating of 75°C or higher can be used, provided the ampacity of such conductors doesn't exceed the 75°C ampacity. ▶Figure 110–35



▶Figure 110–35

(b) Equipment Rated Over 100A.

(1) Conductors with an insulation temperature rating of 75°C must be sized to the 75°C temperature column of Table 310.15(B)(16). ▶Figure 110–36

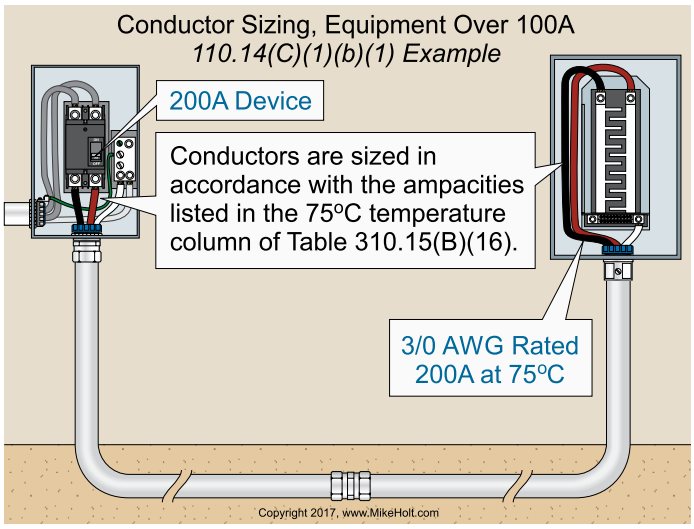


Figure 110–36

(2) Conductors with an insulation temperature rating of 90°C can be sized to the 75°C column of Table 310.15(B)(16).

(2) Separate Connector Provisions. Conductors can be sized to the 90°C column of Table 310.15(B)(16) if the conductors and pressure connectors are rated at least 90°C. Figure 110–37

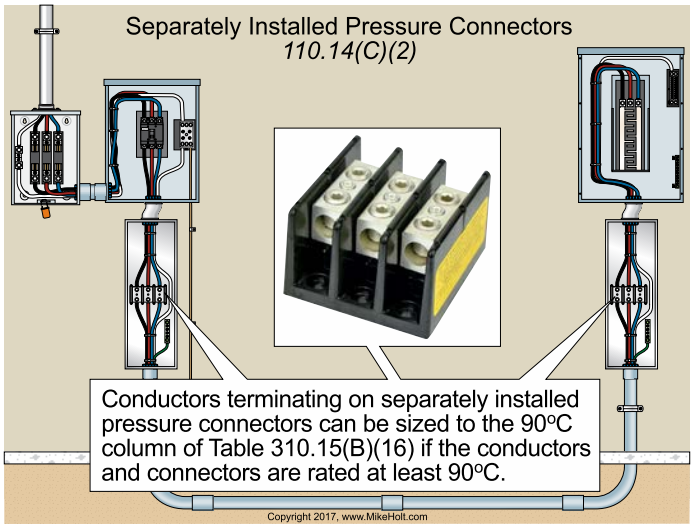


Figure 110–37

Note: Equipment markings or listing information may restrict the sizing and temperature ratings of connected conductors.

(D) Torque. Where tightening torque values are indicated on equipment or installation instructions, a calibrated torque tool must be used to achieve the indicated torque value, unless the equipment manufacturer provides an alternative method of achieving the required torque. Figure 110–38

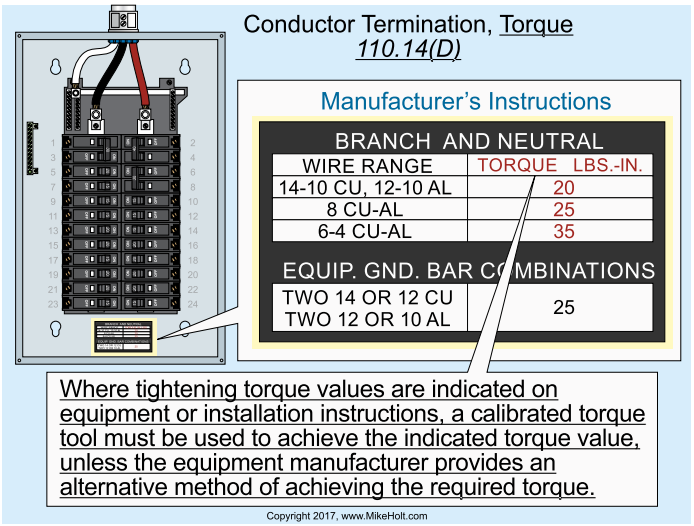


Figure 110–38

Author's Comment:

- Conductors must terminate in devices that have been properly tightened in accordance with the manufacturer's torque specifications included with equipment instructions. Failure to torque terminals properly can result in excessive heating of terminals or splicing devices due to a loose connection. A loose connection can also lead to arcing which increases the heating effect and may also lead to a short circuit or ground fault. Any of these can result in a fire or other failure, including an arc-flash event. In addition, this is a violation of 110.3(B), which requires all equipment to be installed in accordance with listing or labeling instructions.

Top Ten Changes to the *NEC* #2

110.16 Arc-Flash Hazard Warning

The rules for warning qualified persons about arc-flash hazards have been increased, again.

Analysis

EXPANDED

Since arc-flash hazard warnings rules were added in 2002, they've been revised every *Code* cycle like clockwork. There's no question that the continued revisions are due to the fact that electrical safety is taken more seriously than ever before.

Many people who are concerned with worker safety have tried to increase this rule to require information, such as restricted and prohibited approach boundaries, incident energy, arc rating of clothing, and other related information. While those requirements didn't make it into this edition of the *NEC* others did, but only for larger pieces of equipment.

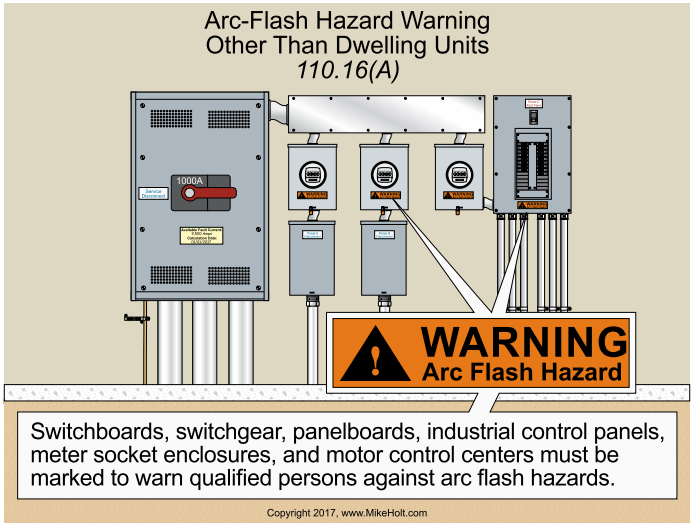
The change is that for other than dwelling units, the arc-flash label must indicate the voltage of the system, the available fault current, the clearing time of the overcurrent protection device(s), and the date the label was installed. The available fault current can be obtained from the electric utility or be calculated with proper field information, and the clearing time can be obtained from the manufacturer of the fuse or circuit breaker.

An exception was added to allow arc-flash labels that are installed "in accordance with acceptable industry practice," and an Informational Note was added to explain what that means. Basically, if you follow the guidelines of NFPA 70E as they relate to labels, you'll meet the new *Code* requirement.

Proponents of this change claim this new rule will result in a safer environment for the electrical worker, but opponents claim these changes shouldn't be in the *NEC* at all, as it's intended to be an installation standard, not a workplace safety standard.

110.16 Arc-Flash Hazard Warning

(A) Arc-Flash Hazard Warning Label. Switchboards, switchgear, panelboards, industrial control panels, meter socket enclosures, and motor control centers in other than dwelling units must be marked to warn qualified persons of the danger associated with an arc flash from short circuits or ground faults. The arc-flash hazard warning marking must be permanently affixed, have sufficient durability to withstand the environment involved [110.21(B)], and be clearly visible to qualified persons before they examine, adjust, service, or perform maintenance on the equipment. ▶Figure 110–40

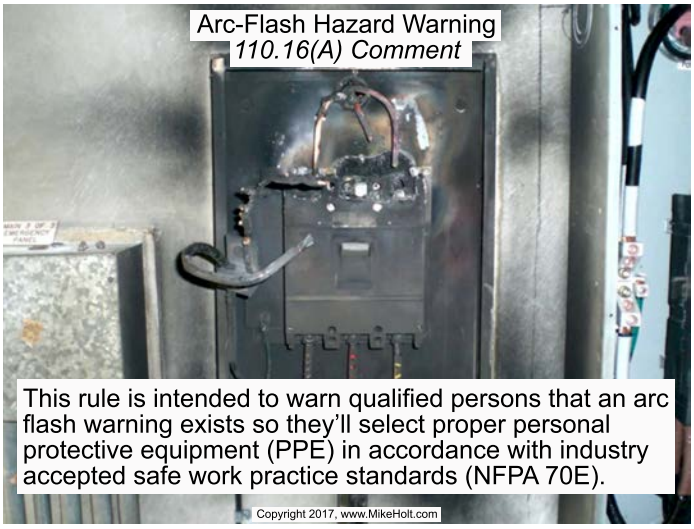


▶Figure 110–40

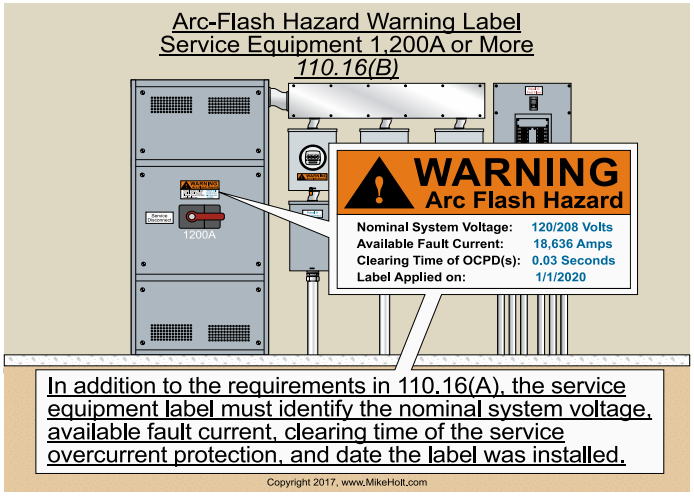
Author's Comment:

- See the definition of "Qualified Person" in Article 100.
- This rule is intended to warn qualified persons who work on energized electrical systems that an arc-flash hazard exists so they'll select proper personal protective equipment (PPE) in accordance with industry accepted safe work practice standards. ▶Figure 110–41

(B) Service Equipment Available Fault Current Label. Service equipment rated 1,200A or more must have a field or factory installed label containing the following details and have sufficient durability to withstand the environment: ▶Figure 110–42



▶Figure 110–41



▶Figure 110–42

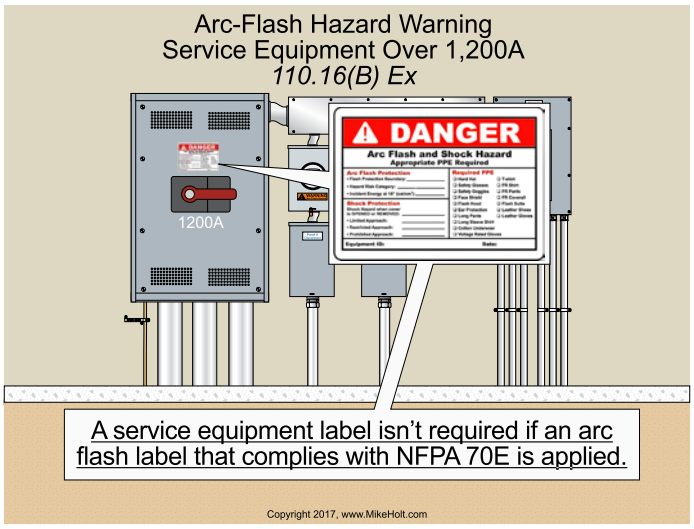
(1) Nominal system voltage

(2) Available fault current at the service overcurrent protection device

(3) Clearing time of the service overcurrent protection device based on the available fault current at the service equipment

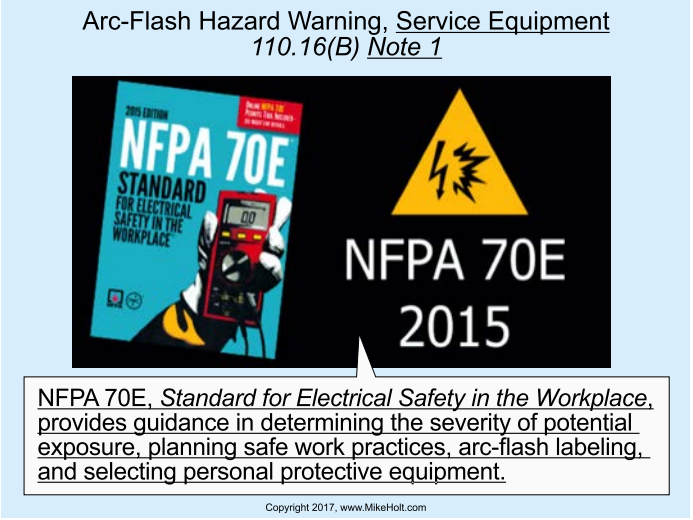
(4) Date the service equipment available fault current label was installed

Ex: Service equipment labeling isn't required if an arc-flash label in accordance with NFPA 70E, Standard for Electrical Safety in the Workplace *[see Note 3] is applied.* ▶Figure 110–43



▶Figure 110–43

Note 1: NFPA 70E, *Standard for Electrical Safety in the Workplace*, provides guidance in determining the severity of potential exposure, planning safe work practices, arc-flash labeling, and selecting personal protective equipment. ▶Figure 110–44



▶Figure 110–44

Note 3: NFPA 70E, *Standard for Electrical Safety in the Workplace* provides specific criteria for developing arc-flash labels, such as nominal system voltage, incident energy levels, arc-flash boundaries, and selecting personal protective equipment.

Top Ten Changes to the *NEC* #3

110.26 Spaces About Electrical Equipment

Changes to 110.26 include a new Informational Note referring to NFPA 70E, *Standard for Electrical Safety in the Workplace*, new requirements for spaces with "limited access," and clarification to the outdoor dedicated space rules.

Analysis

NEW

Informational Note. Most of 110.26 is intended to provide safety for the electrical worker while working on energized equipment. This rule requires clear working space around equipment, it reminds people not to use the working space area for storage, provides rules on a viable escape route in case things go bad around large equipment, mandates illumination for equipment, and provides other safety provisions. Again, most of 110.26 relates to protecting the electrical worker who's working on energized equipment.

In this edition of the *NEC*, the new Informational Note tells the *Code* user to look to NFPA 70E to determine safe work practices, potential exposure, labeling of equipment, and the proper personal protective equipment. It's critical that the electrical the industry, electrician, inspector, contractor, and others follow the safe work practices identified in NFPA 70E as mandated by OSHA.

NEW

Above Suspended Ceilings. New to 2017 are rules for equipment that really can't meet the general working space requirements of 110.26. What do you do when a disconnect is located above a suspended ceiling and has to be there in order for it to be within sight of the equipment it supplies? It's impossible to get a 30 in. by 36 in. working space area in a ceiling grid that only has 24 in. by 48 in. openings. The 2017 change will allow the disconnect above the grid ceiling, but the equipment must be oriented so the depth of the working space required in Table 110.26(A)(1) is satisfied.

This means that the disconnect needs to be mounted so that the 24-in. dimensions of the grid opening are to your left and right when facing the equipment, and the 48-in. dimensions must be in the front-to-back orientation. The equipment must be installed at the edge of the opening to ensure 36, 42, or 48 in. of space, as applicable.

NEW

Crawl Spaces. Installations in crawl spaces must have an access opening of 22 in. by 30 in., which happens to be the standard size of access to crawl spaces required by the International Building Code (IBC) and the International Residential Code (IRC). In addition to this access point, which only gets us into the crawlspace, we still need the required Table 110.26(A)(1) depth, but we don't have to meet the headroom requirements of 110.26(A)(3), which would typically be impossible.

CLARIFIED

Outdoor Equipment. The 2014 *NEC* created a new requirement for panelboards, switchboards, switchgear, and motor control centers installed outdoors to have dedicated electrical space, just like the indoor equipment requirements. As is usually the case, when you write a new rule you need to revise it and address the (sometimes embarrassingly) obvious things you didn't originally consider. This time it's the roof overhangs. Imagine installing a meter and service disconnect on a building, only to be told that you now need to cut out a space in the roof eaves so nothing is above your equipment. Well, you don't need to worry about that any longer.

110.26 Spaces About Electrical Equipment

For the purpose of safe operation and maintenance of equipment, access and working space must be provided about all electrical equipment. ▶Figure 110–51

(A) Working Space. Equipment that may need examination, adjustment, servicing, or maintenance while energized must have working space provided in accordance with 110.26(A)(1), (2), (3), and (4):

Author's Comment:

- The phrase "while energized" is the root of many debates. As always, check with the AHJ to see what equipment he or she believes needs a clear working space.

Figure 110–51

Note: NFPA 70E, *Standard for Electrical Safety in the Workplace*, provides guidance in determining the severity of potential exposure, planning safe work practices, arc-flash labeling, and selecting personal protective equipment.

(1) Depth of Working Space. The working space, which is measured from the enclosure front, isn't permitted to be less than the distances contained in Table 110.26(A)(1). Figure 110–52

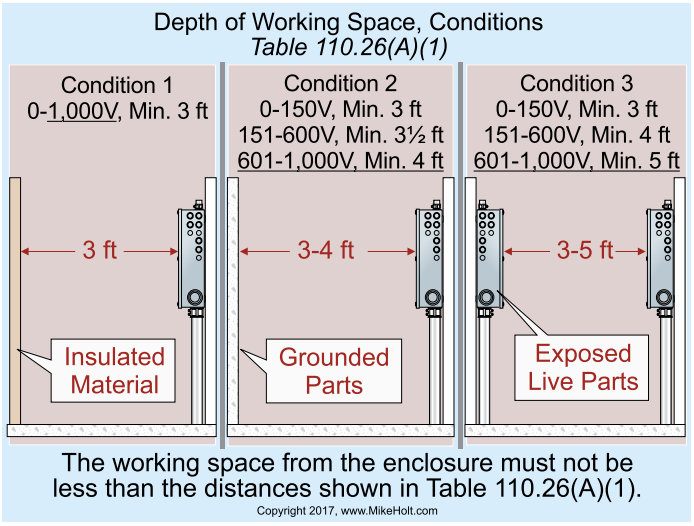


Figure 110–52

Table 110.26(A)(1) Working Space

Voltage-to-Ground	Condition 1	Condition 2	Condition 3
0–150V	3 ft	3 ft	3 ft
151– 600V	3 ft	3½ft	4 ft
601– 1,000V	3 ft	4 ft	5 ft

Figure 110–53, Figure 110–54, and Figure 110–55

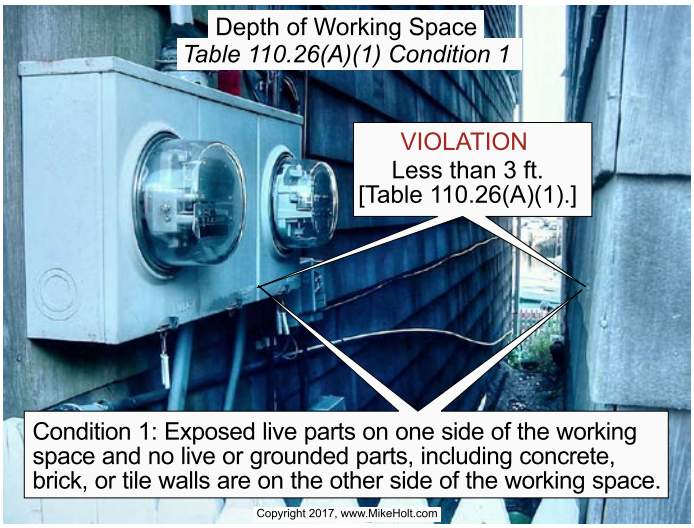


Figure 110–53

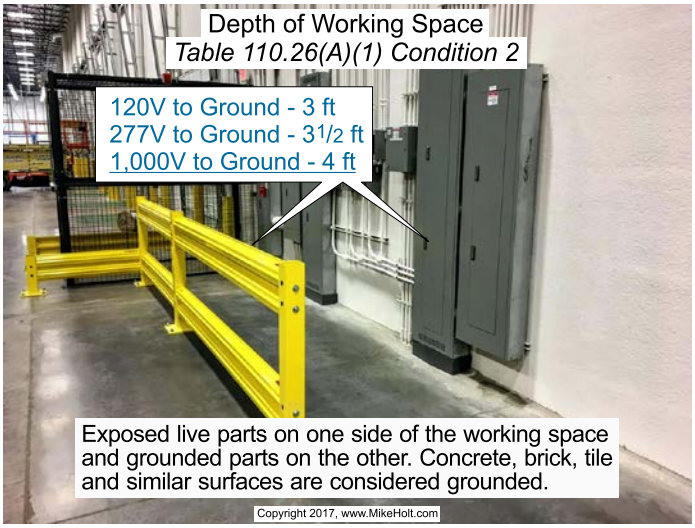


Figure 110–54

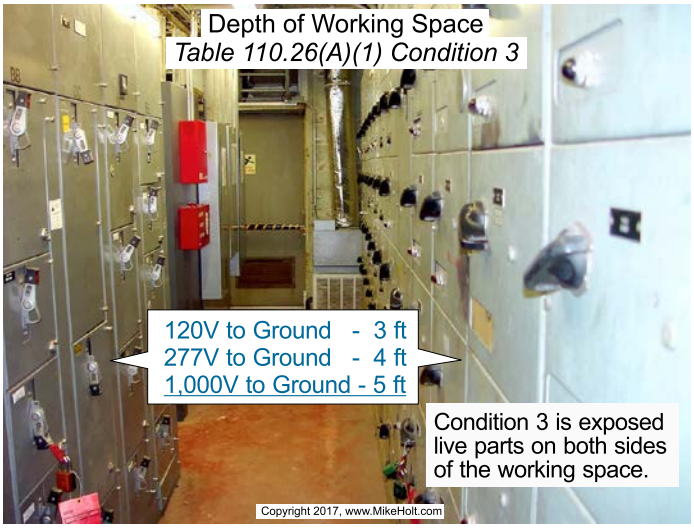


Figure 110–55

(a) Rear and Sides. Working space isn't required for the back or sides of assemblies where all connections and all renewable or adjustable parts are accessible from the front. Figure 110–56

Figure 110–56

(b) Low Voltage. If special permission is granted in accordance with 90.4, working space for equipment that operates at not more than 30V ac or 60V dc can be less than the distance in Table 110.26(A)(1). Figure 110–57

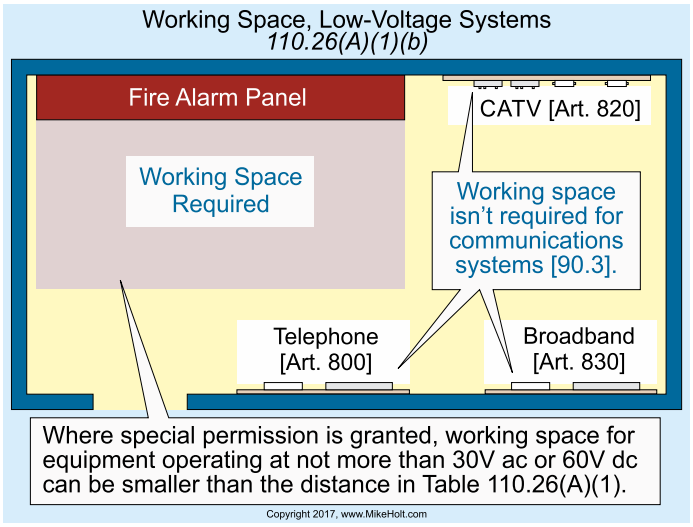


Figure 110–57

Author's Comment:

- See the definition of "Special Permission" in Article 100.

(c) Existing Buildings. If electrical equipment is being replaced, Condition 2 working space is permitted between dead-front switchboards, switchgear, panelboards, or motor control centers located across the aisle from each other where conditions of maintenance and supervision ensure that written procedures have been adopted to prohibit equipment on both sides of the aisle from being open at the same time, and only authorized, qualified persons will service the installation.

Author's Comment:

- The working space requirements of 110.26 don't apply to equipment included in Chapter 8–Communications Circuits [90.3].

(2) Width of Working Space. The width of the working space must be a minimum of 30 in., but in no case less than the width of the equipment. Figure 110–58 and Figure 110–59

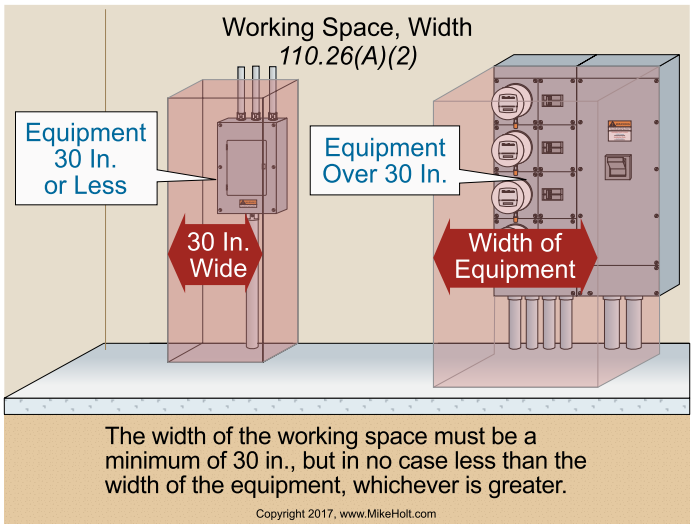


Figure 110–58

Figure 110–59

Author's Comment:

- The width of the working space can be measured from left-to-right, from right-to-left, or simply centered on the equipment, and can overlap the working space for other electrical equipment. Figure 110–60

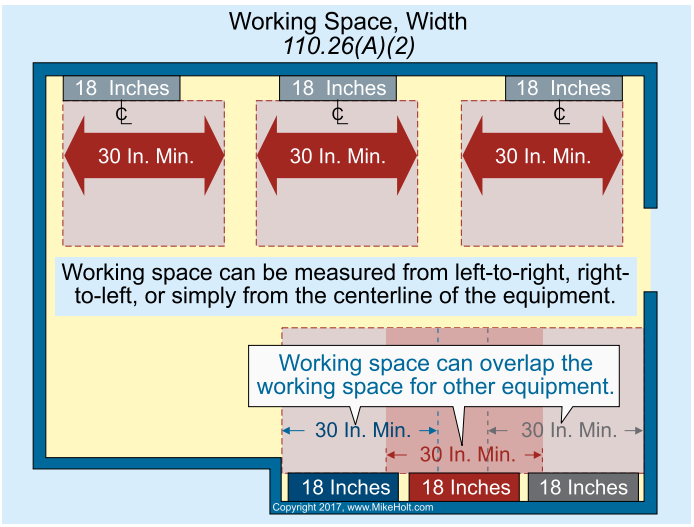


Figure 110–60

The working space must be of sufficient width, depth, and height to permit all equipment doors to open 90 degrees. Figure 110–61

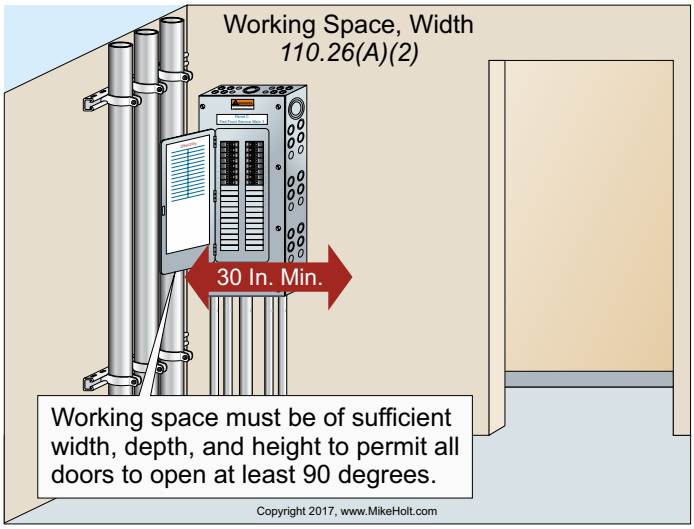
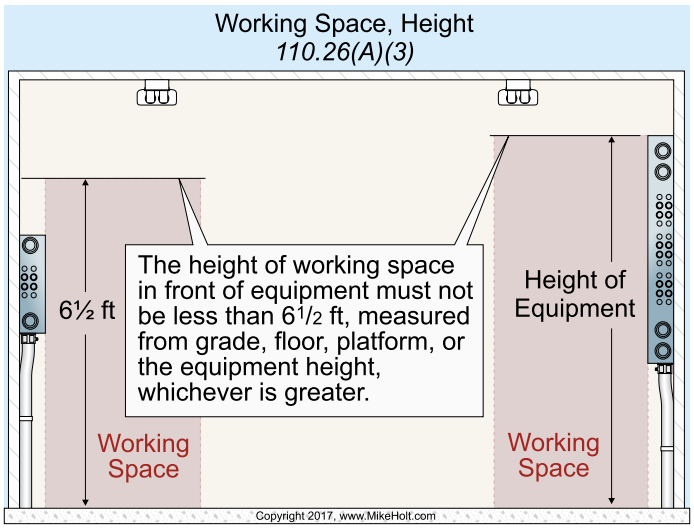


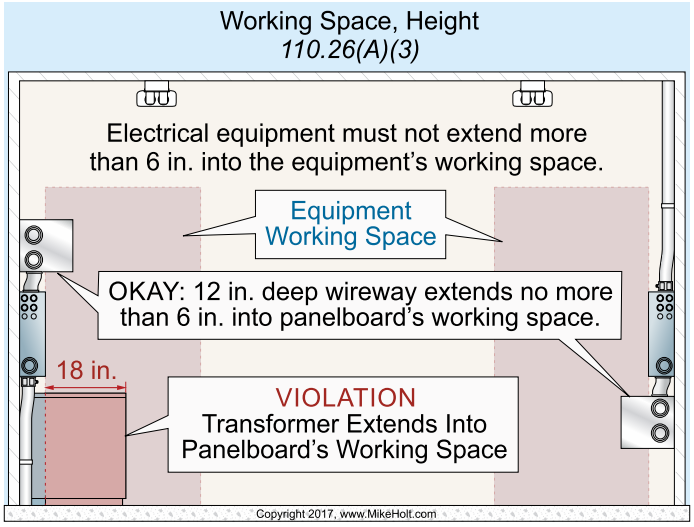
Figure 110–61

(3) Height of Working Space (Headroom). The height of the working space in front of equipment isn't permitted to be less than 6½ ft, measured from the grade, floor, platform, or the equipment height, whichever is greater. Figure 110–62



▶Figure 110–62

Equipment such as raceways, cables, wireways, cabinets, panels, and so on, can be located above or below electrical equipment, but must not extend more than 6 in. into the equipment's working space. ▶Figure 110–63



▶Figure 110–63

Ex 1: The minimum headroom requirement doesn't apply to service equipment or panelboards rated 200A or less located in an existing dwelling unit.

Author's Comment:

- See the definition of "Dwelling Unit" in Article 100.

Ex 2: Meters are permitted to extend beyond the other equipment.

Ex 3: For battery systems, see 480.10(D) for top clearance requirements.

(4) Limited Access. Where equipment is likely to require examination, adjustment, servicing, or maintenance while energized is located in a space with limited access, all of the following conditions apply:

(a)(1) Above Suspended Ceiling. Equipment installed above a suspended ceiling must have an access opening not smaller than 22 in. × 22 in.

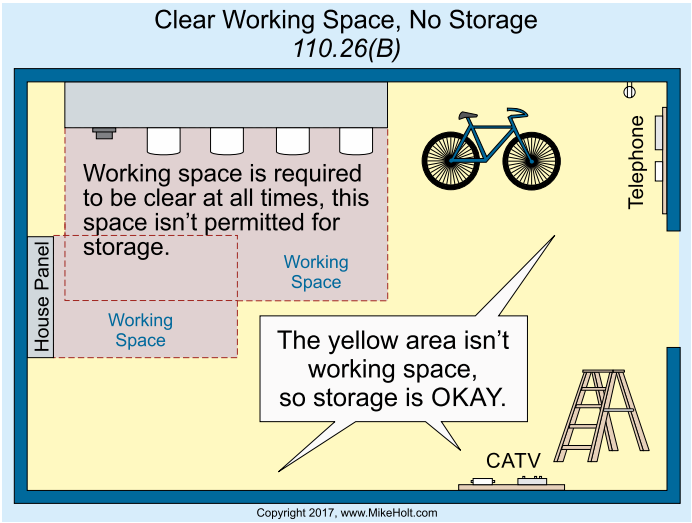
(a)(2) Crawl Space. Equipment installed in a crawl space must have an accessible opening not smaller than 22 in. × 30 in.

(b) The width of the working space must be a minimum of 30 in., but in no case less than the width of the equipment.

(c) The working space must permit equipment doors to open 90 degrees.

(d) The working space in front of the equipment must comply with the depth requirements of Table 110.26(A)(1), and horizontal ceiling structural members are permitted in this space.

(B) Clear Working Space. The working space required by this section must be clear at all times; therefore, this space isn't permitted for storage. ▶Figure 110–64



▶Figure 110–64

When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or open space, must be suitably guarded.

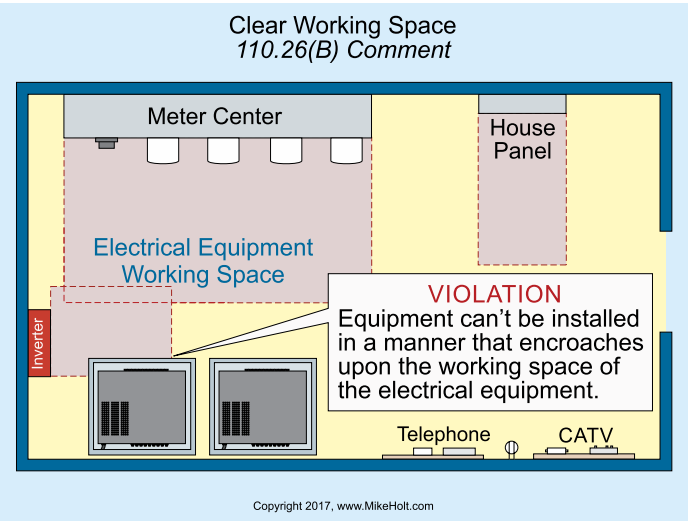
Author's Comment:

- When working in a passageway, the working space should be guarded from occupants using it. When working on electrical equipment in a passageway one must be mindful of a fire alarm evacuation with numerous occupants congregated and moving through the area.

CAUTION: It's very dangerous to service energized parts in the first place, and it's unacceptable to be subjected to additional dangers by working around bicycles, boxes, crates, appliances, and other impediments.

Author's Comment:

- Signaling and communications equipment aren't permitted to be installed in a manner that encroaches on the working space of the electrical equipment. ▶Figure 110–65



▶Figure 110–65

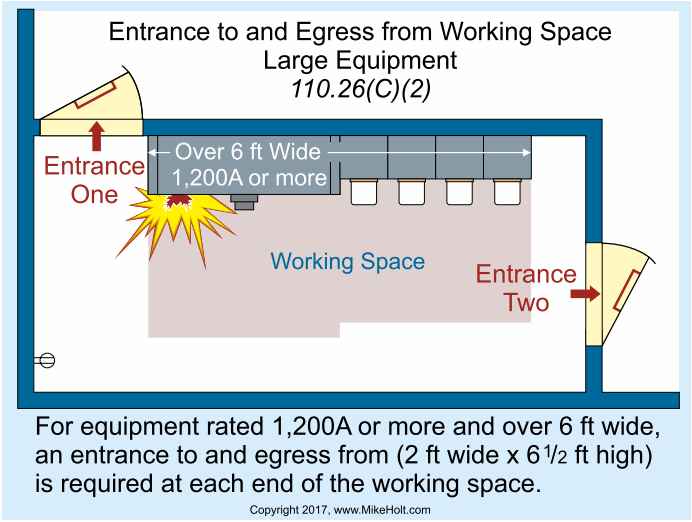
(C) Entrance to and Egress from Working Space.

(1) Minimum Required. At least one entrance of sufficient area must provide access to and egress from the working space.

Author's Comment:

- Check to see what the authority having jurisdiction considers "Sufficient Area." Building codes contain minimum dimensions for doors and openings for personnel travel.

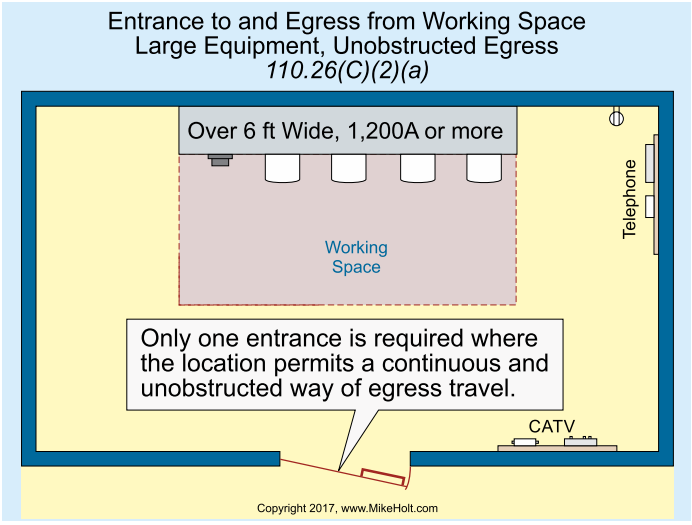
(2) Large Equipment. An entrance to and egress from each end of the working space of electrical equipment rated 1,200A or more that's over 6 ft wide is required. The opening must be a minimum of 24 in. wide and 6½ ft high. ▶Figure 110–66



▶Figure 110–66

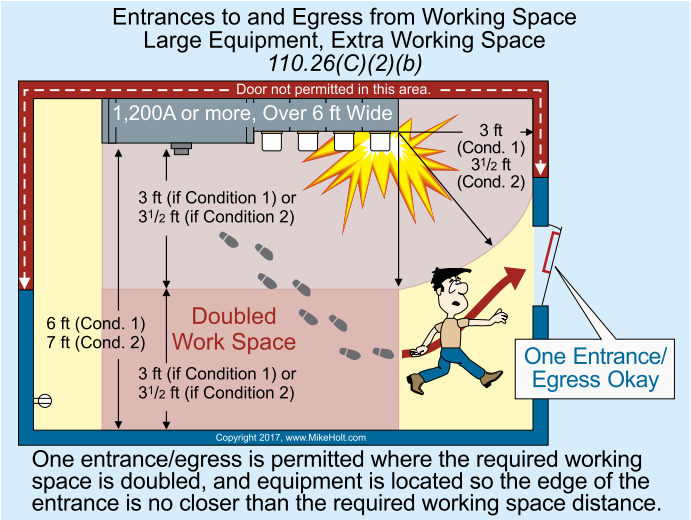
A single entrance to and egress from the required working space is permitted where either of the following conditions is met:

(a) Unobstructed Egress. Only one entrance is required where the location permits a continuous and unobstructed way of egress travel. ▶Figure 110–67



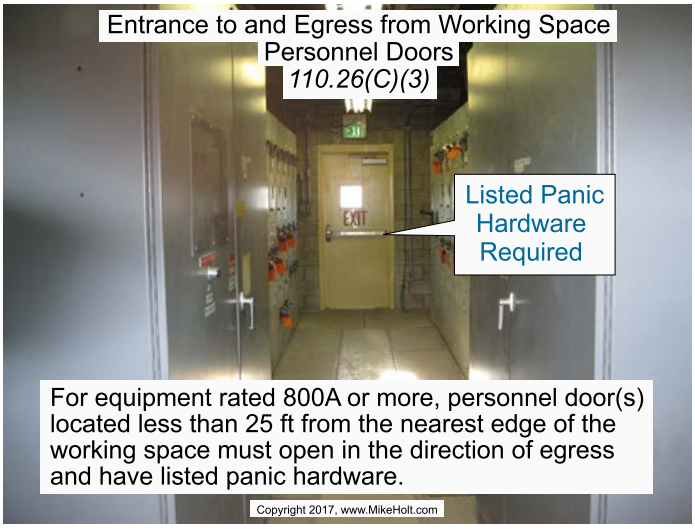
▶Figure 110–67

(b) Double Workspace. Only one entrance is required where the required working space depth is doubled, and the equipment is located so the edge of the entrance is no closer than the required working space distance. ▶Figure 110–68



▶Figure 110–68

(3) Personnel Doors. If equipment with overcurrent or switching devices rated 800A or more is installed, personnel door(s) for entrance to and egress from the working space located less than 25 ft from the nearest edge of the working space must have the door(s) open in the direction of egress and be equipped with listed panic hardware. ▶Figure 110–69

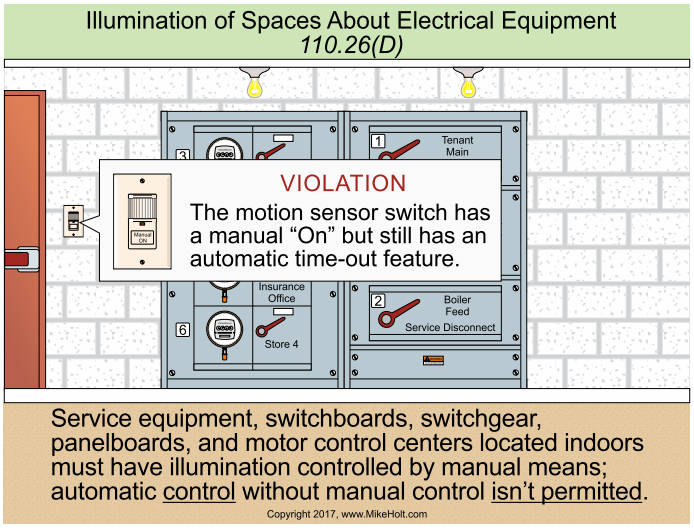


▶Figure 110–69

Author's Comment:

- History has shown that electricians who suffer burns on their hands in electrical arc-flash or arc-blast events often can't open doors equipped with knobs that must be turned.
- Since this requirement is in the *NEC*, the electrical contractor is responsible for ensuring that panic hardware is installed where required. Some are offended at being held liable for nonelectrical responsibilities, but this rule is designed to save the lives of electricians. For this and other reasons, many construction professionals routinely hold "pre-construction" or "pre-con" meetings to review potential opportunities for miscommunication—before the work begins.

(D) Illumination. Service equipment, switchboards, switchgear, and panelboards, as well as motor control centers located indoors must have illumination located indoors controlled by manual means; automatic control without manual control isn't permitted. ▶Figure 110–70



▶Figure 110–70

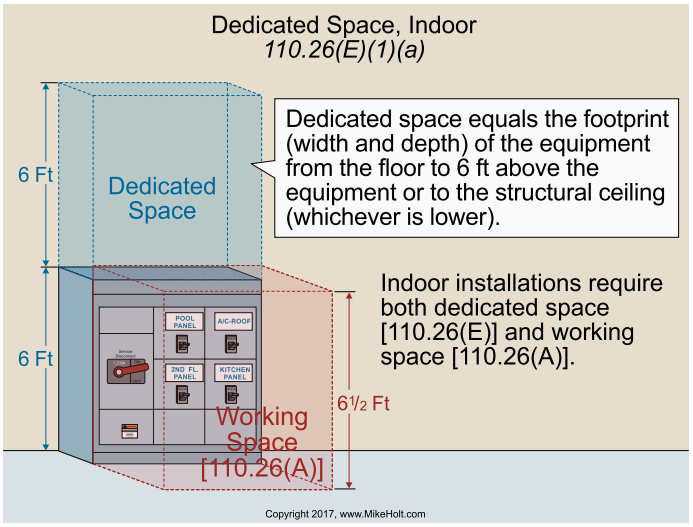
Author's Comment:

- The *Code* doesn't provide the minimum foot-candles required to provide proper illumination. Proper illumination of electrical equipment rooms is essential for the safety of those qualified to work on such equipment.

(E) Dedicated Equipment Space. Switchboards, switchgear, panelboards, and motor control centers must have dedicated equipment space and be protected from damage as follows:

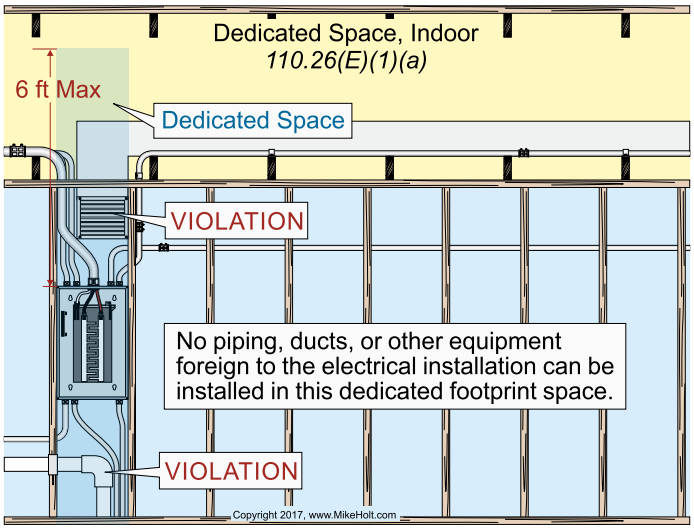
(1) Indoors.

(a) Dedicated Electrical Space. The footprint space (width and depth of the equipment) extending from the floor to a height of 6 ft above the equipment or to the structural ceiling, whichever is lower, must be dedicated for the electrical installation. ▶Figure 110–71



▶Figure 110–71

No piping, ducts, or other equipment foreign to the electrical installation can be installed in this dedicated footprint space. ▶Figure 110–72

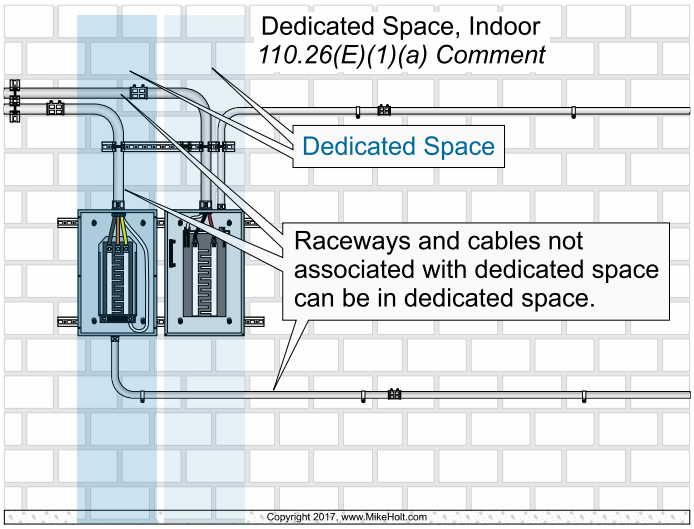


▶Figure 110–72

Ex: Suspended ceilings with removable panels can be within the dedicated footprint space [110.26(E)(1)(d)].

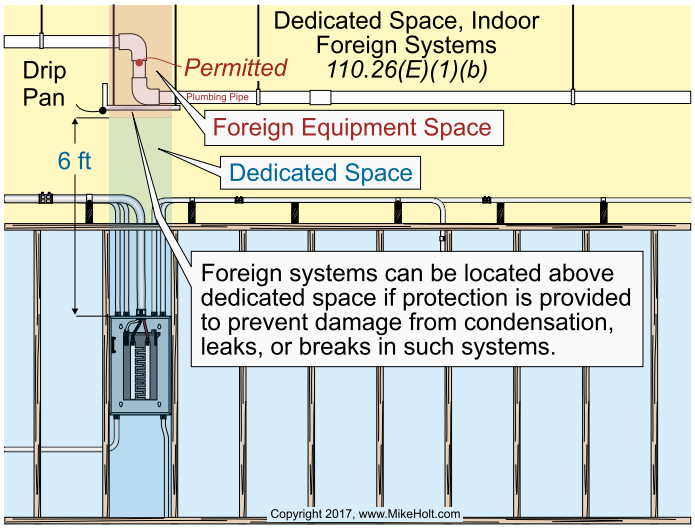
Author's Comment:

- Electrical raceways and cables not associated with the dedicated space can be within the dedicated space. These aren't considered "equipment foreign to the electrical installation." ▶Figure 110–73



▶Figure 110–73

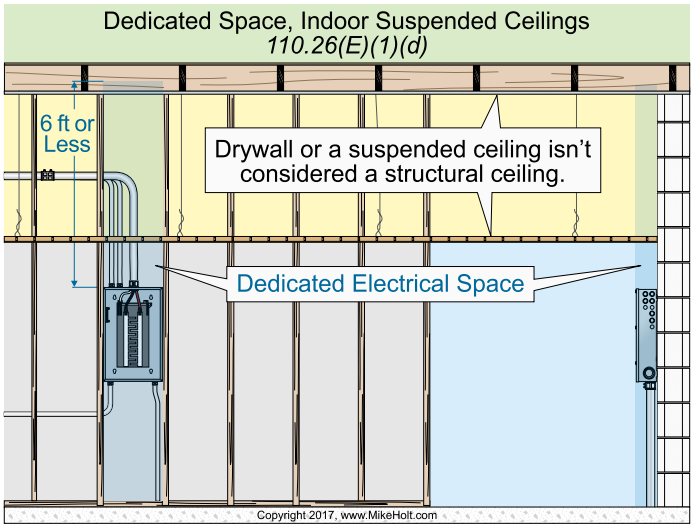
(b) Foreign Systems. Foreign systems can be located above the dedicated space if protection is installed to prevent damage to the electrical equipment from condensation, leaks, or breaks in the foreign systems. Such protection can be as simple as a drip-pan. ▶Figure 110–74



▶Figure 110–74

(c) Sprinkler Protection. Sprinkler protection piping isn't permitted in the dedicated space, but the *NEC* doesn't prohibit sprinklers from spraying water on electrical equipment.

(d) Suspended Ceilings. A dropped, suspended, or similar ceiling isn't considered a structural ceiling. ▶Figure 110–75



▶Figure 110–75

(2) Outdoor. Outdoor installations must comply with the following:

(a) Installation Requirements. Switchboards, switchgear, panelboards, and motor control centers installed outdoors must be:

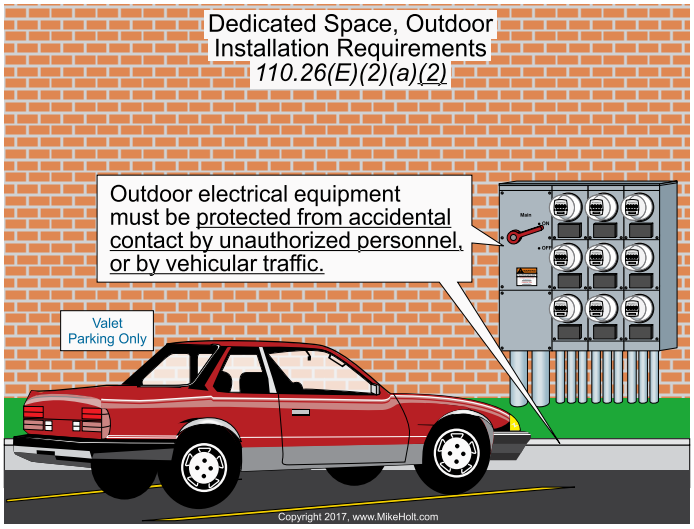
(1) Installed in identified enclosures

(2) Protected from accidental contact by unauthorized personnel, or by vehicular traffic ▶Figure 110–76

(3) Protected by accidental spillage or leakage from piping systems

(b) Work Space. Switchboards, switchgear, panelboards, and motor control centers installed outdoors must have sufficient working space clearance in accordance with 110.26(A). No architectural appurtenance or other equipment is permitted in the work space.

(c) Dedicated Equipment Space Outdoor. The footprint space (width and depth of the equipment) extending from grade to a height of 6 ft above the equipment must be dedicated for the electrical installation. No piping, ducts, or other equipment foreign to the electrical installation can be installed in this dedicated footprint space.



▶Figure 110–76

Author's Comment:

- See the definition of "Accessible (as applied to equipment)" in Article 100.

(F) Locked Electrical Equipment Rooms or Enclosures. Electrical equipment rooms or enclosures containing electrical apparatus controlled by a lock(s) are considered accessible to qualified persons. ▶Figure 110–77

▶Figure 110–77

ARTICLE 210 BRANCH CIRCUITS

Introduction to Article 210—Branch Circuits

This article contains the requirements for branch circuits, such as conductor sizing and identification, GFCI protection, and receptacle and lighting outlet requirements. It consists of three parts:

- Part I. General Provisions
- Part II. Branch-Circuit Ratings
- Part III. Required Outlets

Table 210.3 of this article identifies specific-purpose branch circuits. The provisions for branch circuits that supply equipment listed in Table 210.3 amend or supplement the provisions given in Article 210 for branch circuits, so it's important to be aware of the contents of this table.

Mastering the branch-circuit requirements in Article 210 will give you a jump-start toward completing installations that are free of *Code* violations.

Top Ten Changes to the *NEC* #4

210.12 Arc-Fault Circuit-Interrupter Protection

The AFCI requirements have been greatly expanded.

Analysis

NEW

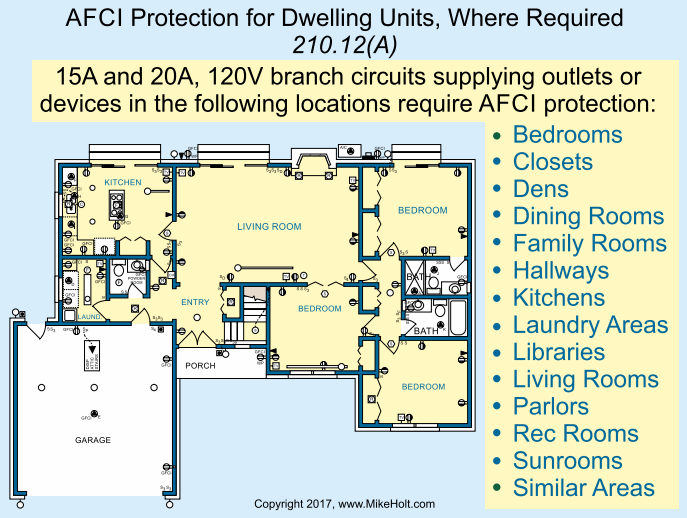
AFCI protection is now required for guest rooms and suites of hotels and motels. This seems to be the progression of *Code* rules, such as the tamper-resistant receptacles required in 406.12. Because these areas are very similar in their use to dwelling units, this new rule was accepted.

The requirement for updating the electrical system when adding or modifying wiring was extended to dormitories. The *NEC* is often three years behind in making new allowances, and this will be the case as long as humans are responsible for the *Code*. Considering that there are typically 3,000 to 5,000 proposals (now called "public input") to change the *NEC*, things are going to slip through the cracks. Why not require the same rules and the same exception to all areas requiring AFCI protection?

210.12 Arc-Fault Circuit-Interrupter Protection

Arc-fault circuit-interrupter protection must be provided in accordance with 210.12(A), (B), (C), and (D). AFCI devices must be installed in readily accessible locations.

(A) Required Locations. A listed combination AFCI breaker is required for all 15A or 20A, 120V branch circuits in dwelling units supplying outlets or devices in kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, or similar rooms or areas. ▶Figure 210–53



▶Figure 210–53

(B) Dormitory Units. A listed combination AFCI breaker is required for all 15A or 20A, 120V branch circuits for outlets and devices in dormitory unit bedrooms, living rooms, hallways, closets, bathrooms, and similar rooms in accordance with 210.12(A).

(C) Guest Rooms and Guest Suites. A listed combination AFCI breaker is required for all 15A or 20A, 120V branch circuits supplying outlets and devices in guest rooms and guest suites of hotels and motels. ▶Figure 210–54

▶Figure 210–54

(D) Branch-Circuit Extensions or Modifications in Dwelling Units and Dormitory Units. Where 15A or 20A, 120V branch-circuit wiring is modified, replaced, or extended in a dwelling unit or dormitory where AFCI protection is required [210.12(A)], the modified, replaced, or extended branch-circuit wiring must be AFCI protected by one of the following methods:

(1) A listed combination AFCI circuit breaker

(2) A listed AFCI receptacle located at the first receptacle outlet of the branch circuit

Ex: AFCI protection isn't required for extension wiring that's less than 6 ft in length if no outlets or devices are added.

Top Ten Changes to the *NEC* #5

210.52 Dwelling Unit Receptacle Outlet Requirements

Many changes were made to dwelling unit receptacle location rules, most having to do with countertops and work surfaces.

Analysis

CLARIFIED

Wall Space. 210.52(A) provides the rules for the placement of receptacles at wall spaces. Wall spaces don't include doorways and similar openings, fireplaces, and fixed cabinetry; unless, new to this edition, the cabinetry has a countertop. This results in the walls in rooms such as libraries, dens, and/or offices with built-in bookcases to not have receptacles installed in them since a bookcase is just a cabinet, not a wall. One area that's often missed is the installation of receptacles in an island or peninsula of a kitchen. This is certainly cabinetry, and as such, the back side of this cabinetry was exempt from the receptacle placement requirements for wall spacing. Oftentimes a peninsula or island creates a wall of sorts, separating the kitchen from, say, the dining room. Because this cabinetry has a countertop it's now considered wall space, so a receptacle(s) will be required to be installed, which serves as a receptacle for the dining room.

EDITED

Similar Work Space. Many changes were made throughout 210.52 to include "similar work spaces" wherever the word "countertop" was used. This clears up any disagreement about work spaces in kitchens that aren't necessarily countertops but are still likely to have appliances being used there.

CLARIFIED

Dedicated 15A Circuit. The receptacle for the kitchen refrigerator has long been allowed to be installed on an individual 15A circuit instead of one of the two required small-appliance branch circuits. This makes sense, and, although it's an exception, it really makes for a better installation. With this said, why not allow the same exception for a trash compactor, garbage disposal, wine coolers, dishwasher, or a built-in microwave? If the refrigerator can have a dedicated 15A circuit, why not the other appliances in the kitchen?

CLARIFIED

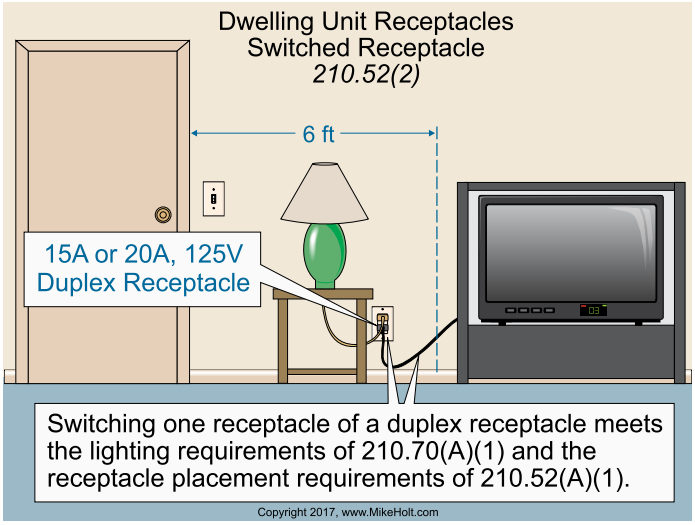
Garages. The last change to 210.52 is found in (G) for garages. The 2014 *Code* added requirements for additional receptacle(s) in the garage based on its size and the 2017 *NEC* specifies that garage receptacles can't be installed above 5 ft 6 in. from the floor, otherwise they don't count as the required receptacle(s).

210.52 Dwelling Unit Receptacle Outlet Requirements

This section provides requirements for 15A and 20A, 125V receptacle outlets and are in addition to any receptacle that's:

(1) Part of a luminaire or appliance,

(2) Controlled by a wall switch in accordance with 210.70(A)(1), Ex 1. ▶Figure 210–75



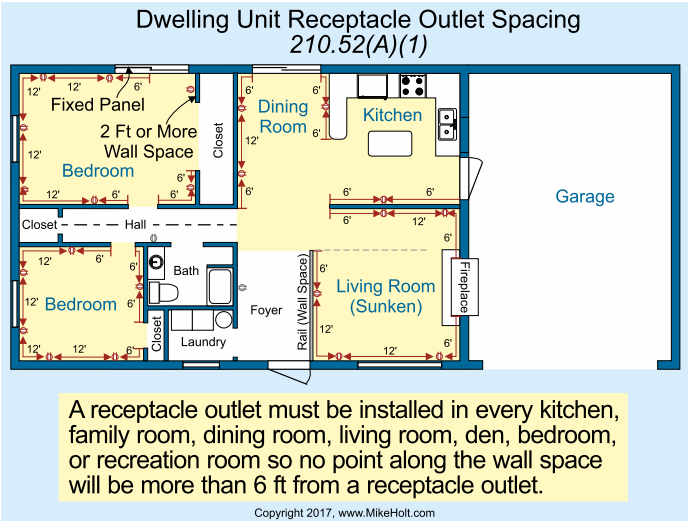
▶Figure 210–75

(3) Located within cabinets or cupboards, or

(4) Located more than 5½ ft above the floor.

(A) General Requirements for Dwelling Unit Receptacle Outlets. A receptacle outlet must be installed in every kitchen, family room, dining room, living room, sunroom, parlor, library, den, bedroom, recreation room, and similar room or area in accordance with (1), (2), (3), and (4):

(1) Receptacle Placement. A receptacle outlet must be installed so that no point along the floor line of any wall is more than 6 ft, measured horizontally along the floor line, from a receptacle outlet. ▶Figure 210–76



▶Figure 210–76

Author's Comment:

- The purpose of this rule is to ensure that a general-purpose receptacle is conveniently located to reduce the chance that an extension cord will be used.

(2) Definition of Wall Space for Placement of Receptacle Outlets.

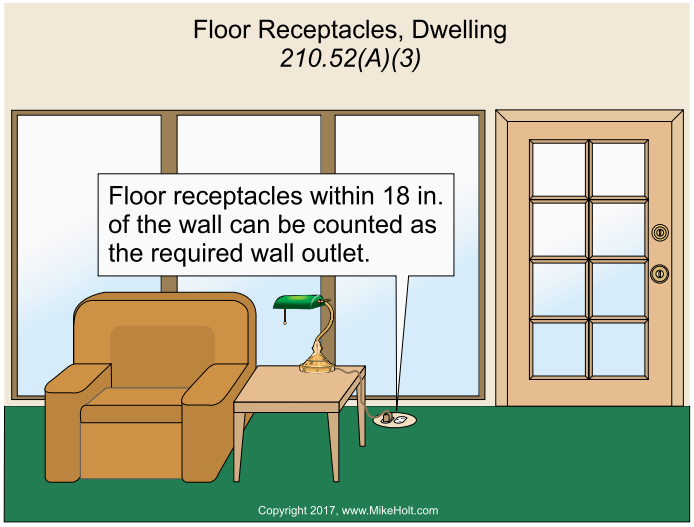
(1) Any space 2 ft or more in width, unbroken along the floor line by doorways and similar openings, fireplaces, and fixed cabinets that don't have countertops or similar work surfaces. ▶Figure 210–77

▶Figure 210–77

(2) The space occupied by fixed panels.

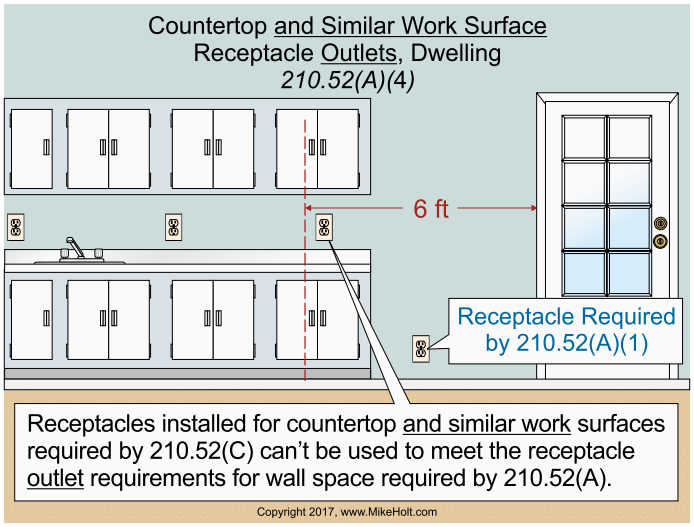
(3) The space occupied by fixed room dividers, such as freestanding bar-type counters or guard rails.

(3) Floor Receptacle Outlets. Floor receptacle outlets aren't counted as the required receptacle wall outlet if they're located more than 18 in. from the wall. ▶Figure 210–78



▶Figure 210–78

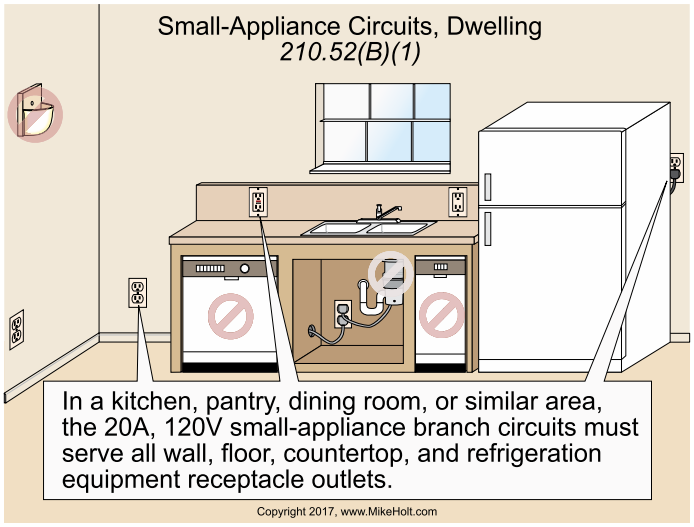
(4) Countertop and Similar Work Surface Receptacle Outlets. Receptacles installed for countertop and similar work surfaces as required by 210.52(C), can't be used to meet the receptacle outlet requirements for wall space as required by 210.52(A). ▶Figure 210–79



▶Figure 210–79

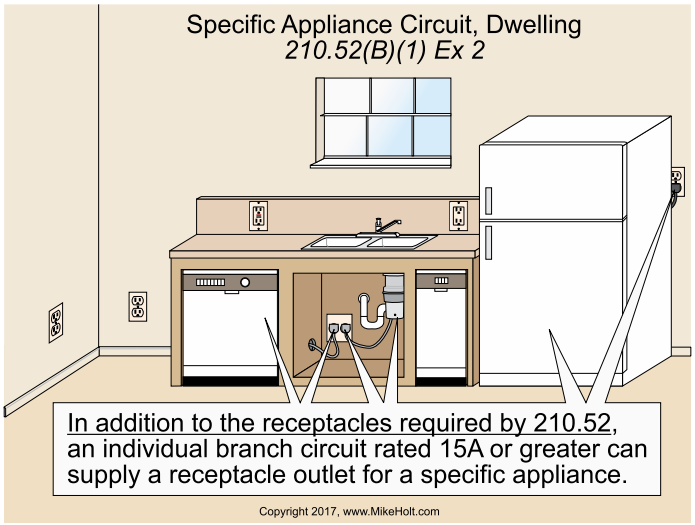
(B) Small-Appliance Circuits.

(1) Receptacle Outlets. The two or more 20A, 120V small-appliance branch circuits serving the kitchen, pantry, breakfast room, and dining room area of a dwelling unit [210.11(C)(1)] must serve all wall, floor, countertop receptacle outlets [210.52(C)], and the receptacle outlet for refrigeration equipment. ▶Figure 210–80



▶Figure 210–80

Ex 2: In addition to the required receptacles specified by 210.52, an individual branch circuit rated 15A or greater can supply a receptacle outlet for a specific appliance, such as a refrigerator in the kitchen, pantry, breakfast room, or dining room area. ▶Figure 210–81

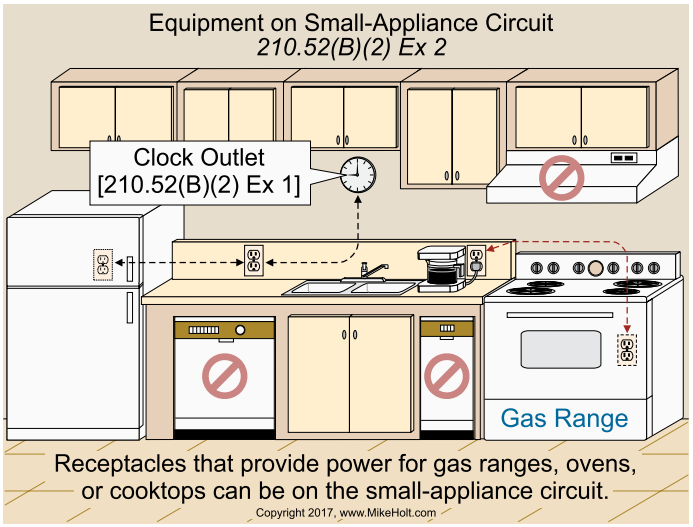


▶Figure 210–81

(2) Not Supply Other Outlets. The 20A, 120V small-appliance circuits required by 210.11(C)(1) must not supply outlets for luminaires or appliances.

Ex 1: The 20A, 120V small-appliance branch circuit can be used to supply a receptacle for an electric clock.

Ex 2: A receptacle can be connected to the small-appliance branch circuit to supply a gas-fired range, oven, or counter-mounted cooking unit. ▶Figure 210–82



▶Figure 210–82

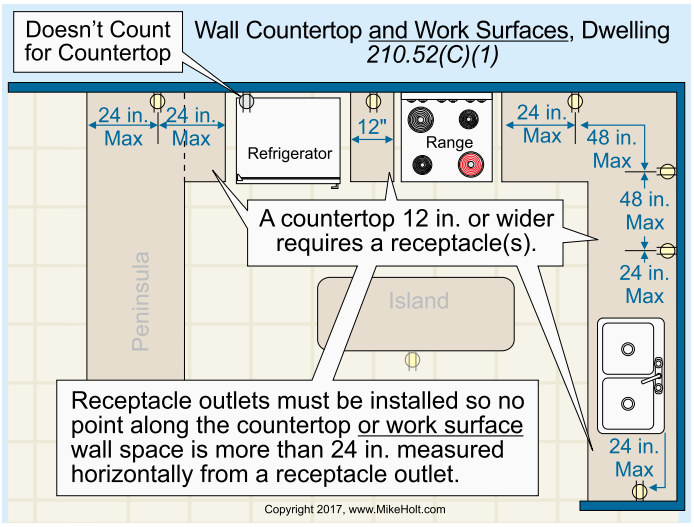
Author's Comment:

- A range hood or over-the-range microwave listed as a range hood that's flexible cord-and-plug-connected must be supplied by an individual branch circuit [422.16(B)(4)(5)].

(C) Countertop and Work Surface Receptacle Outlets. In kitchens, pantries, breakfast rooms, dining rooms, and similar areas of dwelling units, receptacle outlets for countertop spaces and work surfaces must be installed according to (C)(1) through (C)(5) below. ▶Figure 210–83

(1) Wall Countertop and Work Surfaces Receptacle Outlets. A receptacle outlet must be installed for each kitchen and dining area countertop wall space 1 ft or wider, and receptacle outlets must be placed so that no point along the countertop space or work surface wall space is more than 2 ft, measured horizontally, from a receptacle outlet. ▶Figure 210–84

▶Figure 210–83

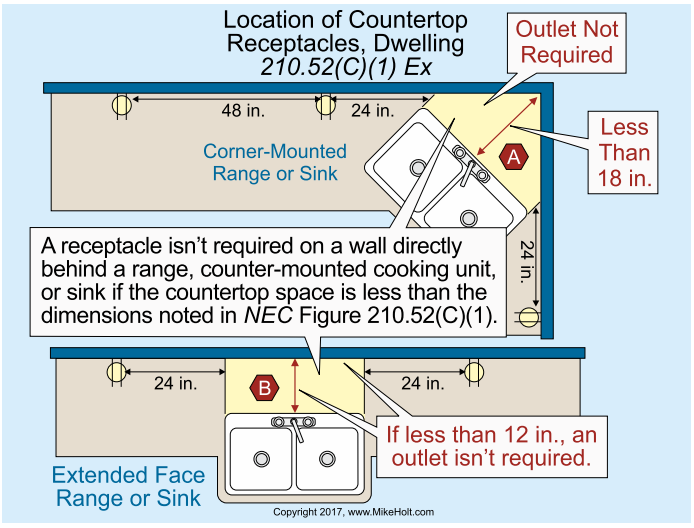


▶Figure 210–84

Ex: A receptacle outlet isn't required on a wall directly behind a range, counter-mounted cooking unit, or sink, in accordance with Figure 210.52(C)(1) in the NEC. ▶Figure 210–85

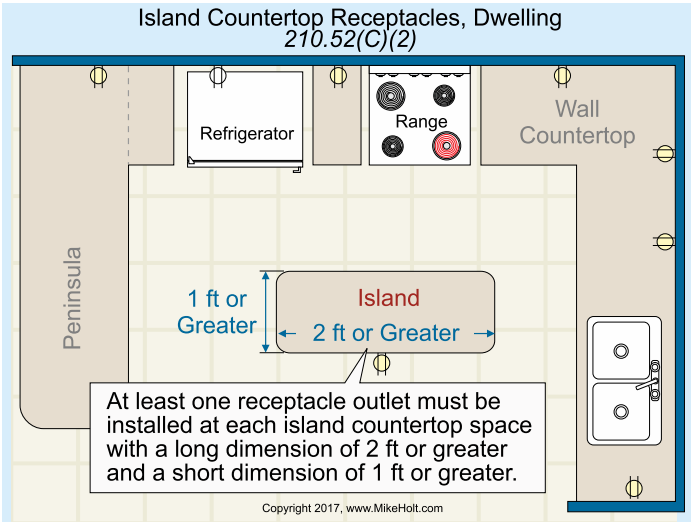
Author's Comment:

- If the countertop space behind a range or sink is larger than the dimensions noted in Figure 210.52(C)(1) of the *NEC*, then a GFCI-protected receptacle must be installed in that space. This is because, for all practical purposes, if there's sufficient space for an appliance, an appliance will be placed there.



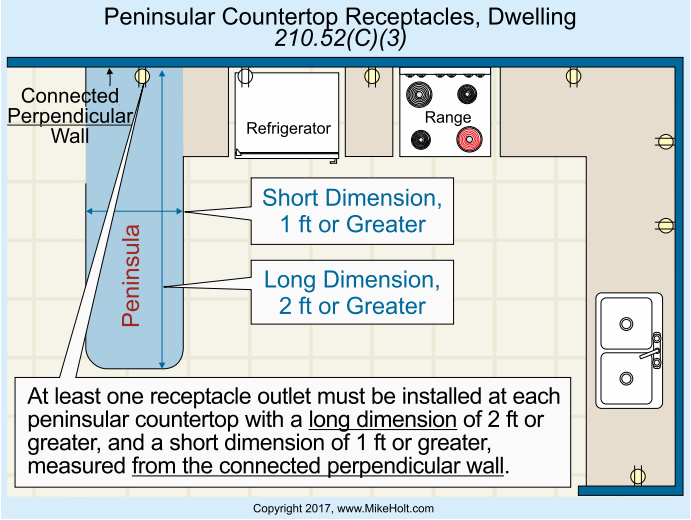
▶Figure 210–85

(2) Island Countertop Space Receptacle Outlets. At least one receptacle outlet must be installed at each island countertop space with a long dimension of 2 ft or more, and a short dimension of 1 ft or more. ▶Figure 210–86



▶Figure 210–86

(3) Peninsular Countertop Space Receptacle Outlets. At least one receptacle outlet must be installed for each peninsular countertop long dimension of 2 ft or greater, and a short dimension of 1 ft or greater. The peninsular countertop is measured from the connected peninsular wall. ▶Figure 210–87

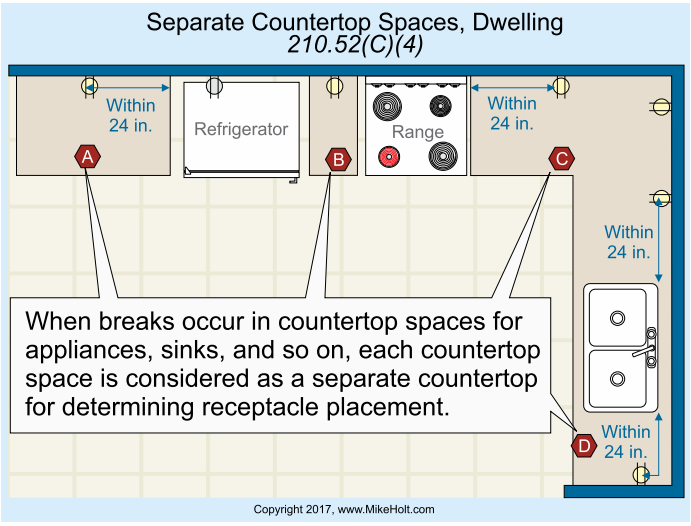


▶Figure 210–87

Author's Comment:

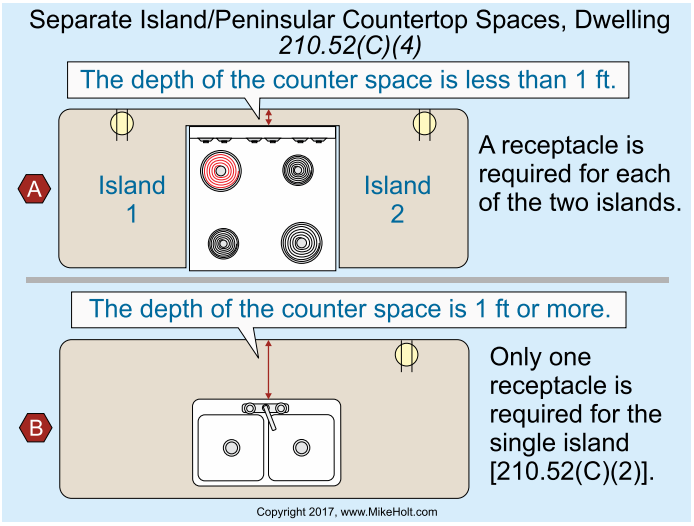
- The *Code* doesn't require more than one receptacle outlet in an island or peninsular countertop space, regardless of the length of the countertop, unless the countertop is broken as described in 210.52(C)(4).

(4) Separate Countertop Spaces. When breaks occur in countertop spaces for rangetops, refrigerators, or sinks, each countertop space is considered as a separate countertop for determining receptacle placement. ▶Figure 210–88



▶Figure 210–88

If a range, counter-mounted cooking unit, or sink is installed in an island or peninsular countertop, and the depth of the counter behind the range, counter-mounted cooking unit, or sink is less than 12 in., the countertop space is considered to be two separate countertop spaces. ▶Figure 210–89

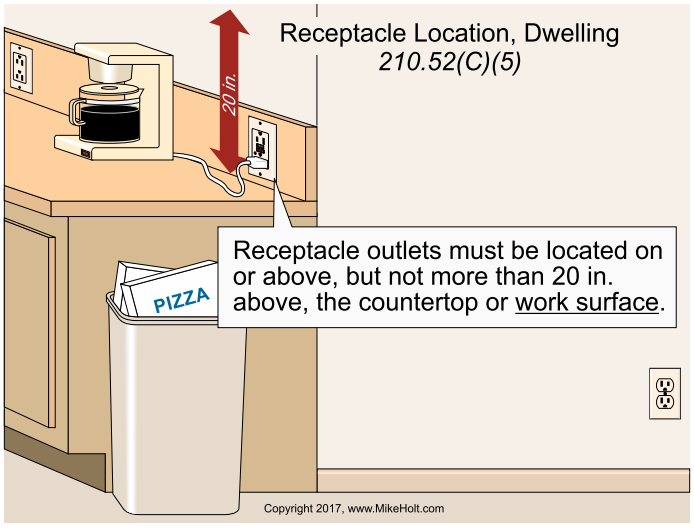


▶Figure 210–89

Author's Comment:

- GFCI protection is required for all 15A and 20A, 125V receptacles that supply kitchen countertop surfaces [210.8(A)(6)].

(5) Receptacle Location. Receptacle outlets required by 210.52(C)(1) must be located on or above, but not more than 20 in. above, the countertop or work surface. ▶Figure 210–90



▶Figure 210–90

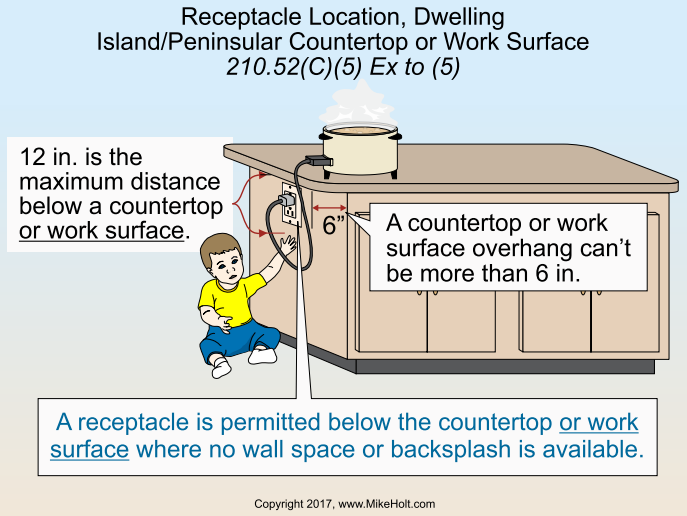
Receptacle outlet assemblies listed for use in countertops or work surfaces can be installed in countertops or work surfaces.

Note: Receptacles aren't permitted to be installed in a face-up position in countertops [406.5(E) and 406.5(G)], nor are receptacles permitted face-up in work surfaces [406.5(F) and 406.5(G)].

Ex. to (5): Receptacle outlets are permitted to be mounted not more than 12 in. below the countertop or work surface, where the countertop or work surface doesn't extend more than 6 in. beyond its support base and the receptacle outlet(s) comply with the following conditions:

(1) The countertop or work surface is construction for the physically impaired

(2) The island and peninsular countertop or work surface is flat across its entire surface (no backsplashes, dividers, and so on) and there are no means to mount a receptacle within 20 in. above the countertop or work surface, such as an overhead cabinet. ▶Figure 210–91



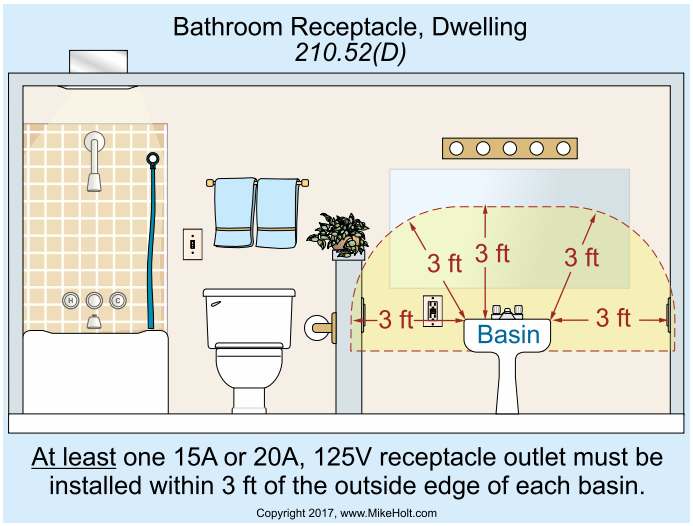
▶Figure 210–91

Receptacle outlets rendered not readily accessible by appliances fastened in place, located in an appliance garage, behind sinks, or rangetops [210.52(C)(1) Ex], or supplying appliances that occupy dedicated space don't count as the required countertop or work surface receptacles.

Author's Comment:

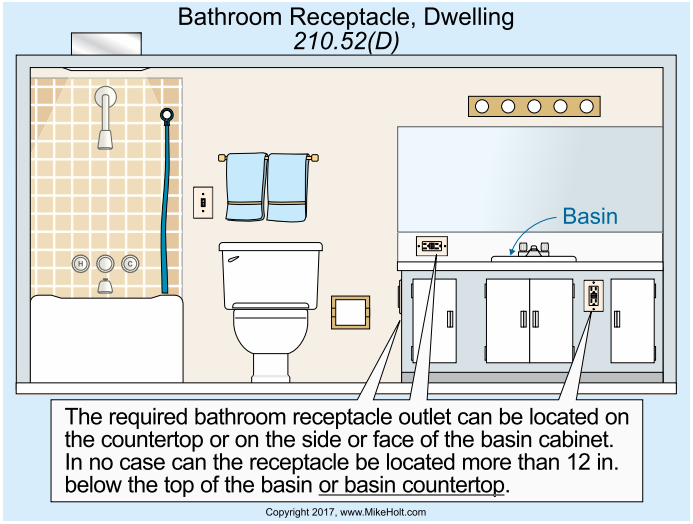
- An "appliance garage" is an enclosed area on the countertop where an appliance can be stored and hidden from view when not in use. If a receptacle is installed inside an appliance garage, it doesn't count as a required countertop receptacle outlet.

(D) Dwelling Unit Bathroom Receptacles. At least one 15A or 20A, 125V receptacle outlet must be installed within 3 ft from the outside edge of each bathroom basin. ▶Figure 210–92



▶Figure 210–92

The receptacle outlet must be located on a wall or partition adjacent to the basin counter surface, or on the side or face of the basin cabinet. In no case can the receptacle be located more than 12 in. below the top of the basin or basin countertop. ▶Figure 210–93

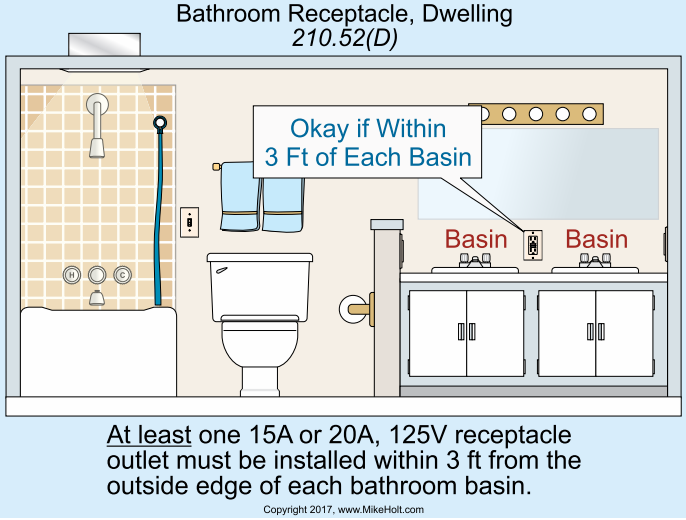


▶Figure 210–93

Note: See 406.5(E) and 406.5(G) for the installation of receptacles in countertops.

Author's Comment:

- One receptacle outlet can be located between two basins to meet this requirement, but only if it's located within 3 ft of the outside edge of each basin. ▶Figure 210–94
- Bathroom receptacles must be GFCI protected [210.8(A)(1)].



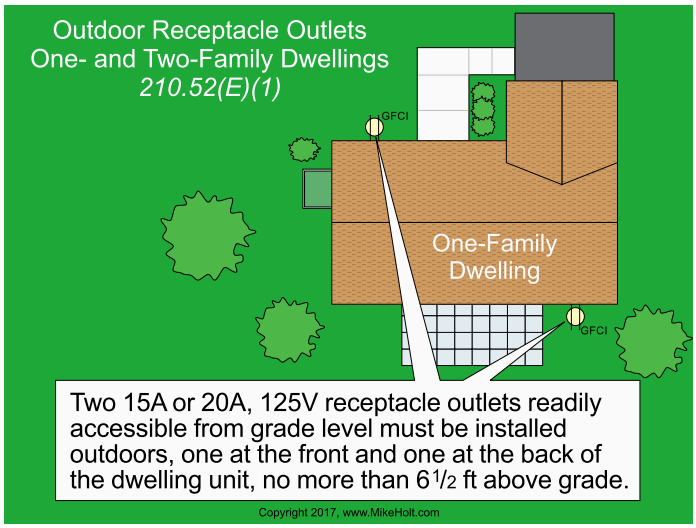
▶Figure 210–94

(E) Dwelling Unit Outdoor Receptacles. Outdoor receptacles must comply with the following: **Note:** See 210.8(A)(3).

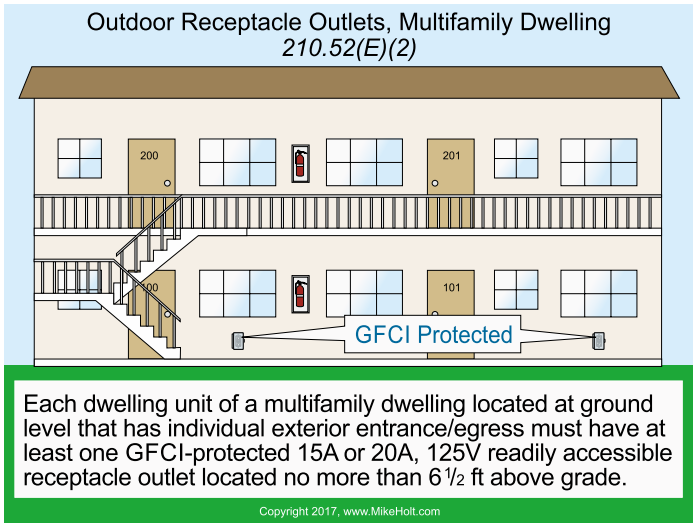
(1) One- and Two-Family Dwellings. Two GFCI-protected 15A or 20A, 125V receptacle outlets that are readily accessible from grade must be installed outdoors for each dwelling unit, one at the front and one at the back, no more than 6½ ft above grade. ▶Figure 210–95

(2) Multifamily Dwelling. Each dwelling unit of a multifamily dwelling that has an individual entrance at grade level must have at least one GFCI-protected 15A or 20A, 125V receptacle outlet readily accessible from grade located not more than 6½ ft above grade. ▶Figure 210–96

(3) Balconies, Decks, and Porches. At least one 15A or 20A, 125V receptacle outlet must be installed not more than 6½ ft above any balcony, deck, or porch surface that's attached to, and accessible from, the inside of a dwelling unit. The receptacle must be accessible from the deck, balcony, or porch surface. ▶Figure 210–97



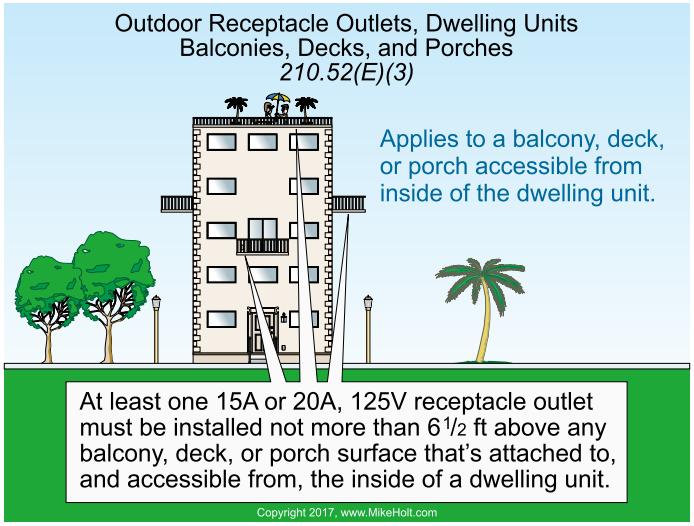
▶Figure 210–95



▶Figure 210–96

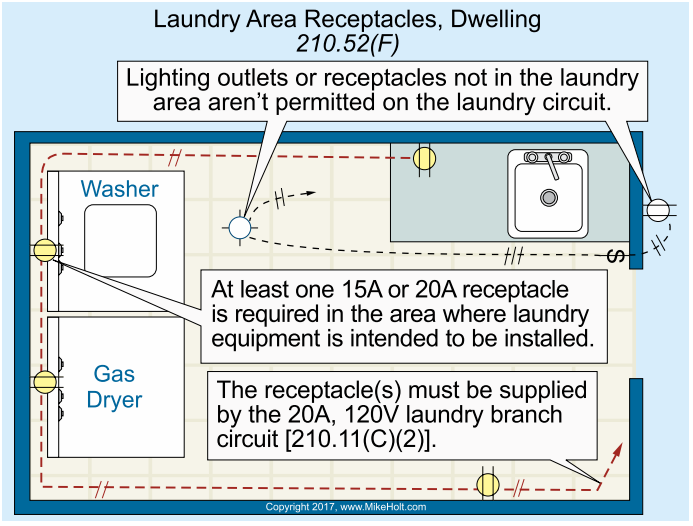
Author's Comment:

- These receptacles must be GFCI protected [210.8(A)(3)].



▶Figure 210–97

(F) Dwelling Unit Laundry Area Receptacles. Each dwelling unit must have not less than one 15A or 20A, 125V receptacle installed in the area where laundry equipment is intended to be installed. The receptacle(s) must be supplied by the 20A, 120V laundry branch circuit, which must not supply any other outlets [210.11(C)(2)]. ▶Figure 210–98



▶Figure 210–98

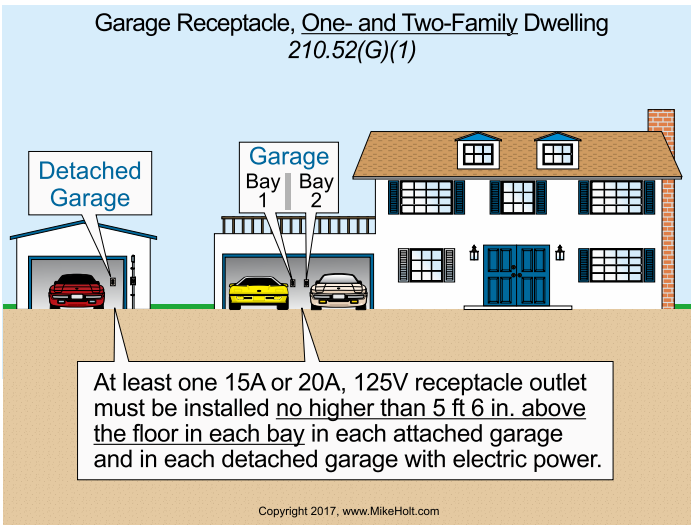
Author's Comment:

- Receptacles located within 6 ft of a laundry room sink require GFCI protection [210.8(A)(7)].

Ex 1: A laundry receptacle outlet isn't required in a dwelling unit located in a multifamily dwelling unit with laundry facilities available to all occupants.

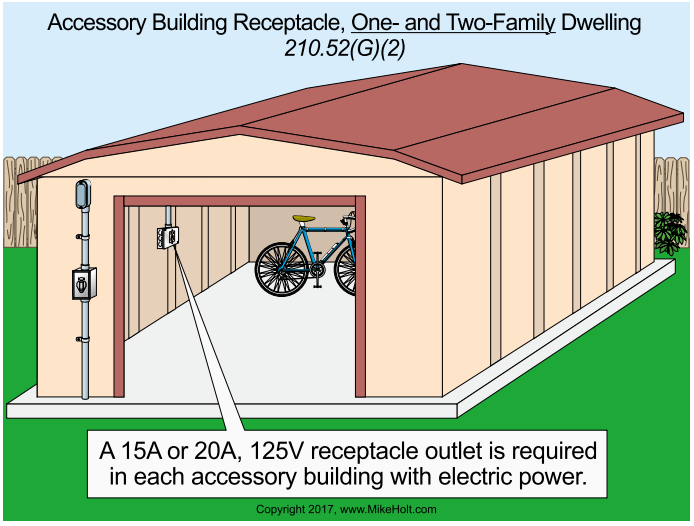
(G) Dwelling Unit Garage, Basement, and Accessory Building Receptacles. For one- and two-family dwellings, at least one receptacle must be installed in accordance with (1) through (3).

(1) Garages. At least one 15A or 20A, 125V receptacle outlet must be installed no higher than 5 ft 6 in. above the floor in each vehicle bay in each attached garage and in each detached garage with electric power. ▶Figure 210–99



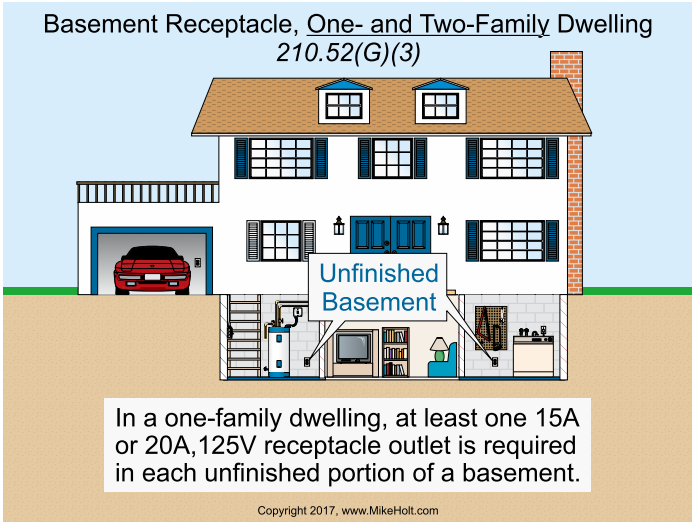
▶Figure 210–99

(2) Accessory Buildings. A 15A or 20A, 125V receptacle is required in each accessory building with electric power. ▶Figure 210–100



▶Figure 210–100

(3) Basements. Each unfinished portion of a basement must have a 15A or 20A, 125V receptacle outlet installed. ▶Figure 210–101



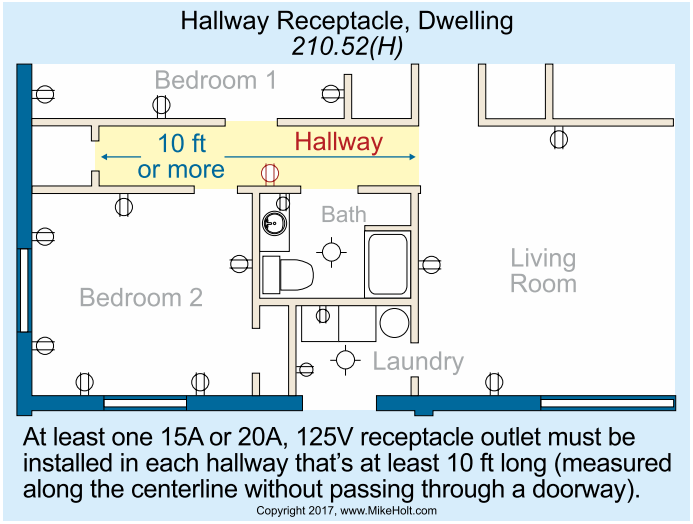
▶Figure 210–101

Author's Comment:

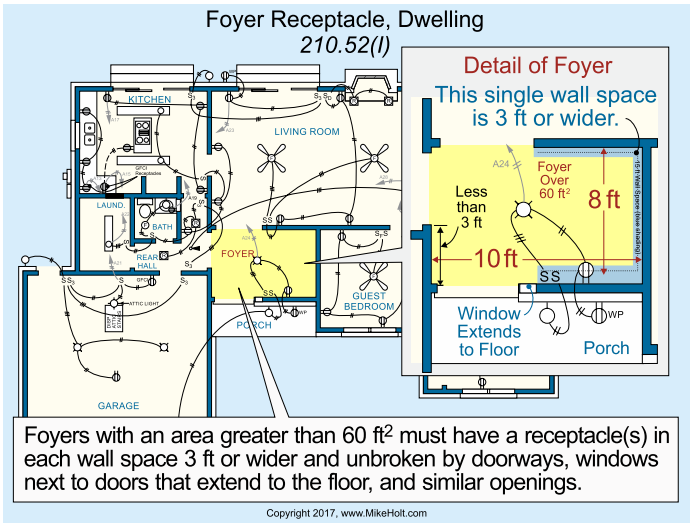
- One 15A or 20A, 125V receptacle outlet is required in a dwelling unit basement even if no portion has been finished into a habitable room.
- The purpose of this requirement is to prevent an extension cord from a non-GFCI-protected receptacle from being used to supply power to loads in the unfinished portion of the basement.
- GFCI protection is required for all 15A or 20A, 125V receptacles installed in unfinished basements [210.8(A)(5)], and detached garages and accessory buildings with electric power [210.8(A)(2)] of dwelling units.

(H) Dwelling Unit Hallway Receptacles. At least one 15A or 20A, 125V receptacle outlet must be installed in each hallway that's at least 10 ft long, measured along the centerline of the hallway without passing through a doorway. ▶Figure 210–102

(I) Foyer Receptacles. Foyers that aren't part of a hallway [210.52(H)] having an area greater than 60 sq ft must have a receptacle located on any wall space 3 ft or more in width and unbroken by doorways, windows next to doors that extend to the floor, and similar openings. ▶Figure 210–103



▶Figure 210–102



▶Figure 210–103

Top Ten Changes to the *NEC* #6

210.71 Meeting Rooms

New rules require receptacle outlets for meeting rooms in commercial occupancies.

Analysis

NEW

Meeting rooms are breeding grounds for cord usage; we all know that! When teaching a seminar, I always need an extension cord to reach my laptop and projector. There are often people in the audience who have laptops and no way of plugging them in, short of running a 25 ft extension cord right across a walkway.

During other types of meetings, every participant usually has and needs a laptop as well. It's not uncommon to see extension cords and daisy-chained relocatable power taps (plug strips) all over the floor.

This requirement was added proactively, as there haven't been any injuries or fires reported...yet. With this new rule we'll hopefully never have any such reports.

Of course, there are also other arguments to discuss as well. I've personally seen people step on cords that were being used at floor receptacles (including my own laptop cord). When this happens the person can trip or roll their ankle, and the attachment plug on the cord can be damaged.

This new requirement only applies to spaces not exceeding 1,000 sq ft. What's magical about 1,000 sq ft? If this is a problem for smaller meeting rooms, why isn't it a problem for larger ones as well?

There are concerns about what is and what isn't a meeting room, hence the inclusion of two Informational Notes. Meeting rooms are where people have meetings. Meeting rooms aren't where people meet, like a coffee shop. Trust me—this rule is going to cause lots of unintended problems...

210.71 Meeting Rooms

(A) General. Meeting rooms not larger than 1,000 sq ft must have receptacle outlets for 15A or 20A, 125V receptacles in accordance with 210.71(B) through (E). ▶Figure 210–119

▶Figure 210–119

Where a room or space is provided with a movable partition(s), the room size must be determined with the partition in the position that results in the smallest size meeting room.

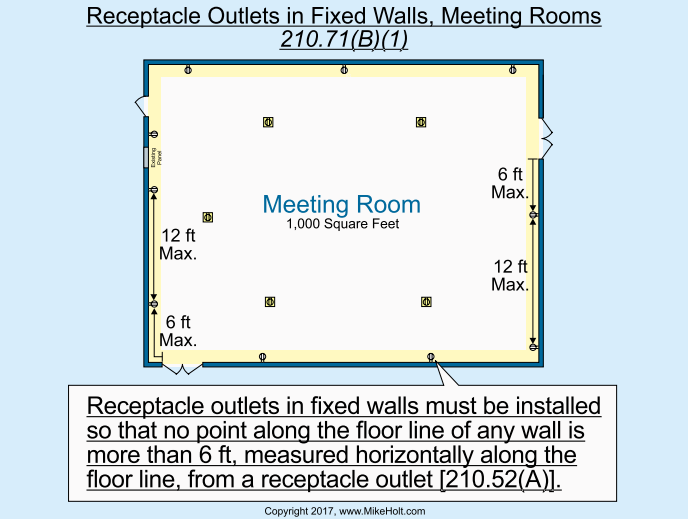
Note 1: Meeting rooms are typically designed or intended for the gathering of seated occupants for conferences, deliberations, or similar purposes, where portable electronic equipment such as computers, projectors, or similar equipment is likely to be used.

Note 2: Examples of rooms that aren't meeting rooms within the scope of 210.70 include auditoriums, school rooms, and coffee shops. ▶Figure 210–120

▶Figure 210–120

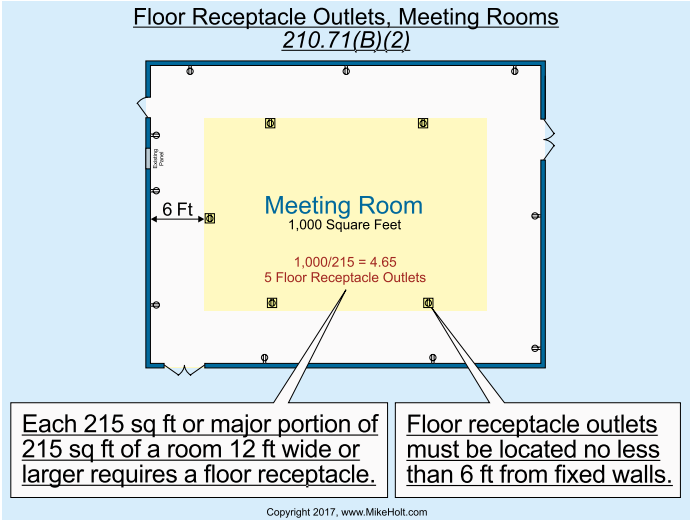
(B) Number of Receptacle Outlets Required. Meeting room receptacle outlets are located by the designer or building owner and the number of receptacle outlets are determined in accordance with (B)(1) and (2) as follows:

(1) Receptacle Outlets in Fixed Walls. Receptacle outlets shall be installed so that no point along the floor line of any wall, 2 ft or more in width, is more than 6 ft, measured horizontally along the floor line, from a receptacle outlet [210.52(A)]. ▶Figure 210–121



▶Figure 210–121

(2) Floor Receptacle Outlets. A meeting room that's at least 12 ft wide with a floor area of at least 215 sq ft must have one floor receptacle outlet not less than 6 ft from any fixed wall for each 215 sq ft or major portion of floor space. ▶Figure 210–122



▶Figure 210–122

Note 1: Receptacle floor boxes must be listed for the purpose [314.27(B)].

Note 2: See Article 518 for assembly occupancies designed for 100 or more persons.

ARTICLE

250 GROUNDING AND BONDING

Introduction to Article 250—Grounding and Bonding

No other article can match Article 250 for misapplication, violation, and misinterpretation. Terminology used in this article has been a source for much confusion, but that's improved during the last few *NEC* revisions. It's very important to understand the difference between grounding and bonding in order to correctly apply the provisions of Article 250. Pay careful attention to the definitions that apply to grounding and bonding both here and in Article 100 as you begin the study of this important article. Article 250 covers the grounding requirements for providing a path to the earth to reduce overvoltage from lightning, and the bonding requirements for a low-impedance fault current path back to the source of the electrical supply to facilitate the operation of overcurrent protection devices in the event of a ground fault.

Over the past several *Code* cycles, this article was extensively revised to organize it better and make it easier to understand and implement. It's arranged in a logical manner, so it's a good idea to just read through Article 250 to get a big picture view—after you review the definitions. Next, study the article closely so you understand the details. The illustrations will help you understand the key points.

Top Ten Changes to the *NEC* #7

250.30 Separately Derived Systems—Grounding and Bonding

The requirement to use either structural metal or water piping as the preferred grounding electrodes was removed. Metal water piping can now be used for multiple separately derived systems, and the dimensions of the busbar used to splice grounding electrode conductors was clarified.

Analysis

The past few *Code* cycles have seen many revisions to 250.30 and 250.68 to clarify what items can and can't be called a grounding electrode. These revisions have had varying amounts of success. This cycle includes a change that definitely makes things easier.

EXPANDED

Grounding Electrode. When grounding a separately derived system, we need to connect the neutral point to the building's grounding electrode system. Previous editions of the *NEC* stipulated that the separately derived system needed to be connected to the structural metal or water pipe, and if those weren't present we could then seek other types of electrodes. Now in 2017, the *Code* simply requires us to connect the separately derived system to the building's grounding electrode system.

CLARIFIED

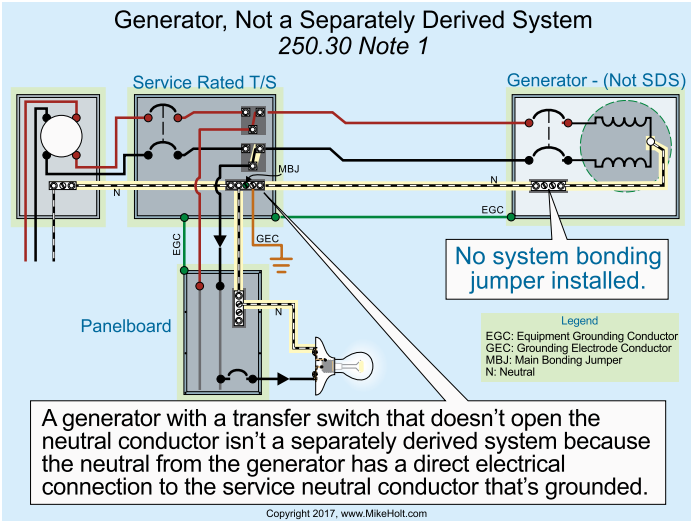
Multiple Separately Derived Systems. When grounding multiple separately derived systems, we've had the option of terminating grounding electrode taps to a common 3/0 AWG copper grounding electrode conductor or to structural metal. Why shouldn't we be allowed to terminate to interior metal water piping? Now we can.

CLARIFIED

Busbar Terminations. Lastly, the dimensions of the busbar that can be used to splice the common grounding electrode conductor and the taps have been clarified. The busbar must be ¼ in. thick by 2 in. wide, and whatever length is necessary to accommodate the terminations.

250.30 Separately Derived Systems—Grounding and Bonding

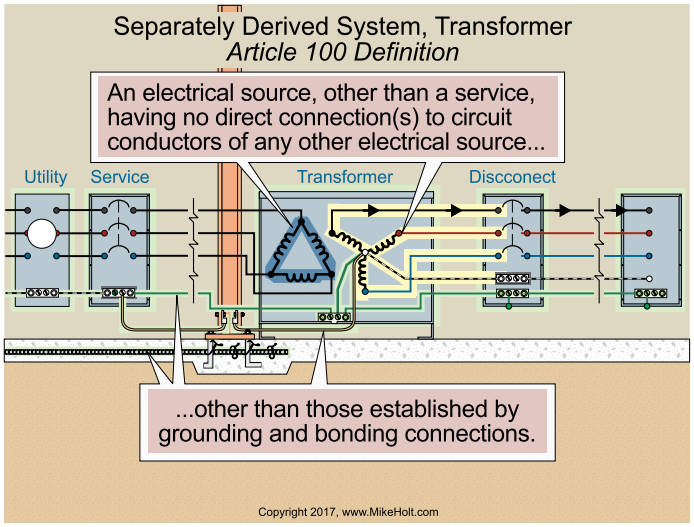
Note 1: An alternate alternating-current power source such as an on-site generator isn't a separately derived system if the neutral conductor is solidly interconnected to a service-supplied system neutral conductor. An example is a generator provided with a transfer switch that includes a neutral conductor that's not switched. ▶Figure 250–65



▶Figure 250–65

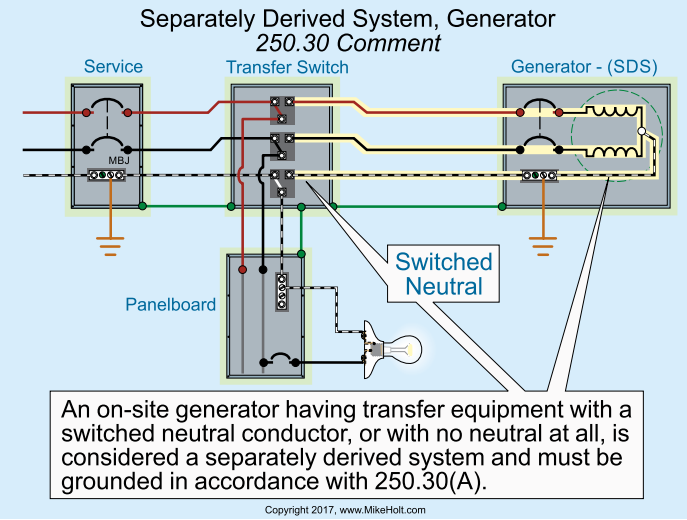
Author's Comment:

- According to Article 100, a separately derived system is a wiring system whose power is derived from a source, other than the electric utility, where there's no direct electrical connection to the supply conductors of another system, other than through grounding and bonding connections.
- Transformers are separately derived when the primary conductors have no direct electrical connection from circuit conductors of one system to circuit conductors of another system, other than connections through grounding and bonding connections. ▶Figure 250–66



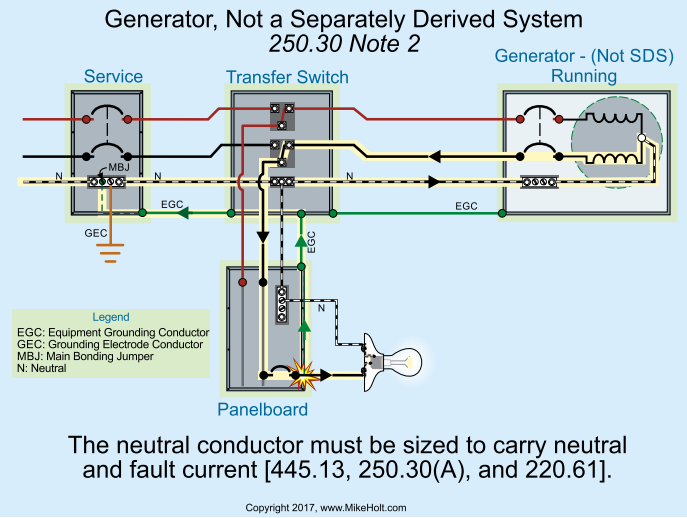
▶Figure 250–66

- A generator having transfer equipment that switches the neutral conductor, or one that has no neutral conductor at all, is a separately derived system and must be grounded and bonded in accordance with 250.30(A). ▶Figure 250–67



▶Figure 250–67

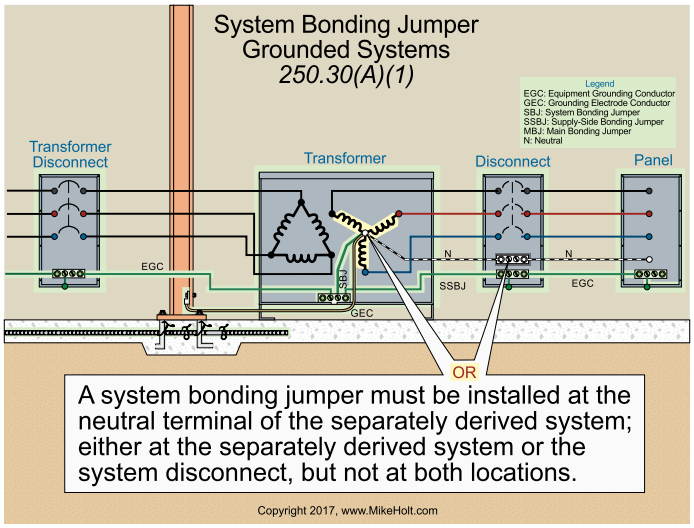
Note 2: For nonseparately derived systems, see 445.13 for the minimum size neutral conductors necessary to carry fault current. ▶Figure 250–68



▶Figure 250–68

(A) Grounded Systems. Separately derived systems must be grounded and bonded in accordance with (A)(1) through (A)(8). A neutral-to-case connection isn't permitted to be made on the load side of the system bonding jumper, except as permitted by 250.142(B).

(1) System Bonding Jumper. A system bonding jumper must be installed at the same location where the grounding electrode conductor terminates to the neutral terminal of the separately derived system; either at the separately derived system or the system disconnect, but not at both locations [250.30(A)(5)]. ▶Figure 250–69

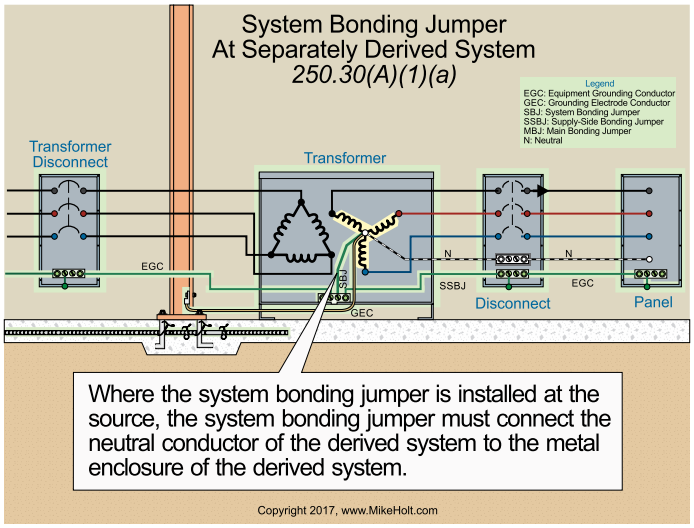


▶Figure 250–69

If the separately derived source is located outside the building or structure supplied, a system bonding jumper must be installed at the grounding electrode connection in accordance with 250.30(C).

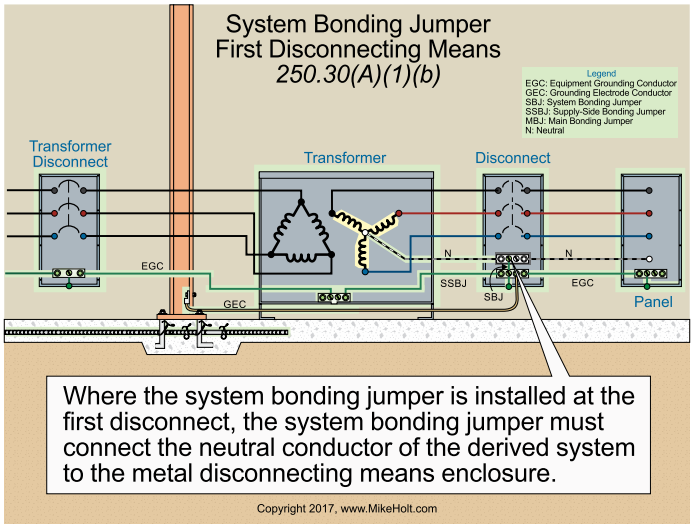
Ex. 2: If a building or structure is supplied by a feeder from an outdoor separately derived system, a system bonding jumper at both the source and the first disconnect is permitted. The grounded conductor isn't permitted to be smaller than the size specified for the system bonding jumper, but it's not required to be larger than the ungrounded conductor(s).

(a) System Bonding Jumper at Source. Where the system bonding jumper is installed at the source of the separately derived system, the system bonding jumper must connect the neutral conductor of the derived system to the metal enclosure of the derived system. ▶Figure 250–70



▶Figure 250–70

(b) System Bonding Jumper at Disconnect. Where the system bonding jumper is installed at the first disconnect of a separately derived system, the system bonding jumper must connect the neutral conductor of the derived system to the metal disconnect enclosure. ▶Figure 250–71



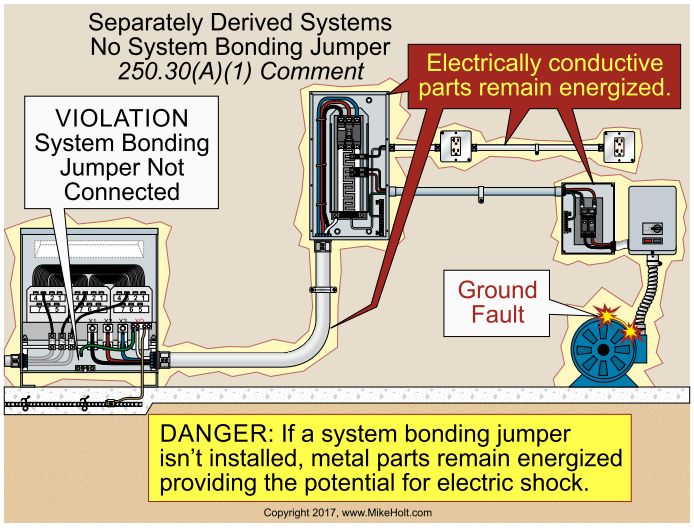
▶Figure 250–71

Author's Comment:

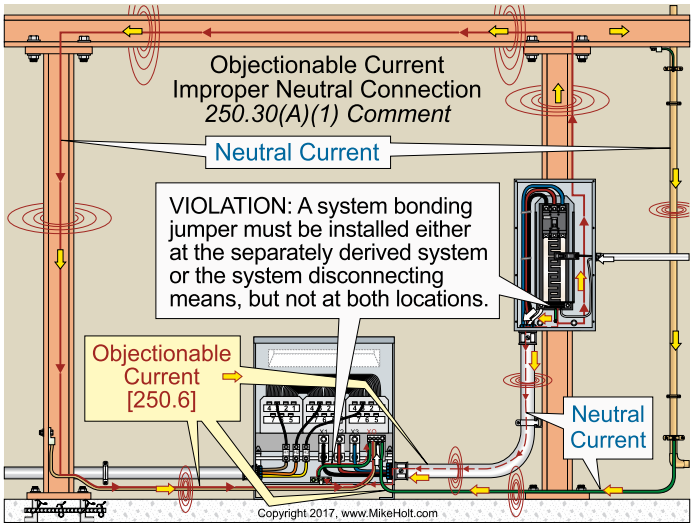
- A system bonding jumper is a conductor, screw, or strap that bonds the metal parts of a separately derived system to the system neutral point [Article 100 Bonding Jumper, System], and it's sized to Table 250.102(C)(1) in accordance with 250.28(D).

DANGER: During a ground fault, metal parts of electrical equipment, as well as metal piping and structural steel, will become and remain energized providing the potential for electric shock and fire if the system bonding jumper isn't installed. ▶Figure 250–72

CAUTION: Dangerous objectionable neutral current will flow on conductive metal parts of electrical equipment as well as metal piping and structural steel, in violation of 250.6(A), if more than one system bonding jumper is installed, or if it's not located where the grounding electrode conductor terminates to the neutral conductor. ▶Figure 250–73



▶Figure 250–72

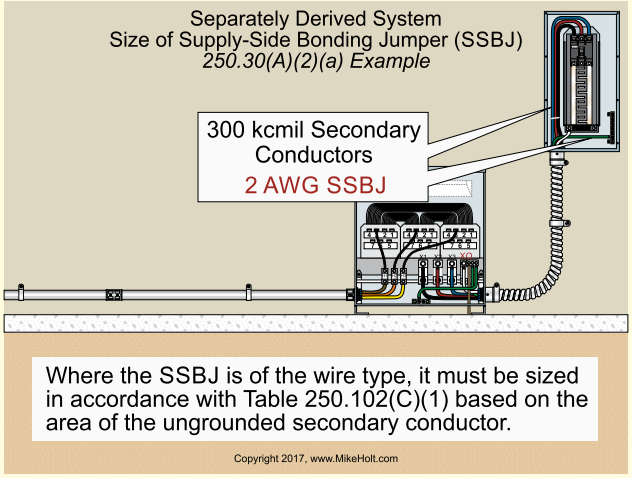


▶Figure 250–73

(2) Supply-Side Bonding Jumper to Disconnect. A supply-side bonding jumper (nonflexible metal raceway or wire) must be run from the derived system to the derived system disconnect.

(a) If the supply-side bonding jumper is of the wire type, it must be sized in accordance with Table 250.102(C)(1), based on the area of the largest ungrounded derived system conductor in the raceway or cable.

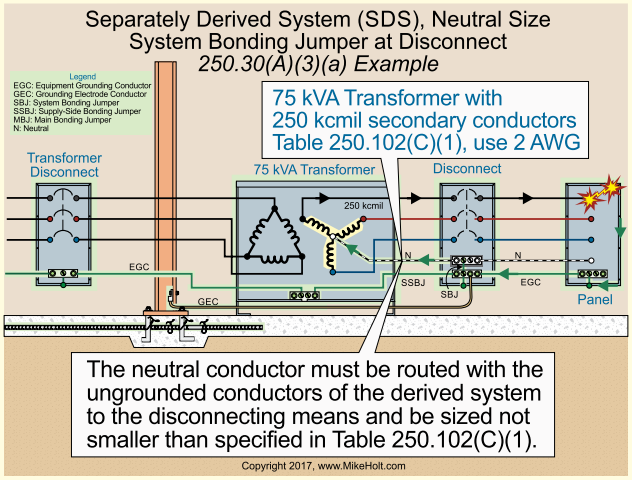
Example: *What size supply-side bonding jumper is required for flexible metal conduit containing 300 kcmil secondary conductors?* ▶Figure 250–74



▶Figure 250–74

Answer: *2 AWG [Table 250.102(C)(1)].*

Example: *What size neutral conductor is required for a 75 kVA transformer with 250 kcmil secondary conductors?* ▶Figure 250–76

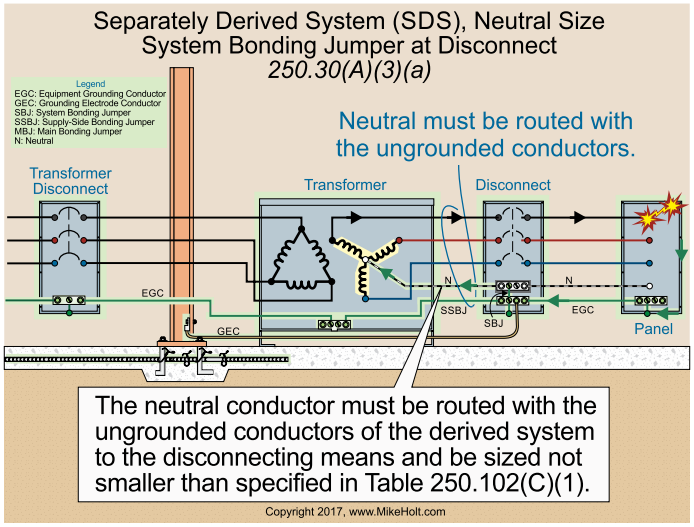


▶Figure 250–76

Answer: *2 AWG [Table 250.102(C)(1)]*

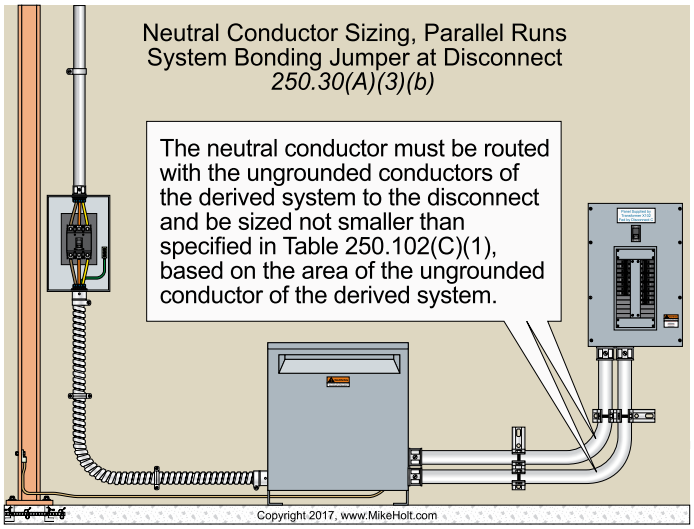
(3) Neutral Conductor Size, System Bonding Jumper at Derived System Disconnect. If the system bonding jumper is installed at the disconnect instead of at the source, the following requirements apply:

(a) Sizing for Single Raceway. The neutral conductor must be routed with the ungrounded conductors of the derived system to the disconnect and be sized not smaller than specified in Table 250.102(C)(1), based on the area of the ungrounded conductor of the derived system. ▶Figure 250–75



▶Figure 250–75

(b) Parallel Conductors in Two or More Raceways. If the conductors from the derived system are installed in parallel in two or more raceways, the neutral conductor of the derived system in each raceway or cable must be sized not smaller than specified in Table 250.102(C)(1), based on the area of the largest ungrounded conductor of the derived system in the raceway or cable. In no case is the neutral conductor of the derived system permitted to be smaller than 1/0 AWG [310.10(H)]. ▶Figure 250–77



▶Figure 250–77

Example: *What size neutral conductor is required for a 112.50 kVA transformer with two sets of 3/0 AWG secondary conductors?*

Answer: *1/0 AWG [310.10(H)(1)]*

(4) Grounding Electrode. Indoor separately derived systems must use the building or structure grounding electrode; outdoor separately derived systems must be grounded in accordance with 250.30(C). Figure 250–78

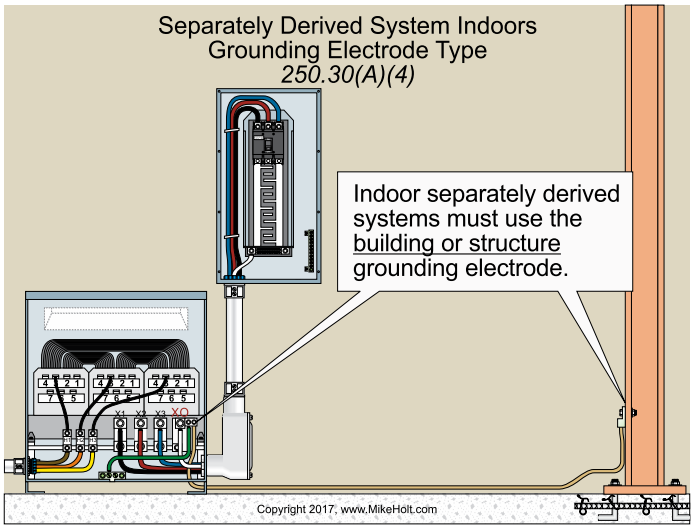


Figure 250–78

Note 1: Interior metal water piping in the area served by separately derived systems must be bonded to the separately derived system in accordance with 250.104(D).

Note 2: See 250.50 and 250.58 for requirements for bonding all electrodes together if located at the same building or structure.

(5) Grounding Electrode Conductor, Single Separately Derived System. The grounding electrode conductor for the separately derived system is sized in accordance with 250.66 and it must terminate to the grounding electrode in accordance with 250.30(A)(4).

The grounding electrode conductor is required to terminate to the neutral conductor at the same point on the separately derived system where the system bonding jumper is connected. Figure 250–79

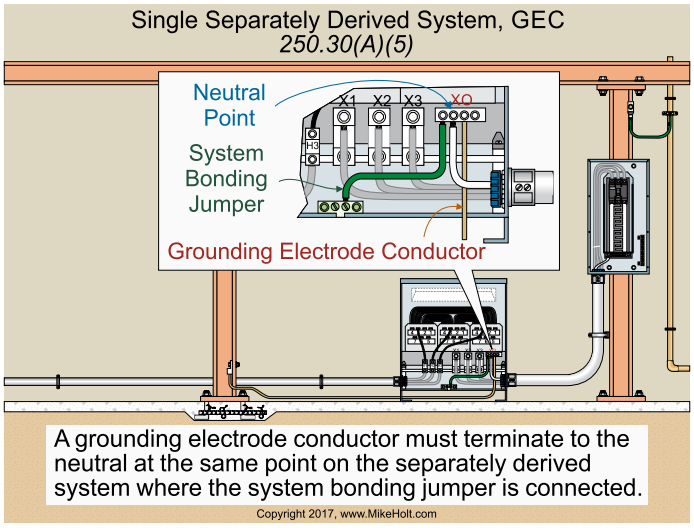


Figure 250–79

Author's Comment:

- System grounding helps reduce fires in buildings as well as voltage stress on electrical insulation, thereby ensuring longer insulation life for motors, transformers, and other system components. Figure 250–80

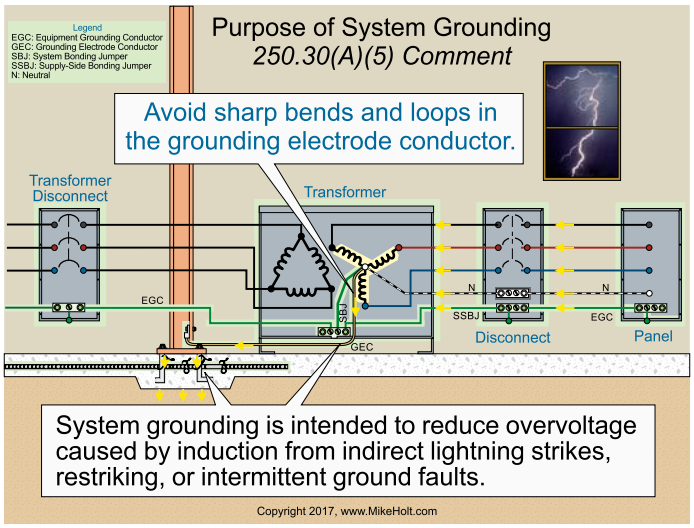
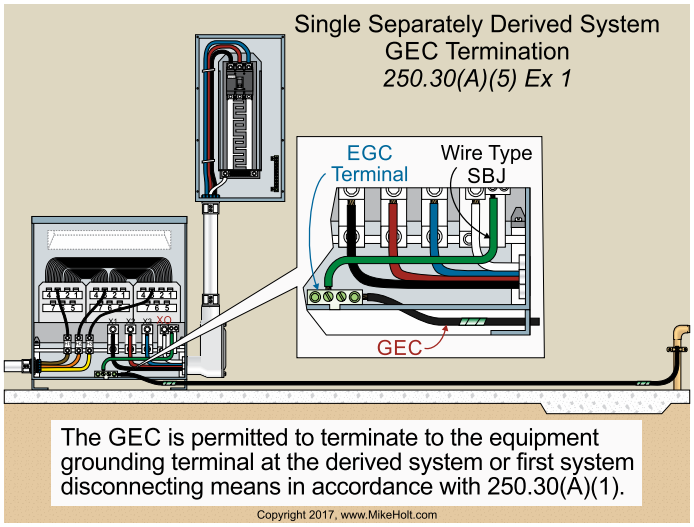


Figure 250–80

- To prevent objectionable neutral current from flowing [250.6] onto metal parts, the grounding electrode conductor must originate at the same point on the separately derived system where the system bonding jumper is connected [250.30(A)(1)].

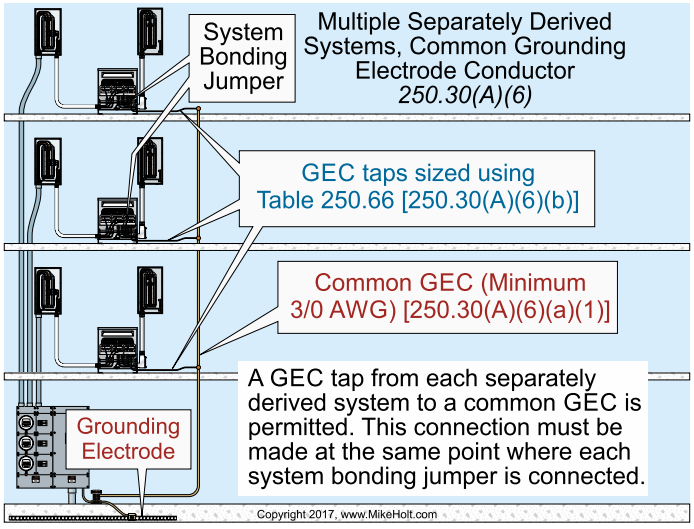
Ex 1: If the system bonding jumper [250.30(A)(1)] is a wire or busbar, the grounding electrode conductor is permitted to terminate to the equipment grounding terminal, bar, or bus. ▶Figure 250–81



▶Figure 250–81

Ex 3: Separately derived systems rated 1 kVA or less aren't required to be grounded (connected to the earth).

(6) Grounding Electrode Conductor, Multiple Separately Derived Systems. Where there are multiple separately derived systems, a grounding electrode conductor tap from each separately derived system to a common grounding electrode conductor is permitted. This connection is to be made at the same point on the separately derived system where the system bonding jumper is connected [250.30(A)(1)]. ▶Figure 250–82



▶Figure 250–82

Ex 1: If the system bonding jumper is a wire or busbar, the grounding electrode conductor tap can terminate to either the neutral terminal or the equipment grounding terminal, bar, or bus in accordance with 250.30(A)(1).

Ex 2: Separately derived systems rated 1 kVA or less aren't required to be grounded (connected to the earth).

(a) Common Grounding Electrode Conductor. The common grounding electrode conductor can be any of the following:

(1) A conductor not smaller than 3/0 AWG copper or 250 kcmil aluminum.

(2) Interior metal water pipe located not more than 5 ft from the point of entrance to the building [250.68(C)(1)].

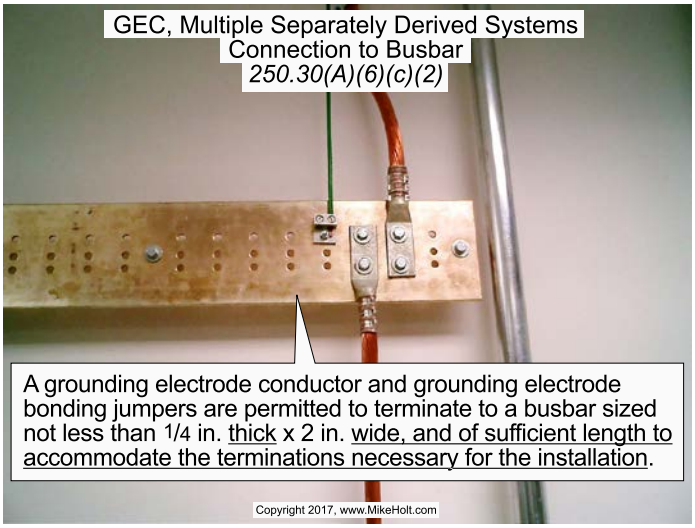
(3) The metal frame of the building or structure that complies with 250.68(C)(2) or is connected to the grounding electrode system by a conductor not smaller than 3/0 AWG copper or 250 kcmil aluminum.

(b) Tap Conductor Size. Grounding electrode conductor taps must be sized in accordance with Table 250.66, based on the area of the largest ungrounded conductor of the given derived system.

(c) Connections. Tap connections to the common grounding electrode conductor must be made at an accessible location by any of the following methods:

(1) A connector listed as grounding and bonding equipment.

(2) Listed connections to aluminum or copper busbars not less than ¼ in. thick × 2 in. wide, and of sufficient length to accommodate the terminations necessary for the installation. ▶Figure 250–83



▶Figure 250–83

(3) Exothermic welding.

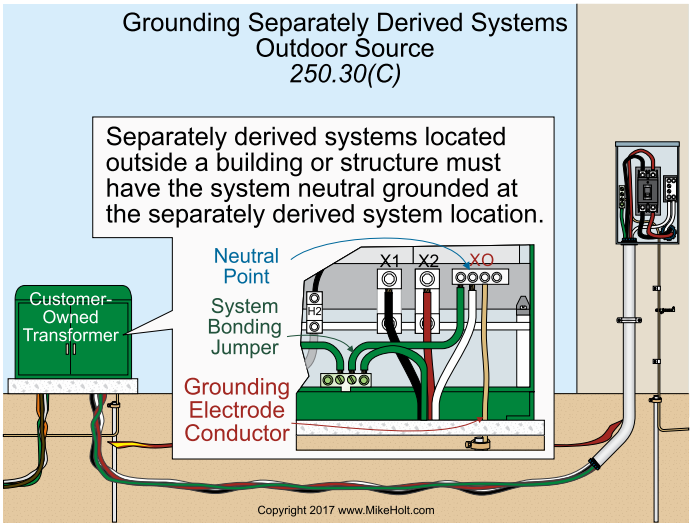
Grounding electrode conductor taps must be connected to the common grounding electrode conductor so the common grounding electrode conductor isn't spliced.

(7) Installation. The grounding electrode conductor must comply with the following:

- Be of copper where within 18 in. of the surface of the earth [250.64(A)].
- Be securely fastened to the surface on which it's carried [250.64(B)].
- Be adequately protected if exposed to physical damage [250.64(B)].
- Metal enclosures enclosing a grounding electrode conductor must be made electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode [250.64(E)].

(8) Structural Steel and Metal Piping. To ensure dangerous voltage on metal parts from a ground fault is removed quickly, structural steel and metal piping in the area served by a separately derived system must be connected to the neutral conductor at the separately derived system in accordance with 250.104(D).

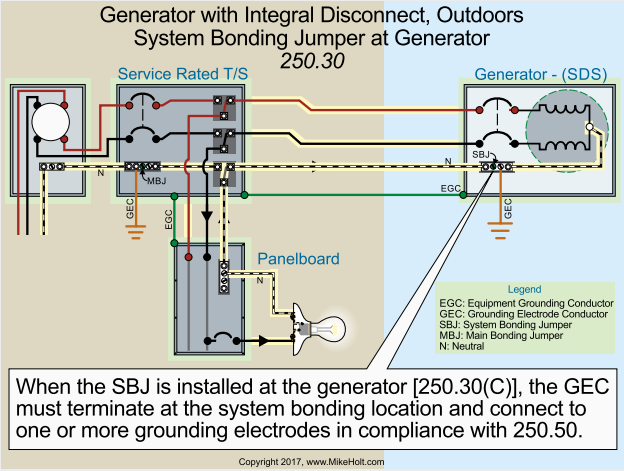
(C) Outdoor Source. Separately derived systems located outside the building must have the grounding electrode connection made at the separately derived system location. ▶Figure 250–84



▶Figure 250–84

Special Section 250.30 Separately Derived Systems Outdoor Installations

Generator System with Integral Disconnect. ▶Figure 250–85



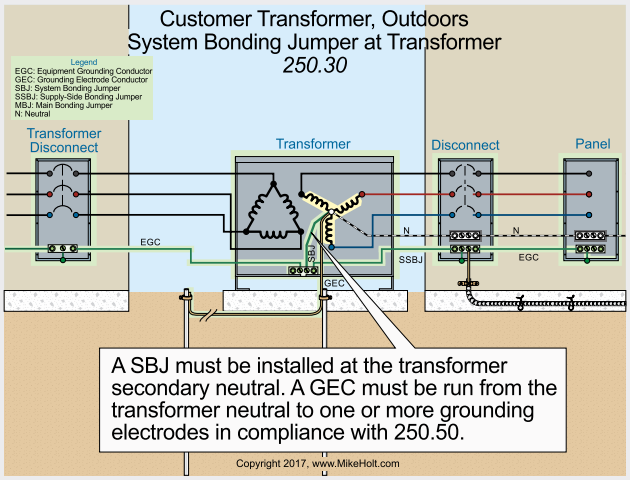
▶Figure 250–85

System Bonding Jumper. Where a separately derived system generator with integral disconnecting means is installed outdoors, a system bonding jumper sized in accordance with Table 250.102(C)(1), is required to be installed at the generator neutral terminal [250.30(A)(1)(a)].

Grounding Electrode Conductor. A grounding electrode conductor, sized in accordance with 250.66, must be run from the generator neutral terminal to one or more grounding electrodes in compliance with 250.50 in accordance with 250.30(C) [250.30(A)(4)].

Where the system bonding jumper is a wire or busbar, the grounding electrode conductor can originate at the generator equipment grounding terminal, bar, or bus [250.30(A)(5) Ex].

Transformer Outdoors. ▶Figure 250–86



▶Figure 250–86

System Bonding Jumper. Where a separately derived system transformer is installed outdoors, a system bonding jumper sized in accordance with Table 250.102(C)(1), is required to be installed at the transformer secondary neutral [250.30(A)(1)].

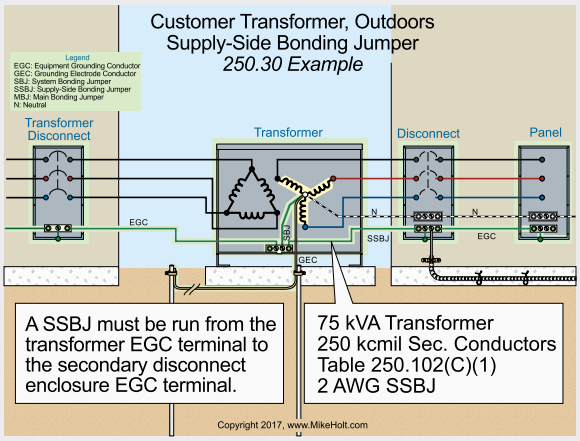
Grounding Electrode Conductor. A grounding electrode conductor, sized in accordance with 250.66, must be run from the transformer neutral terminal to one or more grounding electrodes in compliance with 250.50 in accordance with 250.30(C) [250.30(A)(4)].

Where the system bonding jumper is a wire or busbar, the grounding electrode conductor can originate at the generator equipment grounding terminal, bar, or bus [250.30(A)(5) Ex].

Supply-Side Bonding Jumper. A supply-side bonding jumper must be run from the transformer equipment grounding conductor terminal to the secondary disconnect enclosure equipment grounding conductor terminal.

Where the supply-side bonding jumper is of the wire type, it must be sized in accordance with Table 250.102(C)(1), based on the area of the secondary conductor [250.30(A)(2)].

Example: *What size supply-side bonding jumper is required to be installed at a 75 kVA transformer having 250 kcmil secondary conductors?* ▶Figure 250–87

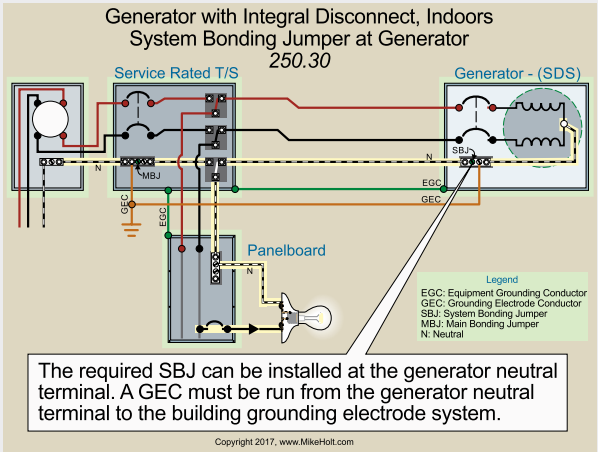


▶Figure 250–87

Answer: *2 AWG [Table 250.102(C)(1)]*

Indoor Installations

Generator System Indoor with Integral Disconnect. ▶Figure 250–88



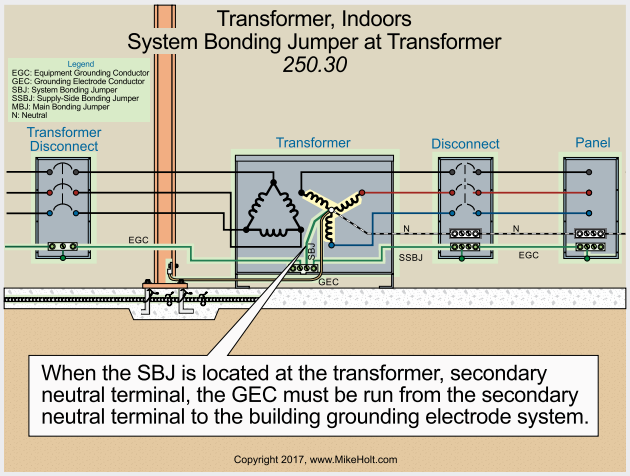
▶Figure 250–88

System Bonding Jumper. Where a separately derived system generator with an integral disconnect is installed indoors, the required system bonding jumper, sized in accordance with Table 250.102(C)(1), can be installed at the generator neutral terminal [250.30(A)(1)(a)].

Grounding Electrode Conductor. A grounding electrode conductor, sized in accordance with 250.66, must be run from the generator neutral terminal to the building or structure grounding electrode system [250.30(A)(4)].

Where the system bonding jumper is a wire or busbar, the grounding electrode conductor can originate at the generator equipment grounding terminal, bar, or bus [250.30(A)(5) Ex].

Transformer System Indoors, System Bonding Jumper at Transformer. ▶Figure 250–89



▶Figure 250–89

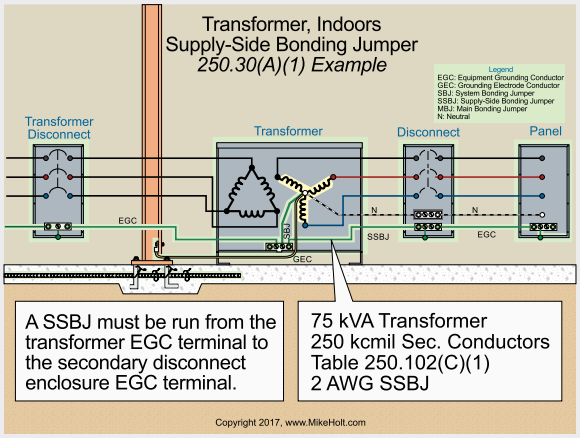
System Bonding Jumper. Where a separately derived system transformer is installed indoors, the required system bonding jumper, sized in accordance with Table 250.102(C)(1), can be installed at the transformer neutral terminal [250.30(A)(1)(a)].

Grounding Electrode Conductor. A grounding electrode conductor, sized in accordance with 250.66, must be run from the transformer neutral terminal to the building or structure grounding electrode system [250.30(A)(4)].

Where the system bonding jumper is a wire or busbar, the grounding electrode conductor can originate at the generator equipment grounding terminal, bar, or bus [250.30(A)(5) Ex].

Supply-Side Bonding Jumper. A supply-side bonding jumper, sized in accordance with Table 250.102(C)(1), must be run from the transformer equipment grounding conductor terminal to the secondary disconnect enclosure equipment grounding conductor terminal [250.30(A)(2)].

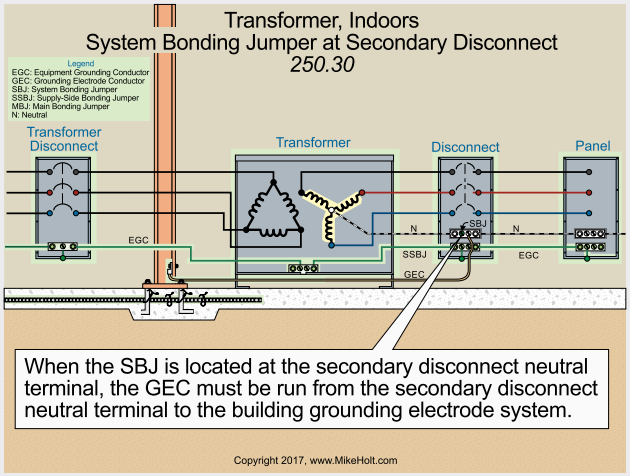
Example: *What size SSBJ is required between a 75 kVA transformer with 250 kcmil secondary conductors in a single raceway to the first disconnect?* ▶Figure 250–90



▶Figure 250–90

Answer: *2 AWG, based on 250 kcmil conductor [Table 250.102(C)(1)]*

Transformer Indoors, System Bonding Jumper at Secondary Disconnect. ▶Figure 250–91



▶Figure 250–91

System Bonding Jumper. Where a separately derived system transformer is installed indoors, the required system bonding jumper, sized in accordance with Table 250.102(C)(1), can be installed at the transformer secondary disconnect [250.30(A)(1)(b)].

Grounding Electrode Conductor. A grounding electrode conductor, sized in accordance with 250.66, must be run from the transformer neutral terminal to the building or structure grounding electrode system [250.30(A)(4)].

Where the system bonding jumper is a wire or busbar, the grounding electrode conductor can originate at the generator equipment grounding terminal, bar, or bus [250.30(A)(5) Ex].

Supply-Side Bonding Jumper. A supply-side bonding jumper, sized in accordance with Table 250.102(C)(1), must be run from the transformer equipment grounding conductor terminal to the secondary disconnect enclosure equipment grounding conductor terminal [250.30(A)(2)].

Example: *What size SSBJ is required between a 112.6 kVA transformer paralleled in two raceways with 250 kcmil secondary conductors to the first disconnect?*

Answer: *1/0 AWG [Table 250.102(C)(1)]. The area of 3/0 AWG is 167,800 circular mills × 2 conductors equals 335,600 circular mills [Chapter 9, Table 8 and Table 250.102(C)(1)].*

Neutral Conductor. When the system bonding jumper is installed at a secondary disconnect, a secondary neutral conductor in each raceway, sized no smaller than specified in Table 250.102(C)(1), must be run from the transformer secondary to the secondary disconnect enclosure.

Example: *What size neutral conductor is required for a 112.50 kVA transformer paralleled in two raceways with 3/0 AWG secondary conductors in each raceway?*

Answer: *1/0 AWG [310.10(H)(1)]*

Author's Comment:

- When the system bonding jumper is installed at the secondary disconnect, the secondary neutral conductor will serve as part of the effective ground-fault current path.

ARTICLE

330

METAL-CLAD CABLE (TYPE MC)

Introduction to Article 330—Metal-Clad Cable (Type MC)

Metal-clad cable encloses insulated conductors in a metal sheath of either corrugated or smooth copper or aluminum tubing, or spiral interlocked steel or aluminum. The physical characteristics of Type MC cable make it a versatile wiring method that you can use in almost any location, and for almost any application. The most commonly used Type MC cable is the interlocking kind, which looks similar to armored cable or flexible metal conduit. Traditional interlocked Type MC cable isn't permitted to serve as an equipment grounding conductor, therefore this cable must contain an equipment grounding conductor in accordance with 250.118(1). There's a fairly new product available called interlocked Type MC$^{AP®}$ cable that contains a bare aluminum grounding/bonding conductor running just below the metal armor, which allows the sheath to serve as an equipment grounding conductor [250.118(10)(b)].

Top Ten Changes to the *NEC* #8

330.15 Exposed Work

New requirements for the installation of exposed Type MC cable have been added.

Analysis

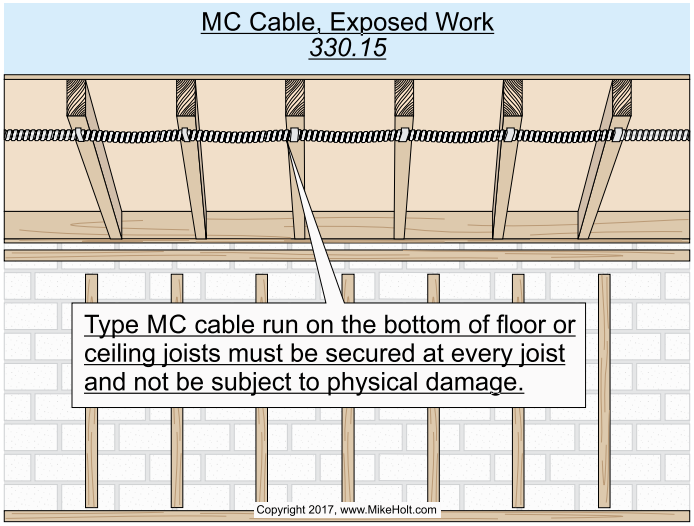
EDITED

There are a number of small changes that improve the *NEC* but go unnoticed by the casual user. One of them is the concept of parallel numbering between *Code* articles. If you look at the rules for cables in Articles 320 through 340, you'll notice that the "dot 1" section is the scope, "dot 2" is a definition, "dot 6" is listing, "dot 10" is uses permitted, and so forth.

This makes good sense, and the Code Making Panels involved should be applauded for their efforts, as every little thing that improves the *NEC* is worth doing. It's rather strange, but most of the cable articles have a "dot 15" section addressing exposed cables. Article 330 didn't have one before, but now it does. As you might expect, it says the same thing as the other cable articles, as it should. Why should the rules on exposed Types MC cable and AC cable be different? They aren't anymore.

330.15 Exposed Work

Exposed runs of Type MC cable must closely follow the surface of the building finish or running boards. Type MC cable installed on the bottom of floor or ceiling joists must be secured at every joist and not be subject to physical damage. ▶Figure 330–5



▶Figure 330–5

ARTICLE

406

RECEPTACLES, CORD CONNECTORS, AND ATTACHMENT PLUGS (CAPS)

Introduction to Article 406—Receptacles, Cord Connectors, and Attachment Plugs (Caps)

This article covers the rating, type, and installation of receptacles, flexible cord connectors, and attachment plugs (cord caps). It also addresses their grounding requirements. Some key points to remember include:

- Following the grounding requirements of the specific type of device you're using.
- Providing GFCI protection where specified by 406.4(D)(3).
- Mounting receptacles according to the requirements of 406.5.

Top Ten Changes to the *NEC* #9

406.12 Tamper-Resistant Receptacles

The locations requiring tamper-resistant receptacles have been expanded, as have the types of receptacles requiring such protection.

Analysis

EXPANDED

Next time you find yourself at a grocery store, hardware store, or just about any store short of a gas station, notice how many plastic receptacle inserts there are. Consumers want more protection than what a standard receptacle provides.

Tamper-resistant receptacles were introduced in the 2008 *Code* for dwelling units and this requirement was expanded in 2011 to include child care facilities, hotels, and motels. Not much changed in the 2014 *NEC*, but the 2017 edition is very different.

The logic is that if 125V receptacles are dangerous to children, then 250V receptacles are as well. The 2017 *Code* adds a requirement that 15A and 20A, 250V receptacles must be tamper resistant as well, although it seems likely that many of these receptacles will be the exception by being installed in a location where the receptacle is covered by an appliance or other piece of equipment. It's worth emphasizing that this rule is only for 15A and 20A receptacles, so those for ranges or dryers need not be tamper resistant.

Several locations where tamper-resistant receptacles will now be required have been added to the list of areas requiring protection. Preschools and elementary schools are now included. While it may seem that these areas already required tamper-resistant receptacles, since they meet the definition of "child care facilities," not all areas of a school needed to comply. The definition of a child care facility is a building or portion of a building where five or more children under the age of eight receive care, education, and so forth. This meant that some of the classrooms in a kindergarten through sixth-grade school met the definition but others didn't. The sixth-grade classroom doesn't need tamper-resistant protection, but the first-grade classroom

does. The offices of the school staff don't need tamper-resistant protection, but lunch areas do.

One of the problems that needed to be addressed was that classrooms often change in terms of grade level. Yesterday this room housed fifth graders, today it houses second graders. To alleviate this problem, the entire school must now meet the requirements.

In addition, business offices, corridors, waiting rooms, and similar areas in medical and dental offices, and outpatient facilities now require tamper-resistant protection. They're also required in dormitories, waiting areas in areas described in article 518 (places of assembly), gymnasiums, skating rinks, and auditoriums.

Tamper-resistance expansion was added due to a report issued by the Consumer Product Safety Commission (CPSC) indicating that the most common areas for shocks due to inserting objects in receptacles is the home (already covered) followed by "unknown" and schools, then sports and recreation facilities and "other public property."

Do you get the feeling that in the near future all 15A and 20A receptacles will be tamper resistant? So do I...

406.12 Tamper-Resistant Receptacles

Nonlocking-type 15A and 20A, 125V and 250V receptacles in the following areas must be listed as tamper resistant:

Author's Comment:

- On a tamper-resistant receptacle, inserting an object into one side of the receptacle doesn't open the internal tamper-resistant shutter. Simultaneous pressure from a two or three pronged plug is required for insertion. ▶Figure 406–32

(1) Dwelling unit areas specified in 210.52 and 550.13 ▶Figure 406–33

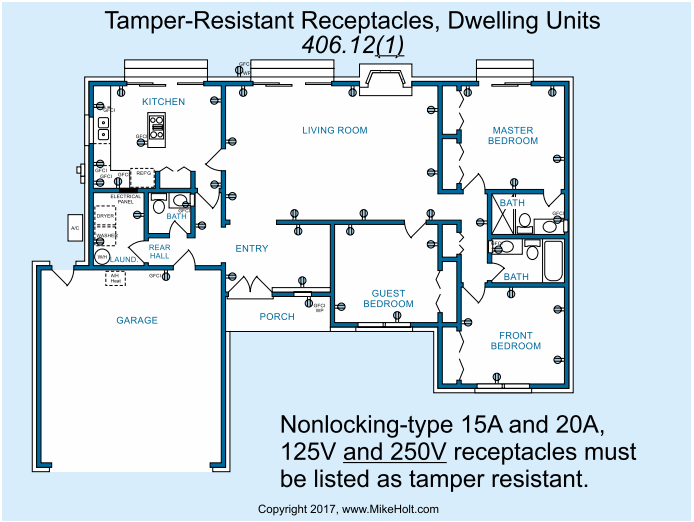
(2) Hotel and motel guest rooms and guest suites

(3) Child care facilities

Author's Comment:

- A child care facility is a building or portions thereof used for educational, supervision, or personal care services for five or more children seven years in age or less [406.2].

▶Figure 406–32



▶Figure 406–33

(4) Preschools and elementary education facilities

(5) Business offices, corridors, waiting rooms and the like in clinics, medical and dental offices, and outpatient facilities.

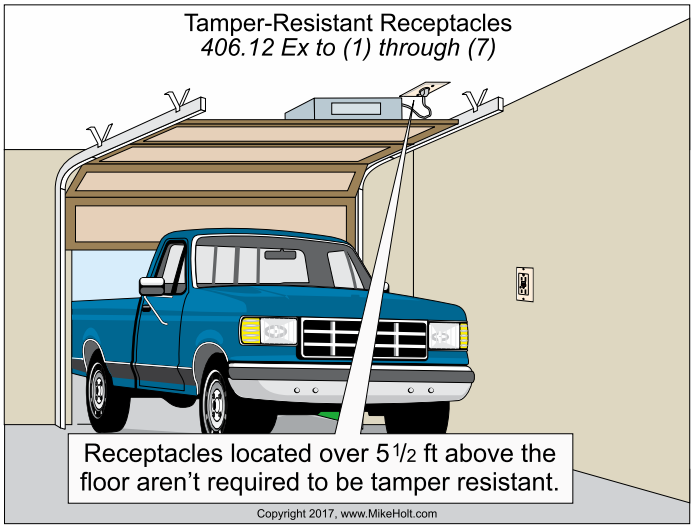
(6) Places of awaiting transportation, gymnasiums, skating rinks, and auditoriums

(7) Dormitories

Note: Receptacle types covered by this requirement are identified as 5-15, 5-20, 6-15, and 6-20 in NEMA WD 6, *Wiring Devices–Dimensional Specifications*.

Ex to (1) through (7): Receptacles in the following locations aren't required to be tamper resistant:

- *(1) Receptacles located more than 5½ ft above the floor.* ▶Figure 406–34
- *(2) Receptacles that are part of a luminaire or appliance.*
- *(3) A receptacle located within dedicated space for an appliance that in normal use isn't easily moved from one place to another.*
- *(4) Nongrounding receptacles used for replacements as permitted in 406.4(D)(2)(a).*



▶Figure 406–34

ARTICLE

680

SWIMMING POOLS, SPAS, HOT TUBS, FOUNTAINS, AND SIMILAR INSTALLATIONS

Introduction to Article 680—Swimming Pools, Spas, Hot Tubs, Fountains, and Similar Installations

The requirements contained in Article 680 apply to the installation of electrical wiring and equipment for swimming pools, spas, hot tubs, fountains, and hydromassage bathtubs. The overriding concern of this article is to keep people and electricity separated.

Article 680 is divided into seven parts. The various parts apply to certain types of installations, so be careful to determine which parts of this article apply to what and where. For instance, Part I and Part II apply to spas and hot tubs installed outdoors, except as modified in Part IV. In contrast, hydromassage bathtubs are only covered by Part VII. Read the details of this article carefully so you'll be able to provide a safe installation.

- Part I. General.
- Part II. Permanently Installed Pools. Installations at permanently installed pools must comply with both Parts I and II of this article.
- Part III. Storable Swimming Pools, Storable Spas, and Storable Hot Tubs. Installations of storable pools, storable spas, and storable hot tubs must comply with Parts I and III of Article 680.
- Part IV. Spas and Hot Tubs. Spas and hot tubs must comply with Parts I and IV of this article; outdoor spas and hot tubs must also comply with Part II in accordance with 680.42.
- Part V. Fountains. Parts I and II apply to permanently installed fountains. If they have water in common with a pool, Part II also applies. Self-contained, portable fountains are covered by Article 422, Parts II and III.
- Part VI. Pools and Tubs for Therapeutic Use. Parts I and VI apply to pools and tubs for therapeutic use in health care facilities, gymnasiums, athletic training rooms and similar installations. If they're portable appliances, then Article 422, Parts II and III apply.
- Part VII. Hydromassage Bathtubs. Part VII applies to hydromassage bathtubs, but no other parts of Article 680 do.

Top Ten Changes to the *NEC* #10

680.7 Grounding and Bonding Terminals

Grounding and bonding terminals now have specific location-driven requirements.

Analysis

NEW

Swimming pools, spas, and hot tubs, along with their surrounding environments, are full of chemicals. The presence of these chemicals, combined with the inherent dampness of the locations, results in a highly corrosive environment. Because of the importance of the continuity of grounding and bonding connections we have this new section in the 2017 *NEC*.

This new rule has two independent requirements. First, all grounding and bonding terminals must be identified (see Article 100) for use in wet and corrosive environments; this applies to terminals installed in the field and by the manufacturer. These grounding and bonding terminals aren't required to be specifically listed for this application because such a product doesn't exist.

Terminals that are field-installed must be copper, copper alloy, or stainless steel and be listed for direct burial. It's worth noting that terminals, such as those commonly used on rebar, that are listed for direct burial are also listed for concrete encasement.

680.7 Grounding and Bonding Terminals

Grounding and bonding terminals must be identified for use in wet and corrosive environments and be listed for direct burial use. ▶Figure 680–10

▶Figure 680–10

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