Understanding the NEC®

Top 101 Rules

Part 1 of 4

Rules 1-25: 90.1 - 225.31

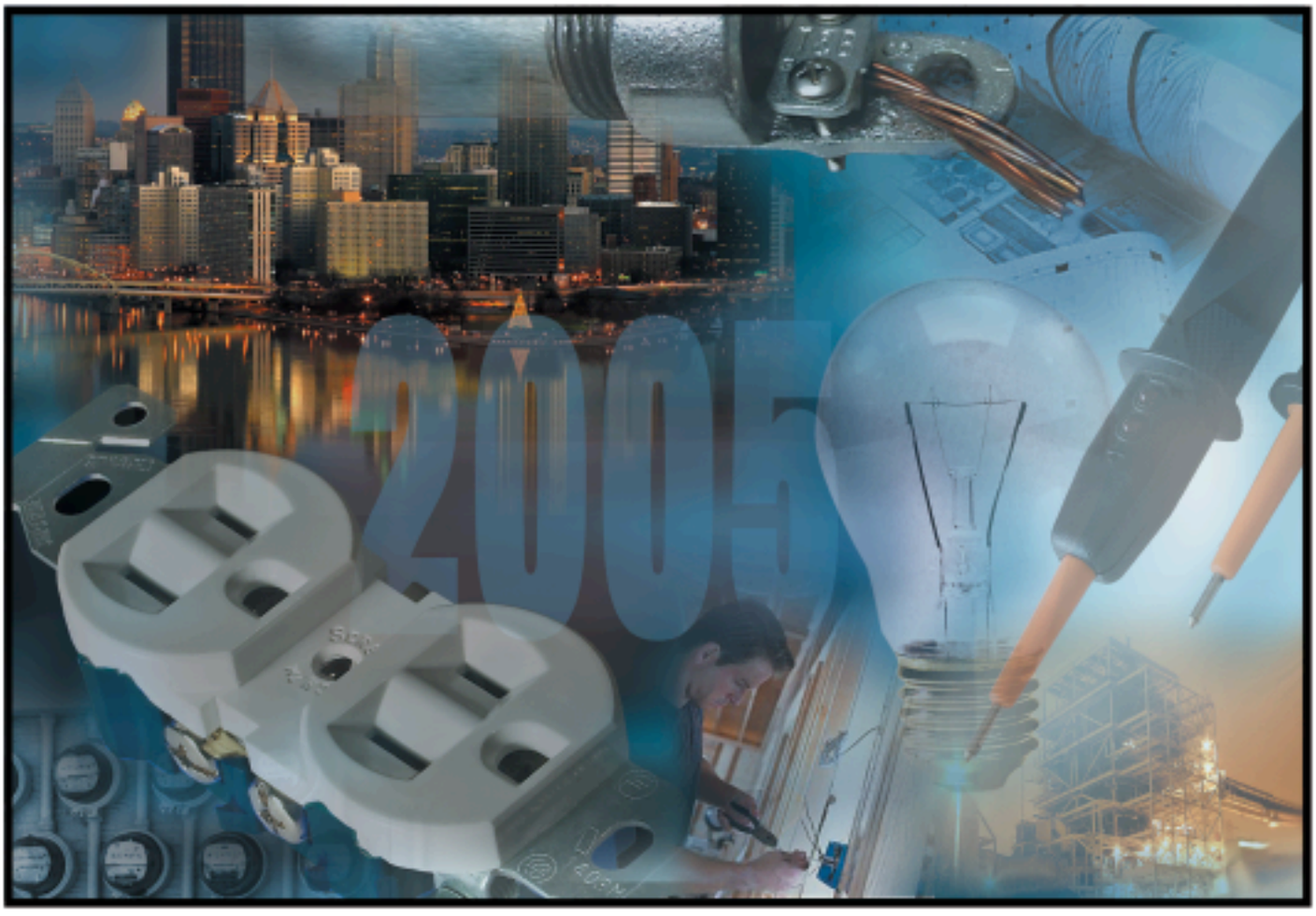

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Table of Contents

Introduction

Introduction

This PDF is a free resource from Mike Holt Enterprises, Inc. It is always our pleasure to give back to the industry as much as we can, whenever we can. For this reason we've created this free "Top 101 Rules" from Mike's *Understanding the NEC, Volume 1*, *2005 Edition* textbook. These are the rules that Mike and his team feel are the most important for every electrician to know.

It's a quick reference and guide to make sure you're up to speed on these very important rules.

About the Author

Mike Holt worked his way up through the electrical trade from an apprentice electrician to become one of the most recognized experts in the world as it relates to electrical power installation. He was a Journeyman Electrician, Master Electrician, and Electrical Contractor. Mike came from the real world, and his dedication to electrical training is the result of his own struggles as an electrician looking for a program that would help him succeed in this challenging industry.

It is for reasons like this that Mike continues to help the industry by providing free resources such as this 101 rules document. It is the goal of Mike Holt and everyone on the Mike Holt Team to do everything in our power to aid in your pursuit of excellence.

For more great Free resources from Mike Holt visit
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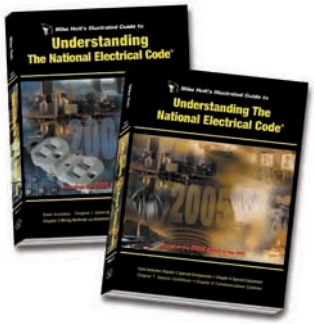
About This Free PDF



These rules were extracted from Mike's *Understanding the NEC, Volume 1, 2005 Edition* textbook. To understand the entire *National Electrical Code*, you need to study Mike's comprehesive textbooks: *Understanding the NEC, Volume 1* and *Volume 2*.

Volume 1 covers general installation requirements, branch circuits, feeders, services and overcurrent protection, grounding versus bonding, conductors, cables and raceways, boxes, panels, motors and transformers, and more, in Articles 90 through 460 (*NEC* Chapters 1 through 4).

Volume 2 covers requirements for wiring in special occupancies, special equipment, under special conditions, as well as communications systems requirements in Articles 500 through 830 (*NEC* Chapters 5-8)

How to Use This PDF

Not an *NEC* Replacement

This PDF is to be used with the *NEC*, not as a replacement for the *NEC,* it is intended to explain the requirements of the *NEC*. Be sure to have a copy of the 2005 *National Electrical Code* handy, and always compare Mike's explanation, comments, and graphics to the actual language contained in the *NEC*.

You'll sometimes notice that the titles of a few Articles and Sections are different than they appear in the actual *Code*. This only occurs when Mike feels it's easier to understand the content of the rule, so please keep this in mind when comparing the two documents.

Compare what Mike has explained in the text to your *Code* book, and discuss those topics that you find difficult to understand with others. As you read through this PDF, be sure to take the time to review the text with the outstanding graphics and examples.

Cross-References

This PDF contains thousands of *NEC* cross-references to other related *Code* requirements to help you develop a better understanding of how the *NEC* rules relate to one another. These cross-references are identified by a *Code* Section number in brackets, such as "90.4," which would look like "[90.4]."

Author's Comments

This PDF contains hundreds of "Author's Comments." These sections were written by Mike to help you better understand the *NEC* material, and to bring to your attention things he believes you should be aware of. To help you find them more easily, they are printed differently than the rest of the material.

PDF Format

This PDF follows the *NEC* format, but each rule doesn't always cover the entire *Code* subsection. So don't be concerned if you see that the Rule contains Exception No. 1 and Exception No. 3, but not Exception No. 2. In addition, at times, the title of an Article, Section, or Subsection might be rephrased differently.

Difficult Concepts

As you progress through this PDF, you might find that you don't understand every explanation, example, calculation, or comment. Don't get frustrated, and don't get down on yourself. Remember, this is the *National Electrical Code* and sometimes the best attempt to explain a concept isn't enough to make it perfectly clear. When this happens to you, just make it a point to highlight the section that is causing you difficulty. If you can, take this PDF to someone you feel can provide additional insight, possibly your boss, the electrical inspector, a co-worker, your instructor, etc.

PDF Errors and Corrections

Humans develop the text, graphics, and layout of this PDF, and since currently none of us is perfect, there may be a few errors. This could occur because the *NEC* is dramatically changed each *Code* cycle; new Articles are added, some deleted, some relocated, and many renumbered. In addition, this PDF must be written within a very narrow window of opportunity; after the *NEC* has been published (September), yet before it's enforceable (January).

You can be sure we work a tremendous number of hours and use all of our available resources to produce the finest product with the fewest errors. We take great care in researching the *Code* requirements to ensure this textbook is correct. If you feel there's an error of any type in this textbook (typo, grammar, or technical), no matter how insignificant, please let us know.

Any errors found after printing are listed on our Website, so if you find an error, first check to see if it has already been corrected. Go to www.MikeHolt.com, click on the "Books" link, and then the "Corrections" link (www.MikeHolt.com/bookcorrections.htm).

If you do not find the error listed on the Website, contact us by E-mailing corrections@MikeHolt.com, calling 1.888.NEC.CODE (1.888.632.2633), or faxing 954.720.7944. Be sure to include the book title, page number, and any other pertinent information.

Internet

Today as never before, you can get your technical questions answered by posting them to Mike Holt's *Code* Forum. Just visit www.MikeHolt.com and click on the "*Code* Forum" link.

Different Interpretations

Some electricians, contractors, instructors, inspectors, engineers, and others enjoy the challenge of discussing the *Code* requirements, hopefully in a positive and a productive manner. This action of challenging each other is important to the process of better understanding the *NEC*'s requirements and its intended application. However, if you're going to get into an *NEC* discussion, please do not spout out what you think without having the actual *Code* in your hand. The professional way of discussing an *NEC* requirement is by referring to a specific section, rather than by talking in vague generalities.

The National Electrical Code

The *National Electrical Code (NEC)* is written for persons who understand electrical terms, theory, safety procedures, and electrical trade practices. These individuals include electricians, electrical contractors, electrical inspectors, electrical engineers, designers, and other qualified persons. The *Code* was not written to serve as an instructive or teaching manual for untrained individuals [90.1(C)].

Learning to use the *NEC* is somewhat like learning to play the game of chess; it's a great game if you enjoy mental warfare. You must first learn the names of the game pieces, how the pieces are placed on the board, and how each piece moves.

In the electrical world, this is equivalent to completing a comprehensive course on basic electrical theory, such as:

- What electricity is and how is it produced
- Dangers of electrical potential: fire, arc blast, arc fault, and electric shock
- Direct current
- Series and parallel circuits
- Electrical formulas
- Alternating current
- Induction, motors, generators, and transformers

Once you understand the fundamentals of the game of chess, you're ready to start playing the game. Unfortunately, at this point all you can do is make crude moves, because you really do not understand how all the information works together. To play chess well, you will need to learn how to use your knowledge by working on subtle strategies before you can work your way up to the more intriguing and complicated moves.

Again, back to the electrical world, this is equivalent to completing a course on the basics of electrical theory. You have the foundation upon which to build, but now you need to take it to the next level, which you can do by reading this textbook, watching the companion video or DVD, and answering the *NEC* practice questions in the *Workbook to Accompany Understanding the National Electric Code, Volume 1.*

Not a Game

Electrical work isn't a game, and it must be taken very seriously. Learning the basics of electricity, important terms and concepts, as well as the basic layout of the *NEC* gives you just enough knowledge to be dangerous. There are thousands of specific and unique applications of electrical installations, and the *Code* doesn't cover every one of them. To safely apply the *NEC*, you must understand the purpose of a rule and how it affects the safety aspects of the installation.

NEC Terms and Concepts

The *NEC* contains many technical terms, so it's crucial that *Code* users understand their meanings and their applications. If you do not understand a term used in a *Code* rule, it will be impossible to properly apply the *NEC* requirement. Be sure you understand that Article 100 defines the terms that apply to *two or more* Articles. For example, the term "Dwelling Unit" applies to many Articles. If you do not know what a Dwelling Unit is, how can you possibly apply the *Code* requirements for it?

In addition, many Articles have terms that are unique for that specific Article. This means that the definition of those terms is only applicable for that given Article. For example, Article 250 Grounding and Bonding has the definitions of a few terms that are only to be used within Article 250.

Small Words, Grammar, and Punctuation

It's not only the technical words that require close attention, because even the simplest of words can make a big difference to the intent of a rule. The word "or" can imply alternate choices for equipment wiring methods, while "and" can mean an additional requirement. Let's not forget about grammar and punctuation. The location of a comma "," can dramatically change the requirement of a rule.

Slang Terms or Technical Jargon

Electricians, engineers, and other trade-related professionals use slang terms or technical jargon that isn't shared by all. This makes it very difficult to communicate because not everybody understands the intent or application of those slang terms. So where possible, be sure you use the proper word, and do not use a word if you do not understand its definition and application. For example, lots of electricians use the term "pigtail" when describing the short conductor for the connection of a receptacle, switch, luminaire, or equipment. Although they may understand it, not everyone does. Figure 1

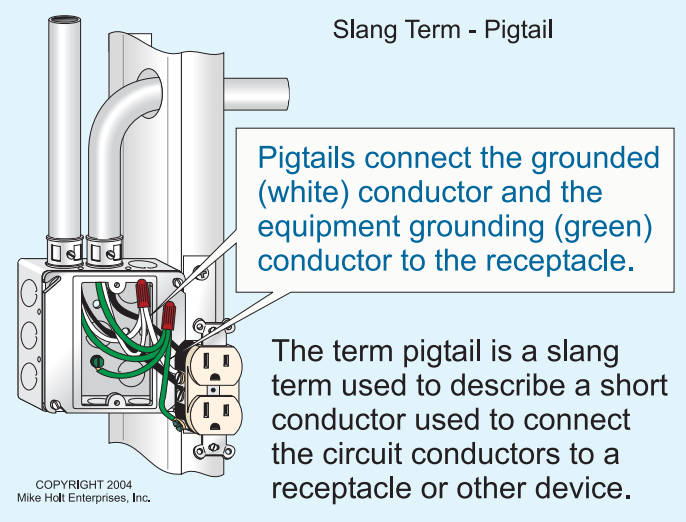


Figure 1

NEC Style and Layout

Before we get into the details of the *NEC*, we need to take a few moments to understand its style and layout. Understanding the structure and writing style of the *Code* is very important before it can be used effectively. If you think about it, how can you use something if you don't know how it works? Okay, let's get started. The *National Electrical Code* is organized into nine components.

- Table of Contents
- Chapters 1 through 9 (major categories)
- Articles 90 through 830 (individual subjects)
- Parts (divisions of an Article)
- Sections and Tables (*Code* requirements)
- Exceptions (*Code* permissions)
- Fine Print Notes (explanatory material)
- Index
- Annexes (information)

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* section 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, and Cable TV)
- Chapter 9 Tables—Conductor and Raceway Specifications

3. Articles. The *NEC* contains approximately 140 Articles, each of which covers a specific subject. For example:

- Article 110 General Requirements
- Article 250 Grounding
- Article 300 Wiring Methods
- Article 430 Motors
- Article 500 Hazardous (Classified) Locations
- Article 680 Swimming Pools, Spas, Hot Tubs, and Fountains
- Article 725 Remote-Control, Signaling, and Power-Limited Circuits
- Article 800 Communications Systems

4. Parts. Larger Articles are subdivided into Parts. For example, Article 110 has been divided into multiple parts:

- Part I. General (Sections 110.1—110.23)
- Part II. 600 Volts, Nominal, or Less (110.26—110.27)
- Part III. Over 600 Volts, Nominal (110.30—110.59)

Note: Because the Parts of a *Code* Article aren't included in the Section numbers, we have a tendency to forget what "Part" the *NEC* rule is relating to. For example, Table 110.34(A) contains the 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 contains the requirements for Over 600 Volts, Nominal installations. The rules for working clearances for electrical

equipment for systems 600V or less are contained in Table 110.26(A)(1), which is located in Part II. 600 Volts, Nominal, or Less.

5. Sections and Tables.

Sections: Each *NEC* rule is called a *Code* Section. A *Code* Section may be broken down into subsections by letters in parentheses (A), (B), etc. Numbers in parentheses (1), (2), etc., may further break down a subsection, and lower-case letters (a), (b), etc., further breaks the rule down to the 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). Section 210.8(A)(1) 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."

Tables: Many *Code* requirements are contained within Tables, which are lists of *NEC* requirements placed in a systematic arrangement. The titles of the Tables are extremely important; they must be carefully read in order to understand the contents, applications, limitations, etc., of each Table in the *Code*. Many times notes are provided in a table; be sure to read them as well, since they are 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.

6. Exceptions. Exceptions are *Code* requirements that provide an alternative method to a specific requirement. 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 Exception: 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 term "shall not" means it isn't permitted.

Permissive Exception: A permissive exception uses words such as "is permitted," which means that it's acceptable to do it in this way.

7. Fine Print Note (FPN). A Fine Print Note contains explanatory material intended to clarify a rule or give assistance, but it isn't a *Code* requirement.

8. Index. The Index contained in the *NEC* is excellent and is helpful in locating a specific rule.

9. 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. Conduit and Tubing Fill Tables for Conductors and Fixture Wires of the Same Size
- Annex D. Examples
- Annex E. Types of Construction
- Annex F. Cross-Reference Tables (1999, 2002, and 2005 *NEC*)
- Annex G. Administration and Enforcement

Note: Changes to the *NEC*, since the previous edition(s) are identified in the margins by a vertical line (|), but rules that have been relocated aren't identified as a change. In addition, the location from which the *Code* rule was removed has no identifier.

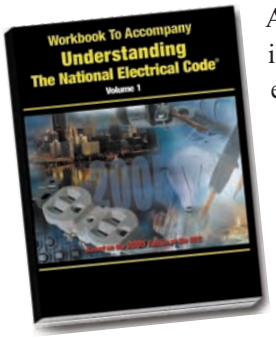
How to Locate a Specific Requirement

How to go about finding what you're looking for in the *Code* depends, to some degree, on your experience with the *NEC*. *Code* experts typically know the requirements so well that they just go to the *NEC* rule without any outside assistance. The Table of Contents might be the only thing very experienced *Code* users need to locate their requirement. On the other hand, average *Code* users should use all of the tools at their disposal, and that includes the Table of Contents and the Index.

Table of Contents: Let's work out a simple example: What *NEC* rule specifies the maximum number of disconnects permitted for a service? If you're an experienced *Code* user, you'll know that Article 230 applies to "Services," and because this Article is so large, it's divided up into multiple parts (actually 8 parts). With this knowledge, you can quickly go to the Table of Contents (page 70-2) and see that it lists the Service Equipment Disconnecting Means requirements in Part VI, starting at page 70-77.

Note: The number 70 precedes all page numbers because the *NEC* is standard number 70 within the collection of *NFPA* standards.

Index: If you used the Index, which lists subjects in alphabetical order, to look up the term "service disconnect," you would see that there's no listing. If you tried "disconnecting means," then "services," you would find the Index specifies that the rule is located at 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 get the page number, or flip through the *Code* to Article 230, then continue to flip until you find Part VI.



As you can see, although the index is very comprehensive, it's not that easy to use if you do not understand how the index works. But if you answer the over 1,200 *NEC* practice questions or seven 50-question exams contained in the *Workbook to Accompany Understanding the National Electric Code, Volume 1,* you'll become a master at finding things in the *Code* quickly.

Many people complain that the *NEC* only confuses them by taking them in circles. As you gain experience in using the *Code* and deepen your understanding of words, terms, principles, and practices, you will 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* is to customize it to meet your needs. You can do this by highlighting and underlining important *NEC* requirements, and by attaching tabs to important pages.

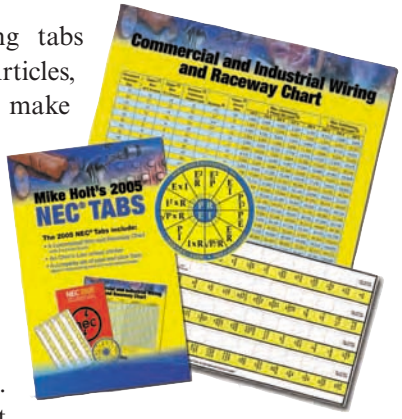
Highlighting: As you read through this textbook and answer the questions in the workbook, be sure you highlight those requirements in the *Code* that are most important to you. Use yellow for general interest and orange for important requirements you want to find quickly. Be sure to highlight terms in the Index and Table of Contents as you use them.

Because of the size of the 2005 *NEC*, I recommend you highlight in green the Parts of Articles that are important for your applications, particularly:

Article 230 Services
Article 250 Grounding
Article 430 Motors

Underlining: Underline or circle key words and phrases in the *NEC* with a red pen (not a lead pencil) and use a 6-in. ruler to keep lines straight and neat. This is a very handy way to make important requirements stand out. A small 6-in. ruler also comes in handy for locating specific information in the many *Code* tables.

Tabbing the *NEC*: Placing tabs on important *Code* Articles, Sections, and Tables will make it very easy to access important *NEC* requirements. However, too many tabs will defeat the purpose. You can order a custom set of *Code* tabs, designed by Mike Holt, online at www.MikeHolt.com, or by calling us at 1.888.NEC.Code (1.888.632.2633).



ARTICLE 90

Introduction to the National Electrical Code

Introduction

This Article provides general information necessary to use the *NEC*. It contains the purpose, scope, information about how the *Code* is written and arranged, and information about how the *NEC* is enforced and interpreted.

90.1 Purpose of the *NEC*.

(A) Practical Safeguarding. The purpose of the *NEC* is to ensure that electrical systems are installed in a manner that protects people and property by minimizing the risks associated with the use of electricity.

(B) Adequacy. The *Code* contains requirements that are considered necessary for a safe electrical installation. When an electrical installation is installed in compliance with the *NEC*, it will be essentially free from electrical hazards. The *NEC* is a safety standard, not a design guide.

The *NEC* requirements aren't intended to ensure that the electrical installation will be efficient, convenient, adequate for good service, or suitable for future expansion. Specific items of concern, such as electrical energy management, maintenance, and power quality issues aren't within the scope of the *NEC*. Figure 90–1

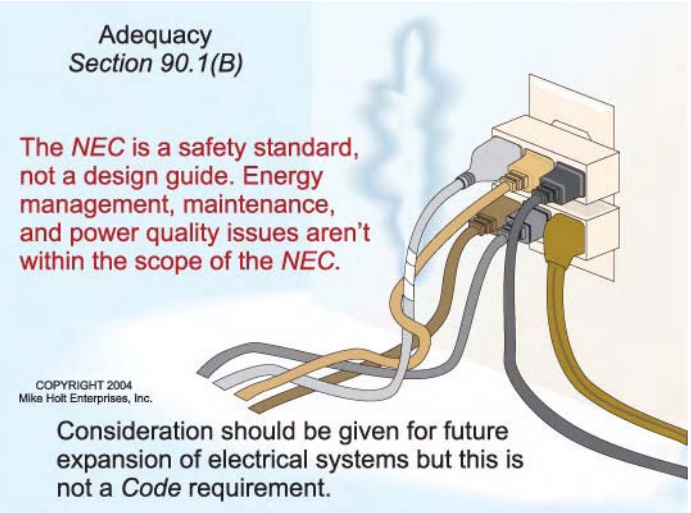


Figure 90–1

FPN: Hazards in electrical systems often occur because circuits are overloaded or not properly installed in accordance with the *NEC*. The initial wiring often did not provide reasonable provisions for system changes or for the increase in the use of electricity.

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Overload."
- The *NEC* does not require electrical systems to be designed or installed to accommodate future loads. However, the electrical designer, typically an electrical engineer, is concerned with not only ensuring electrical safety (*Code* compliance), but also ensuring that the system meets the customers' needs, both of today and in the near future. To satisfy customers' needs, electrical systems must be designed and installed above the minimum requirements contained in the *NEC*.

(C) Intention. The *Code* is to be used by those skilled and knowledgeable in electrical theory, electrical systems, construction, and the installation and operation of electrical equipment. It isn't a design specification standard or instruction manual for the untrained and unqualified.

(D) Relation to International Standards. The requirements of the *NEC* address the fundamental safety principles contained in International Electrotechnical Commission standards, including protection against electric shock, adverse thermal effects, overcurrent, fault currents, and overvoltage. Figure 90–2

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Overcurrent."
- The *NEC* is used in Chile, Ecuador, Peru, and the Philippines. It's also the *Electrical Code* for Colombia, Costa Rica, Mexico, Panama, Puerto Rico, and Venezuela. Because of these adoptions, the *NEC* is available in Spanish from the National Fire Protection Association, 1.617.770.3000.

Figure 90–2

2 90.2 Scope of the *NEC*.

(A) What is Covered. The *NEC* contains requirements necessary for the proper electrical installation of electrical conductors, equipment, and raceways; signaling and communications conductors, equipment, and raceways; as well as fiber optic cables and raceways for the following locations: Figure 90–3

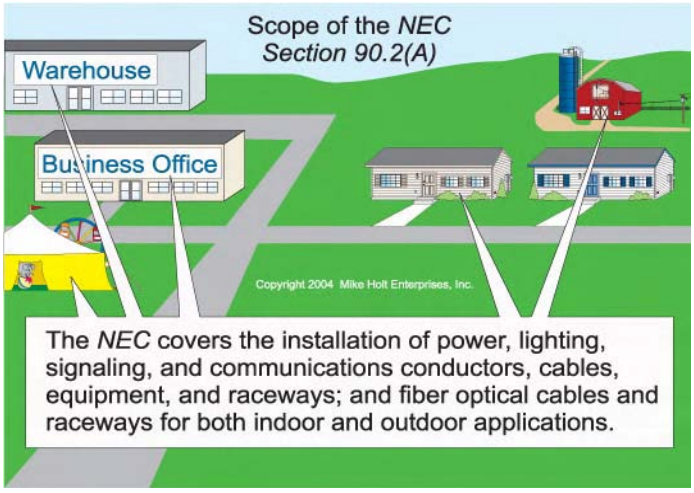


Figure 90–3

(1) Public and private premises, including buildings or structures, mobile homes, recreational vehicles, and floating buildings.

(2) Yards, lots, parking lots, carnivals, and industrial substations.

(3) Conductors and equipment that connect to the utility supply.

(4) Installations used by an electric utility, such as office buildings, warehouses, garages, machine shops, recreational buildings, and other electric utility buildings that are not an integral part of a utility's generating plant, substation, or control center. Figure 90–4

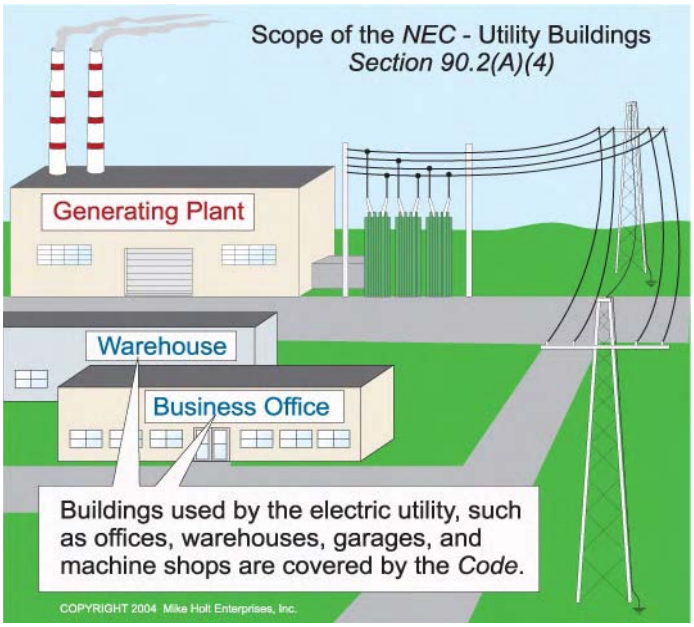


Figure 90–4

(B) What isn't Covered. The *National Electrical Code* doesn't apply to the following applications:

(1) Transportation Vehicles. Installations in cars, trucks, boats, ships and watercraft, planes, electric trains, or underground mines.

(2) Mining Equipment. Installations underground in mines and self-propelled mobile surface mining machinery and its attendant electrical trailing cables.

(3) Railways. Railway power, signaling, and communications wiring.

(4) Communications Utilities. The installation requirements of the *NEC* do not apply to communications (telephone), CATV, or network-powered broadband utility equipment located in building spaces used exclusively for such use or outdoors, if the installation is under the exclusive control of the communications utility. Figure 90–5

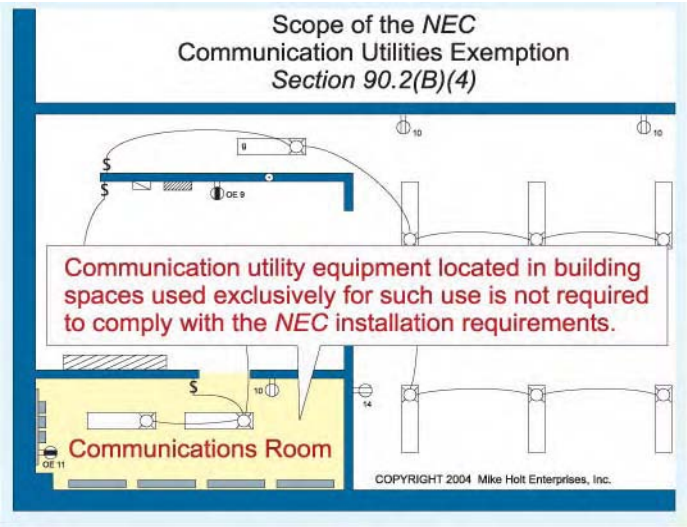


Figure 90–5

AUTHOR'S COMMENT: Interior wiring for communications systems, not in building spaces used exclusively for such use, must be installed in accordance with the following Chapter 8 requirements: Figure 90–6

- Phone and Data, Article 800
- CATV, Article 820
- Network-Powered Broadband, Article 830

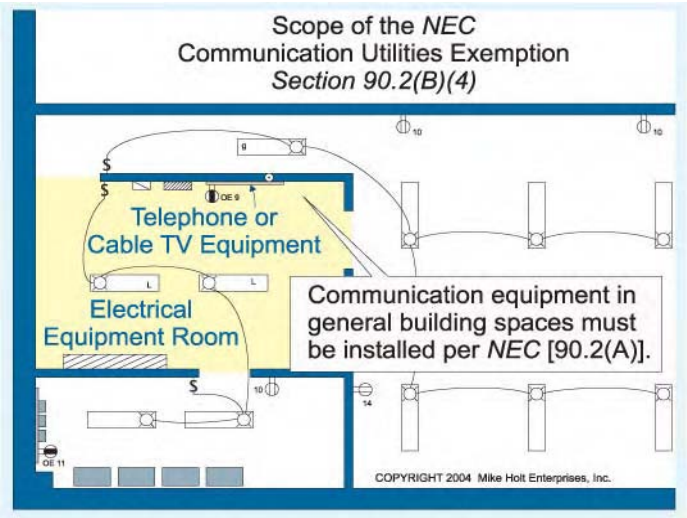


Figure 90–6

(5) Electric Utilities. The *NEC* doesn't apply to electric installations under the exclusive control of an electric utility where such installations:

a. Consist of service drops or service laterals and associated metering. Figure 90–7

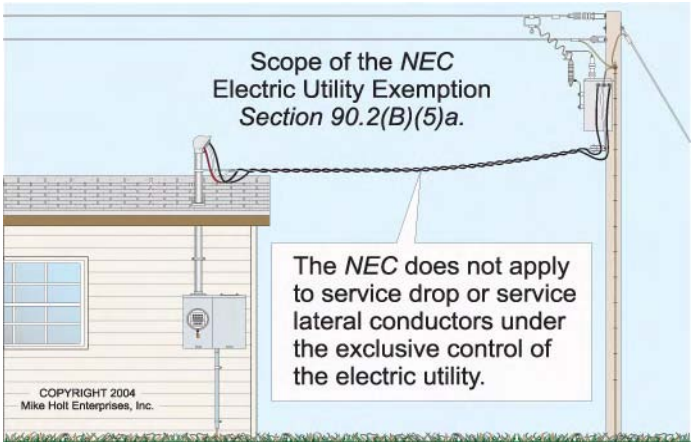


Figure 90–7

b. Are located on legally established easements, rights-of-way, or by other agreements recognized by public/utility regulatory agencies, or property owned or leased by the electric utility. Figure 90–8

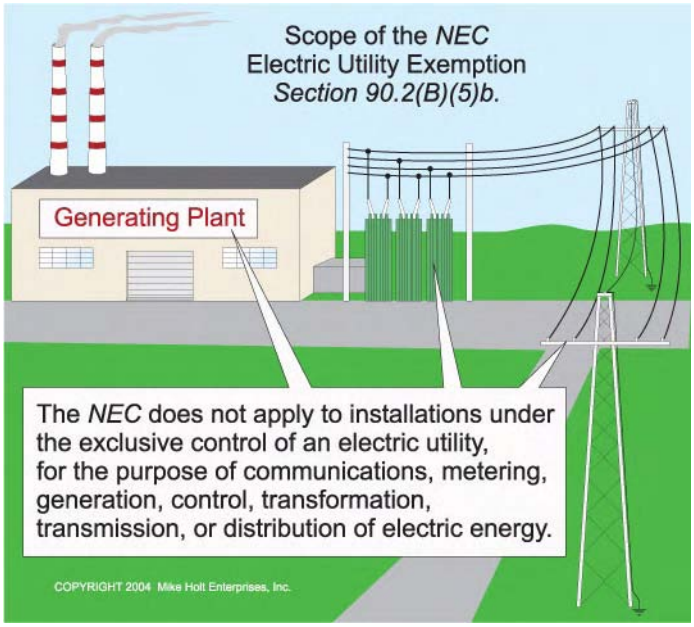


Figure 90–8

c. Are on property owned or leased by the electric utility for the purpose of generation, transformation, transmission, distribution, or metering of electric energy. See Figure 90–8.

AUTHOR'S COMMENT: Luminaires (lighting fixtures) located in legally established easements, or rights-of-way, such as at poles supporting transmission or distribution lines, are exempt from the requirements of the *NEC*. However, if the electric utility provides site and public lighting on private property, then the installation must comply with the *NEC* [90.2(A)(4)]. Figure 90–9

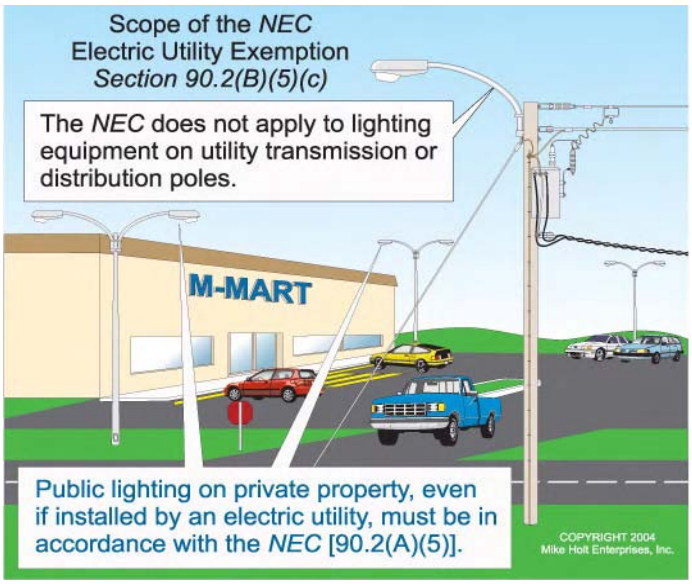


Figure 90–9

FPN to 90.2(B)(4) and (5): Utilities include entities that install, operate, and maintain communications systems (telephone, CATV, Internet, satellite, or data services) or electric supply systems (generation, transmission, or distribution systems) and are designated or recognized by governmental law or regulation by public service/utility commissions. Utilities may be subject to compliance with codes and standards covering their regulated activities as adopted under governmental law or regulation.

3 90.3 *Code* Arrangement

The *Code* is divided into an Introduction and nine chapters. Figure 90–10

General Requirements. The requirements contained in Chapters 1, 2, 3, and 4 apply to all installations.

AUTHOR'S COMMENT: The scope of this textbook includes *NEC* Chapters 1 through 4.

Special Requirements. The requirements contained in Chapters 5, 6, and 7 apply to special occupancies, special equipment, or other special conditions. They can supplement or modify the requirements in Chapters 1 through 4.

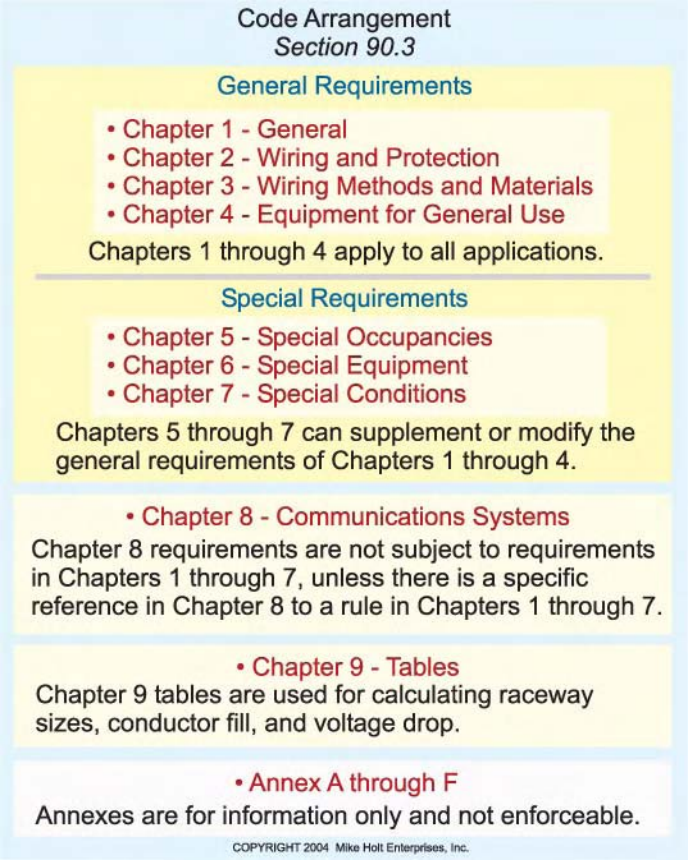


Figure 90–10

For example, the general requirement contained in 250.118 of Article 250 Grounding and Bonding states that a metal raceway, such as Electrical Metallic Tubing, is considered suitable to provide a low-impedance path to the power supply for ground-fault current. However, 517.13(B) of Article 517 Health Care Facilities doesn't consider the raceway to be sufficient. It requires an insulated copper conductor to be installed in the raceway for this purpose.

Communications Systems. Chapter 8 contains the requirements for communications systems, such as telephone, antenna wiring, CATV, and network-powered broadband systems. Communications systems aren't subject to the general requirements of Chapters 1 through 4, or the special requirements of Chapters 5 through 7, unless there's a specific reference in Chapter 8 to a rule in Chapters 1 through 7.

AUTHOR'S COMMENT: Mike Holt's *Understanding the NEC, Volume 2* [Articles 500 through 830], explains the wiring requirements of special occupancies, special equipment, and special conditions, as well as communications systems.

Table. Chapter 9 consists of tables necessary to calculate raceway sizing, conductor fill, and voltage drop.

Annexes. Annexes aren't part of the *Code*, but are included for informational purposes. They are:

- Annex A. Product Safety Standards
- Annex B. Conductor Ampacity Under Engineering Supervision
- Annex C. Raceway Size Tables
- Annex D. Examples
- Annex E. Types of Construction
- Annex F. Cross-Reference Tables

90.4 Enforcement

This *Code* is intended to be suitable for enforcement by governmental bodies that exercise legal jurisdiction over electrical installations for power, lighting, signaling circuits, and communications systems, such as: Figure 90–11

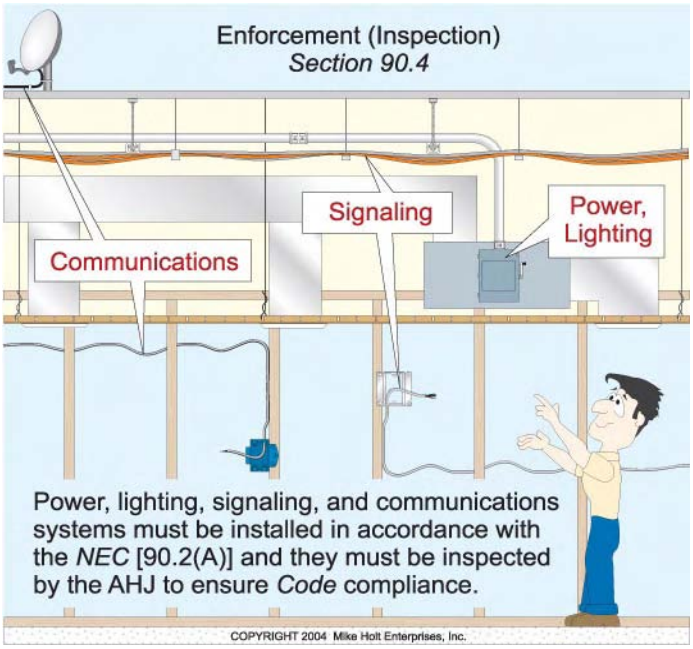


Figure 90–11

Signaling circuits, which include:

- Article 725 Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits
- Article 760 Fire Alarm Systems
- Article 770 Optical Fiber Cables and Raceways

Communications circuits, which include:

- Article 800 Communications Circuits (twisted-pair conductors)
- Article 810 Radio and Television Equipment (satellite dish and antenna)
- Article 820 Community Antenna Television and Radio Distribution Systems (coaxial cable)
- Article 830 Network-Powered Broadband Communications Systems

AUTHOR'S COMMENT: The installation requirements for signaling circuits and communications circuits are covered in Mike's *Understanding the NEC, Volume 2* textbook.

The enforcement of the *NEC* is the responsibility of the authority having jurisdiction (AHJ), who is responsible for interpreting requirements, approving equipment and materials, waiving *Code* requirements, and ensuring that equipment is installed in accordance with listing instructions.

AUTHOR'S COMMENT: See Article 100 for the definition of "Authority Having Jurisdiction."

Interpretation of the Requirements. The authority having jurisdiction is responsible for interpreting the *NEC*, but his or her decisions must be based on a specific *Code* requirement. If an installation is rejected, the authority having jurisdiction is legally responsible for informing the installer which specific *NEC* rule was violated.

AUTHOR'S COMMENT: The art of getting along with the authority having jurisdiction consists of doing good work and knowing what the *Code* actually says (as opposed to what you only think it says). It's also useful to know how to choose your battles when the inevitable disagreement does occur.

Approval of Equipment and Materials. Only the authority having jurisdiction has authority to approve the installation of equipment and materials. Typically, the authority having jurisdiction will approve equipment listed by a product testing organization, such as Underwriters Laboratories Inc. (UL), but the *NEC* doesn't require all equipment to be listed. See 90.7, 110.2, 110.3, and the definitions in Article 100 for Approved, Identified, Labeled, and Listed. Figure 90–12

AUTHOR'S COMMENT: According to the *NEC*, the authority having jurisdiction determines the approval of equipment. This means that he/she can reject an installation of listed equipment and he/she can approve the use of unlisted equipment. Given our highly litigious society, approval of unlisted equipment is becoming increasingly difficult to obtain.

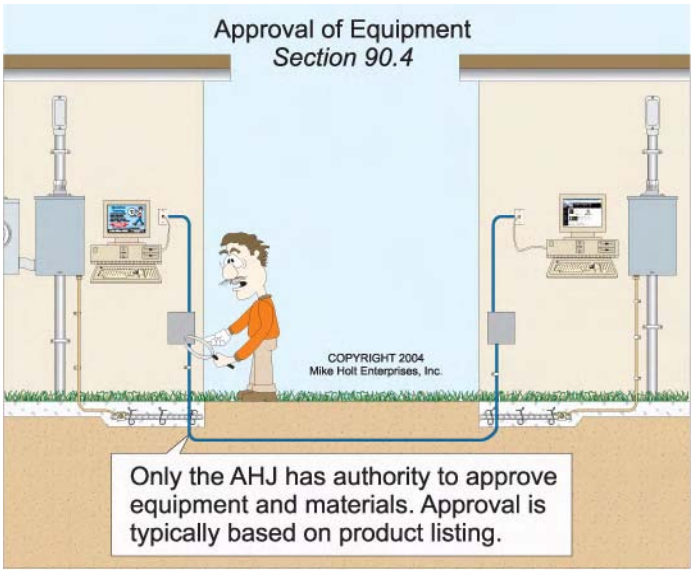


Figure 90–12

Waiver of Requirements. By special permission, the authority having jurisdiction can waive specific requirements in this *Code* or permit alternative methods where it's assured that equivalent safety can be achieved and maintained.

AUTHOR'S COMMENT: Special permission is defined in Article 100 as the written consent of the authority having jurisdiction.

Waiver of New Product Requirements. If the 2005 *NEC* requires products that aren't yet available at the time the *Code* is adopted, the authority having jurisdiction can allow products that were acceptable in the previous *Code* to continue to be used.

AUTHOR'S COMMENT: Sometimes it takes years before testing laboratories establish product standards for new *NEC* product requirements, and then it takes time before manufacturers can design, manufacture, and distribute these products to the marketplace.

Compliance with Listing Instructions. It's the authority having jurisdiction's responsibility to ensure that electrical equipment is installed in accordance with equipment listing and/or labeling instructions [110.3(B)]. In addition, the authority having jurisdiction can reject the installation of equipment modified in the field [90.7].

AUTHOR'S COMMENT: The *NEC* doesn't address the maintenance of electrical equipment (NFPA 70B does), because the *Code is an* installation standard, not a maintenance standard.

90.5 Mandatory Requirements and Explanatory Material.

(A) Mandatory Requirements. In the *NEC* the words "shall" or "shall not," indicate a mandatory requirement.

AUTHOR'S COMMENT: For the ease of reading this textbook, the word "shall" has been replaced with the word "must," and the words "shall not" have been replaced with the word "cannot."

(B) Permissive Requirements. When the *Code* uses "shall be permitted" it means the identified actions are allowed but not required, and the authority having jurisdiction is not to restrict an installation from being done in that manner. A permissive rule is often an exception to the general requirement.

AUTHOR'S COMMENT: For ease of reading, the phrase "shall be permitted" as used in the *Code*, has been replaced in this textbook with the words "is permitted."

(C) Explanatory Material. References to other standards or sections of the *NEC*, or information related to a *Code* rule, are included in the form of Fine Print Notes (FPN). Fine Print Notes are for information only and aren't intended to be enforceable.

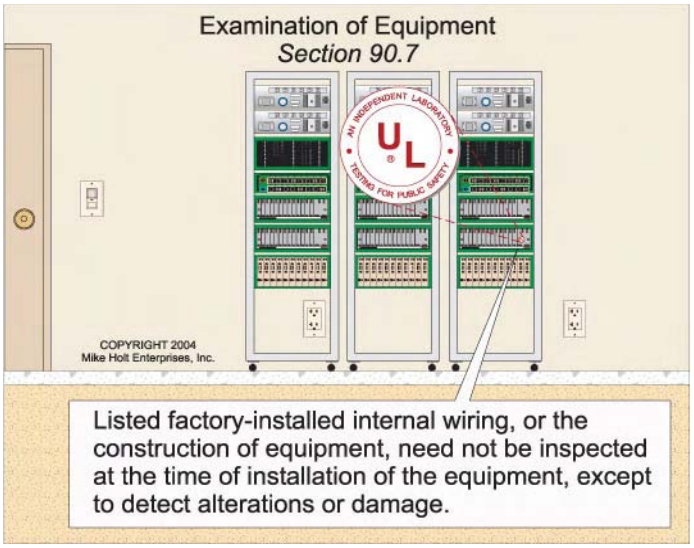
For example, Fine Print Note No. 4 in 210.19(A)(1) recommends that the circuit voltage drop not exceed three percent. This isn't a requirement; it's just a recommendation.

90.7 Examination of Equipment for Product Safety

Product evaluation for safety is typically performed by a testing laboratory, which publishes a list of equipment that meets a nationally recognized test standard. Products and materials listed, labeled, or identified by a testing laboratory are generally approved by the authority having jurisdiction.

AUTHOR'S COMMENT: See Article 100 for the definition of "Approved."

Listed, factory-installed, internal wiring and construction of equipment need not be inspected at the time of installation, except to detect alterations or damage [300.1(B)]. Figure 90–13


Examination of Equipment
Section 90.7
AN INDEPENDENT LABORATORY
UL
TESTING FOR PUBLIC SAFETY
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Mike Holt Enterprises, Inc.
Listed factory-installed internal wiring, or the construction of equipment, need not be inspected at the time of installation of the equipment, except to detect alterations or damage.

Figure 90–13

ARTICLE 110 Requirements for Electrical Installations

Introduction

This Article contains general requirements for electrical installations.

110.2 Approval of Equipment

The authority having jurisdiction must approve all electrical conductors and equipment. Figure 110–1

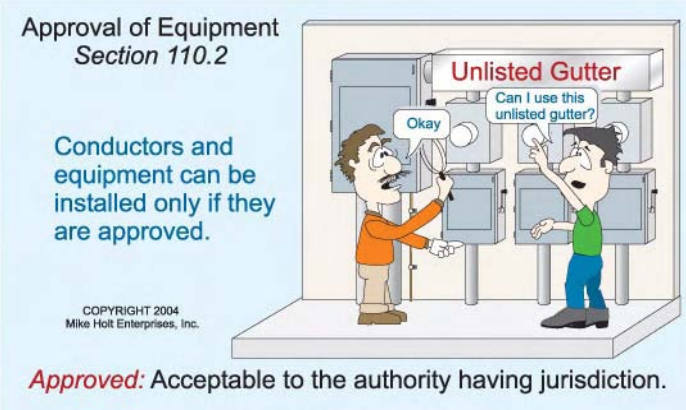

Figure 110–1

AUTHOR'S COMMENT: For a better understanding of product approval, review 90.4, 90.7, 110.3 and the definitions for Approved, Identified, Labeled, and Listed in Article 100.

110.3 Examination, Identification, Installation, and Use of Equipment

(A) Guidelines for Approval. The authority having jurisdiction must approve equipment, and consideration must be given to the following:

(1) Listing or labeling
(2) Mechanical strength and durability
(3) Wire-bending and connection space
(4) Electrical insulation
(5) Heating effects under conditions of use
(6) Arcing effects
(7) Classification by voltage, current capacity, and specific use
(8) Other factors contributing to the practical safeguarding of persons using or in contact with the equipment

(B) Installation and Use. Equipment must be installed and used in accordance with any instructions included in the listing or labeling requirements.

AUTHOR'S COMMENTS:

- See Article 100 for the definitions of "Labeling" and "Listing."
- Equipment is listed for a specific condition of use, operation, or installation, and it must be installed and used in accordance with those listed instructions. Failure to follow product listing instructions, such as torquing of terminals and sizing of conductors, is a violation of this *Code* rule [110.3(B)]. Figure 110–2

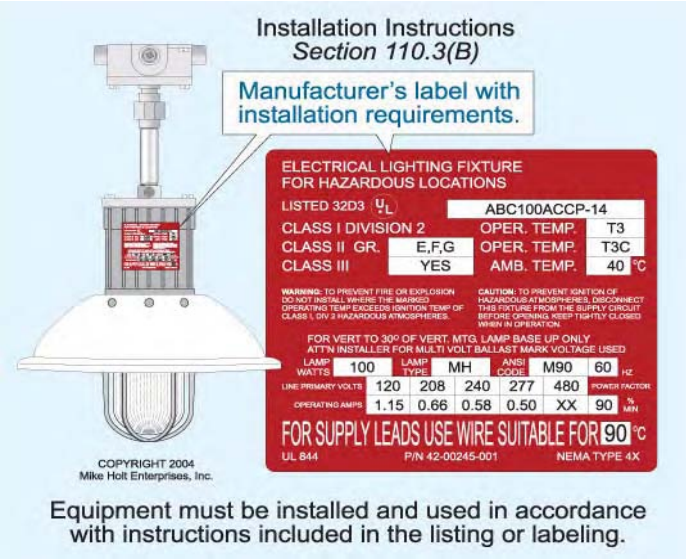

Figure 110–2

- When an air conditioner nameplate specifies "Maximum Fuse Size," one-time or dual-element fuses must be used to protect the equipment. Figure 110–3

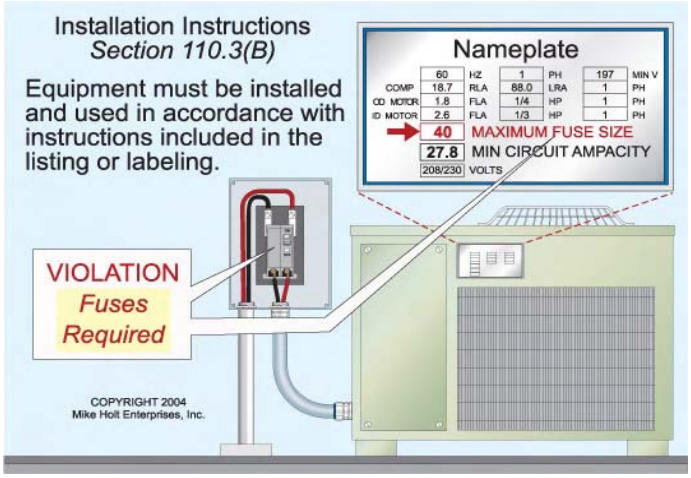

Figure 110–3

110.14 Conductor Termination

Terminal Conductor Material. Conductor terminal and splicing devices must be identified for the conductor material and they must be properly installed and used. Devices that are suitable only for aluminum must be marked AL, and devices that are suitable for both copper and aluminum must be marked CO/ALR [404.14(C) and 406.2(C)]. Figure 110–19

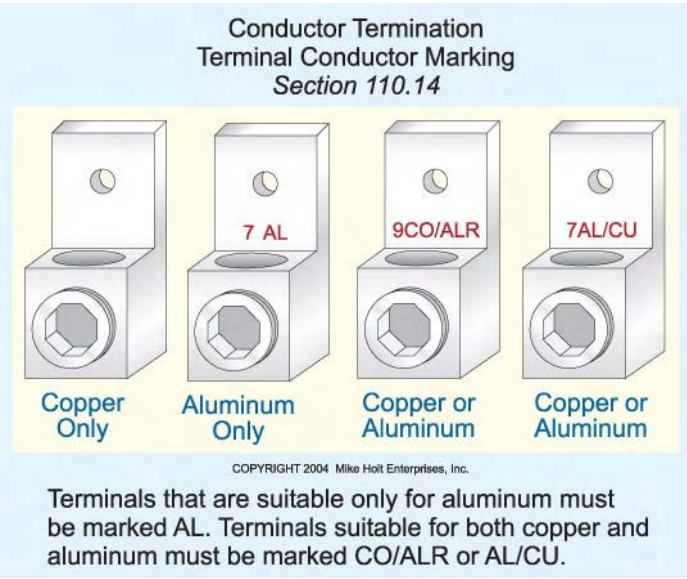

Figure 110–19

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Identified."
- Existing inventories of equipment or devices might be marked AL/CU to indicate a terminal suitable for both copper and aluminum conductors.
- Conductor terminations must comply with manufacturer's instructions as required by 110.3(B). For example, if the instructions for the device state "Suitable for 18-2 AWG Stranded," then only stranded conductors can be used with the terminating device. If the instructions state "Suitable for 18-2 AWG Solid," then only solid conductors are permitted, and if the instructions state "Suitable for 18-2 AWG," then either solid or stranded conductors can be used with the terminating device.

Aluminum. To reduce the contact resistance between the aluminum conductor and the terminal, terminals listed for aluminum conductors are often filled with an antioxidant gel.

Copper. Some terminal manufacturers sell a compound intended to reduce corrosion and heat at copper conductor terminations that is especially helpful at high-amperage terminals. This compound is messy, but apparently it's effective.

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.

AUTHOR'S COMMENT: Few terminations are listed for the mixing of aluminum wire and copper, but if they are, they will be marked on the product package or terminal device. The reason copper and aluminum should not be in contact with each other is because corrosion will develop between the two different metals due to galvanic action, resulting in increased contact resistance at the splicing device. This increased resistance can cause overheating of the splice and cause a fire. See http://tis-hq.eh.doe.gov/docs/ sn/nsh9001.html for more information on how to properly terminate aluminum and copper conductors together.

FPN: Many terminations and equipment are marked with a tightening torque.

AUTHOR'S COMMENT: All conductors must terminate in devices that have been properly tightened in accordance with manufacturer's torque specifications included with equipment instructions. Failure to torque terminals can result in excessive heating of terminals or splicing devices (due to loose connection), which could result in a fire because of a short circuit or ground fault. In addition, this is a violation of 110.3(B), which requires all equipment to be installed in accordance with listed or labeling instructions. Figure 110–20

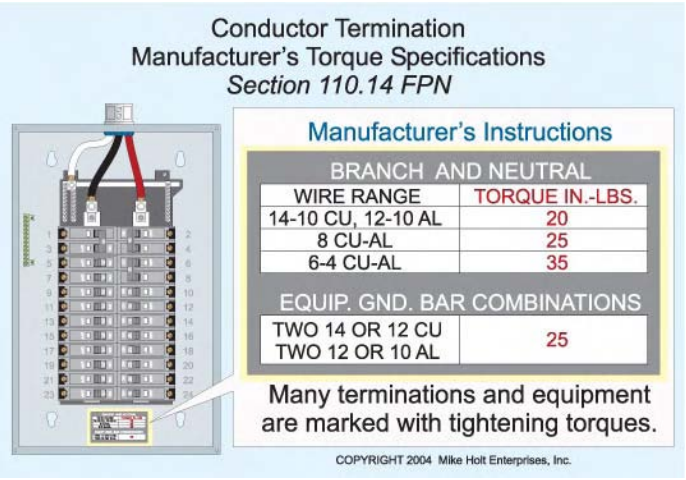

Figure 110–20

Question: *What do you do if the torque value isn't provided with the device?*

Answer: *Call the manufacturer, visit the manufacturer's website, or have the supplier make a copy of the installation instructions.*

AUTHOR'S COMMENT: Terminating conductors without a torque tool can result in an improper and unsafe installation. If a torque screwdriver is not used, there's a good chance the conductors are not properly terminated.

(A) Terminations. Conductor terminals must ensure a good connection without damaging the conductors and must be made by pressure connectors (including set-screw type) or splices to flexible leads.

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Pressure Connector."
- Grounding (earthing) conductors and bonding jumpers must be connected by exothermic welding, pressure connectors, clamps, or other means listed for grounding (earthing) [250.8].

Question: *What if the wire is larger than the terminal device?*

Answer: *This condition needs to be anticipated in advance, and the equipment should be ordered with terminals that will accommodate the larger wire. However, if you're in the field, you should:*

- *Contact the manufacturer and have them express deliver you the proper terminals, bolts, washers and nuts, or*
- *Order a terminal device that crimps on the end of the larger conductor and reduces the termination size, or splice the conductors to a smaller wire.*

One Wire Per Terminal: Terminals for more than one wire must be identified for this purpose, either within the equipment instructions or on the terminal itself. Figure 110–21

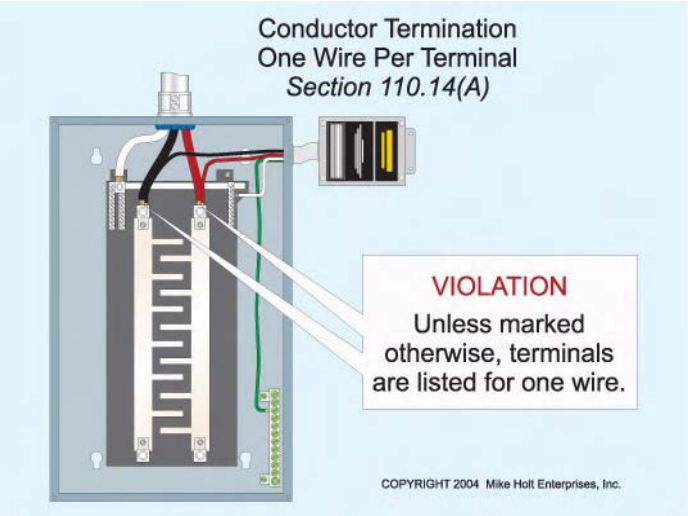

Figure 110–21

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 110–22

Split-bolt connectors for aluminum-to-aluminum or aluminum-to-copper conductors must be identified as suitable for the application.

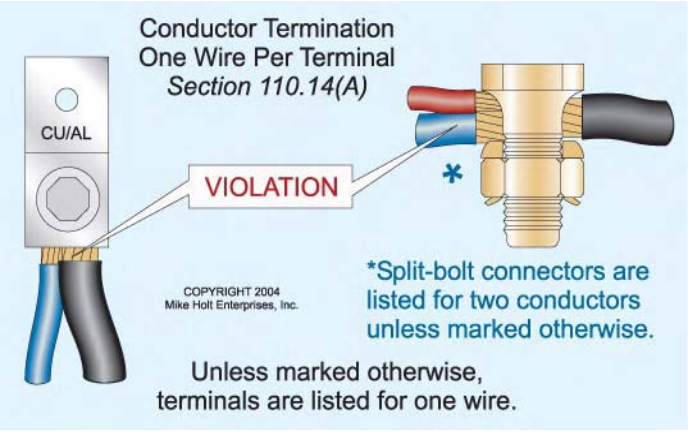

Figure 110–22

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

AUTHOR'S COMMENT: Conductors are not required to be twisted together prior to the installation of a twist-on wire connector. Figure 110–23

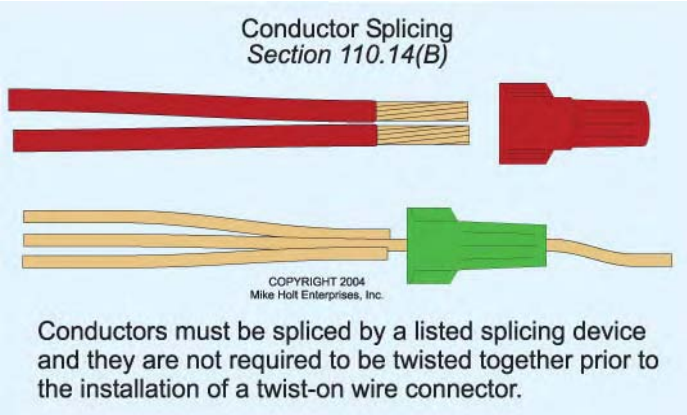

Figure 110–23

Splices, joints, and the free ends of all conductors must be covered with insulation that is equal to that of the conductor.

AUTHOR'S COMMENTS:

- Circuit conductors not being used are not 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 110–24
- See Article 100 for the definition of "Energized."

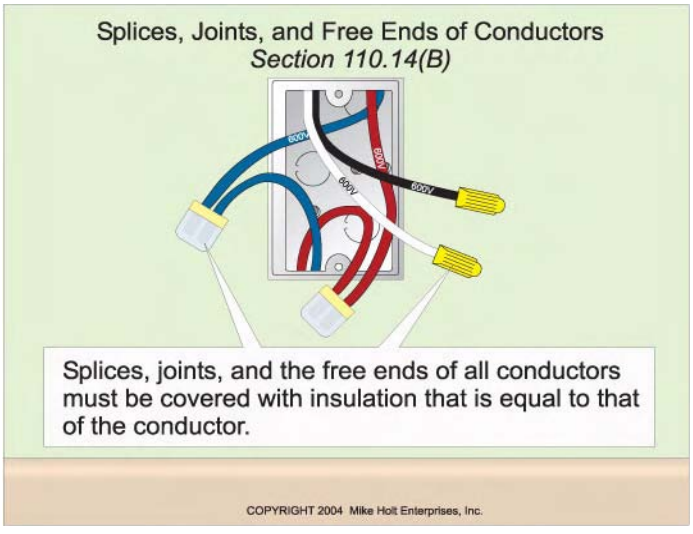

Figure 110–24

Underground Splices: Single Conductors: Single direct burial conductors of Type UF or USE can be spliced underground without a junction box, but the conductors must be spliced with a device that is listed for direct burial. See 300.5(E) and 300.15(G). Figure 110–25

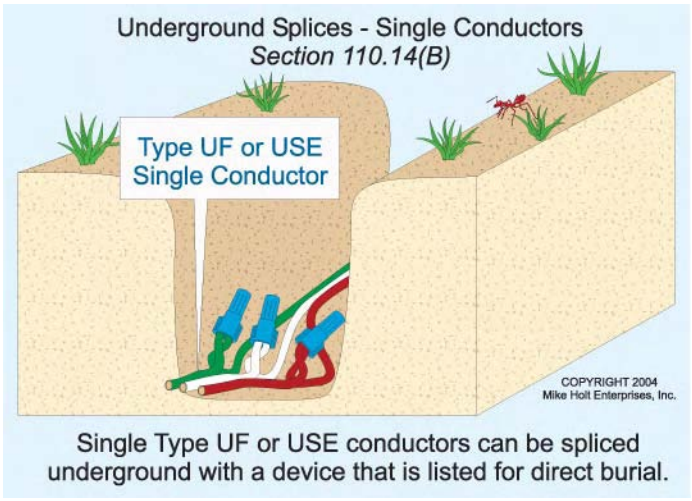

Figure 110–25

Multiconductor Cable: Multiconductor Type UF or Type USE cable can have the individual conductors spliced underground with a listed splice kit that encapsulates the conductors and the cable jacket.

(C) Temperature Limitations (Conductor Size). Conductors are to be sized to the lowest temperature rating of any terminal, device, or conductor of the circuit in accordance with (1) for terminals of equipment, and (2) for independent pressure connectors on a bus.

Conductor Ampacity. Conductors with insulation temperature ratings higher than the termination's temperature rating can be used for conductor ampacity adjustment, correction, or both.

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Ampacity."
- This means that conductor ampacity must be based on the conductor's insulation temperature ratings listed in Table 310.16, as adjusted for ambient temperature correction factors, conductor bundling adjustment factors, or both. This means that conductor ampacity, when required to be adjusted, is based on the conductor insulation temperature rating in accordance with Table 310.16. For example, the ampacity of each 12 THHN conductor is 30A, based on the values listed in the 90°C column of Table 310.16.

If we bundle nine current-carrying 12 THHN conductors in the same raceway or cable, the ampacity for each conductor (30A at 90°C, Table 310.16) needs to be adjusted by a 70 percent adjustment factor [Table 310.15(B)(2)(a)]. Figure 110–26

Adjusted Conductor Ampacity = 30A x 0.70
Adjusted Conductor Ampacity = 21A

See *necdigest* magazine, winter 2003 issue, page 32, and the *NEC Handbook*, 310.15(B)(2)(a) Ex. 5, for examples of 90°C ampacity for conductor ampacity adjustment.

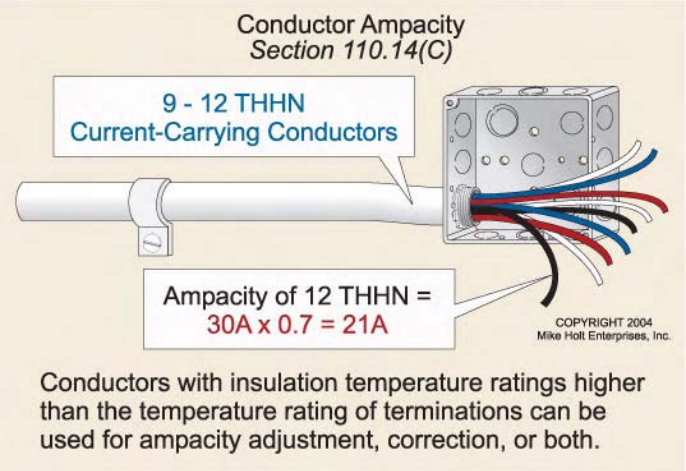

Figure 110–26

(1) Equipment Provisions. Unless the equipment is listed and marked otherwise, conductor sizing for equipment termination must be based on Table 310.16 in accordance with (a) or (b):

(a) Equipment Rated 100A and Less.

(1) Conductor sizing for equipment rated 100A or less must be sized using the 60°C temperature column of Table 310.16. Figure 110–27

AUTHOR'S COMMENT: Conductors are sized to prevent the overheating of terminals, in accordance with listing standards. For example, a 50A circuit with 60°C terminals requires the circuit conductors to be sized not smaller than 6 AWG, in accordance with the 60°C ampacity listed in Table 310.16. However, an 8 THHN insulated conductor has a 90°C ampacity of 50A, but 8 AWG cannot be used for this circuit because the conductor's operating temperature at full-load ampacity (50A) will be near 90°C, which is well in excess of the 60°C terminal rating. Figure 110–28

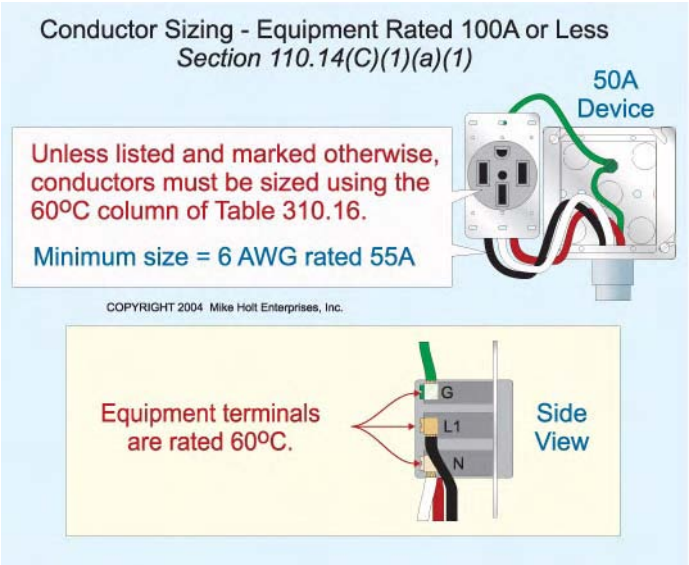

Figure 110–27

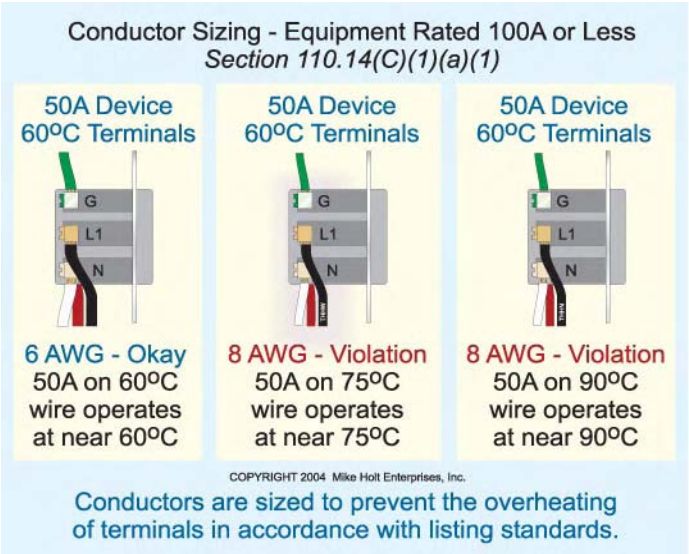

Figure 110–28

(2) Conductors with an insulation temperature rating greater than 60°C, such as THHN, which is rated 90°C, can be used on terminals that are rated 60°C, but the conductor must be sized based on the 60°C temperature column of Table 310.16. Figure 110–29A

(3) If the terminals are listed and identified as suitable for 75°C, then conductors rated at least 75°C can be sized to the 75°C temperature column of Table 310.16. Figure 110–29B

(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.

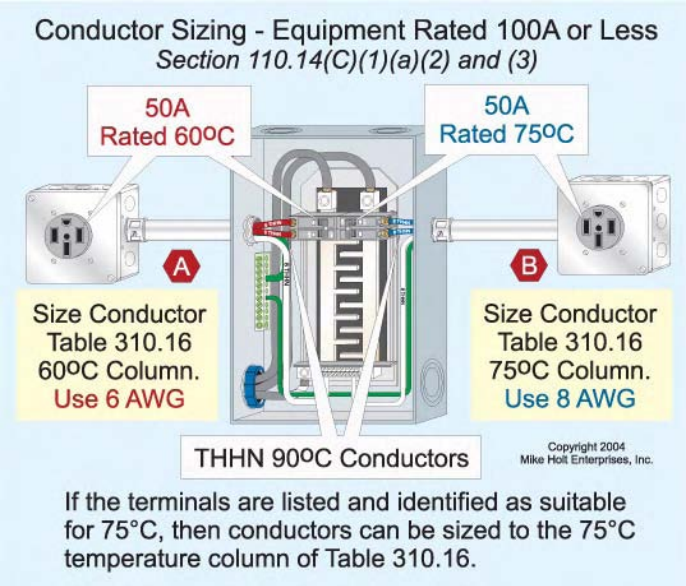

Figure 110–29

(b) Equipment Rated Over 100A.

(1) Conductors for equipment rated over 100A must be sized based on the 75°C temperature column of Table 310.16. Figure 110–30

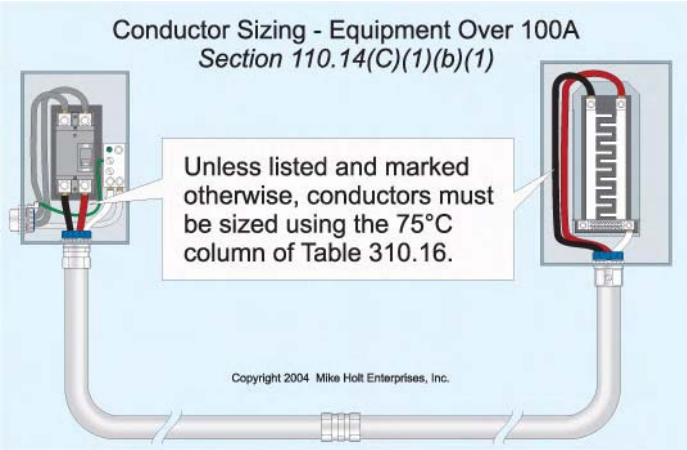

Figure 110–30

(2) Conductors with an insulation temperature rating greater than 75°C can be used on terminals that are rated 75°C, but the conductor must be sized based on the 75°C temperature column of Table 310.16. Figure 110–31

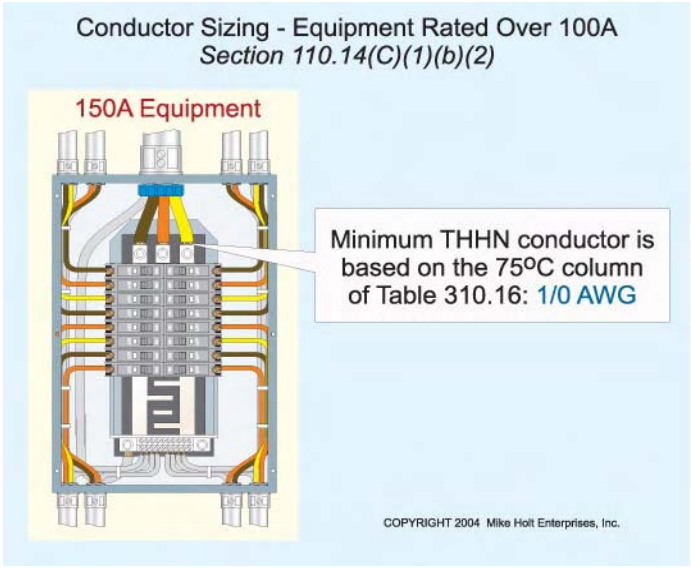

Figure 110–31

(2) Separate Connector Provisions. Conductors can be sized to the 90°C ampacity rating of THHN, if the conductor terminates to a bus connector that is rated 90°C. Figure 110–32

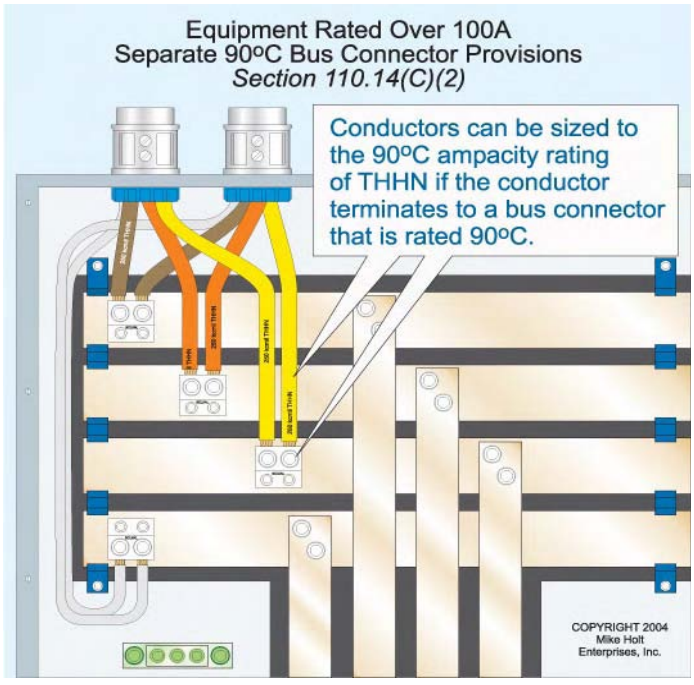

Figure 110–32

10 110.16 Flash Protection Warning

Switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers in commercial and industrial occupancies that are likely to require examination, adjustment, servicing, or maintenance while energized must be field marked to warn qualified persons of the danger associated with an arc flash from line-to-line or ground faults. The field marking must be clearly visible to qualified persons before they examine, adjust, service, or perform maintenance on the equipment. Figure 110–34

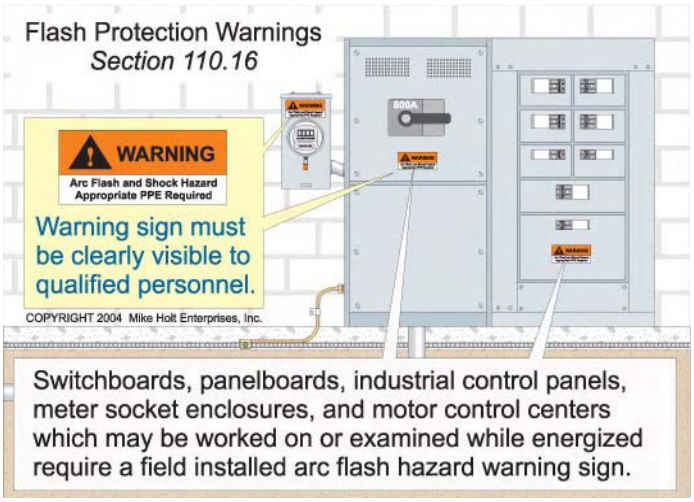

Figure 110–34

AUTHOR'S COMMENTS:

- See Article 100 for the definitions of "Panelboard" and "Qualified Persons."
- This rule is meant to warn qualified persons who work on energized electrical systems that an arc flash hazard exists so they will select proper personal protective equipment (PPE) in accordance with industry accepted safe work practice standards.

FPN No. 1: NFPA 70E, *Standard for Electrical Safety in the Workplace*, provides assistance in determining the severity of potential exposure, planning safe work practices, and selecting personal protective equipment.

AUTHOR'S COMMENT: In some installations, the use of current-limiting protection devices may significantly reduce the degree of arc flash hazards. For more information about flash protection, visit http://bussmann.com/safetybasics. Figure 110–35

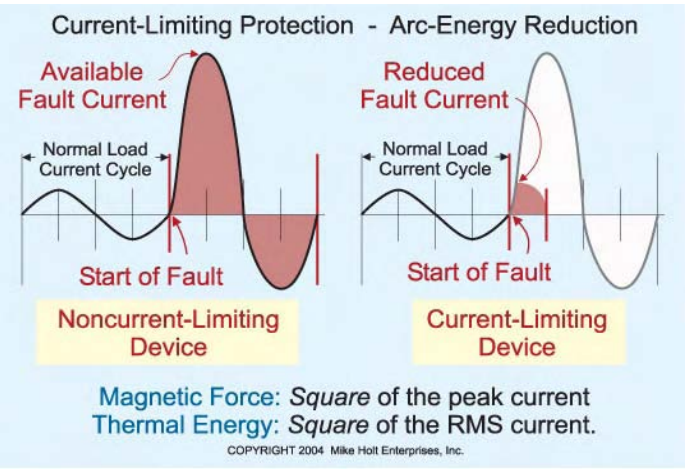

Figure 110–35

11 110.26 Spaces About Electrical Equipment

For the purpose of safe operation and maintenance of equipment, sufficient access and working space must be provided. Enclosures housing electrical apparatus that are controlled by locks are considered accessible to qualified persons who require access. Figure 110–37

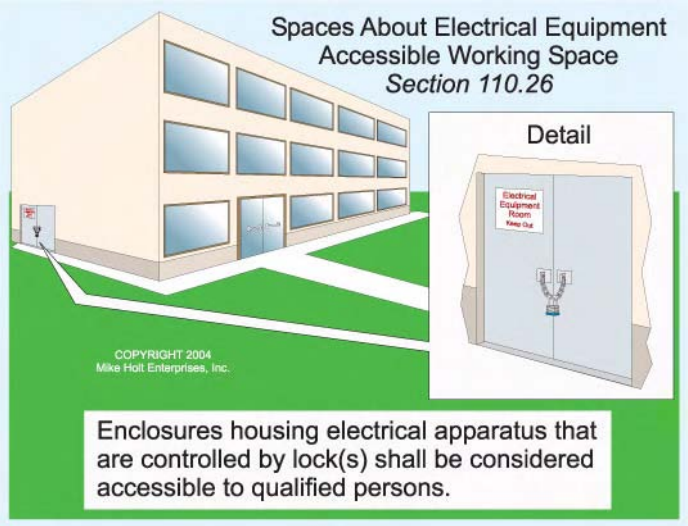

Figure 110–37

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Accessible" as it applies to equipment.
- It might be unwise to use an electrically operated lock, if it locks in the de-energized condition!

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

AUTHOR'S COMMENT: The phrase "while energized" is the root of many debates. Since electric power to almost all equipment can be turned off, one could argue that working space is never required!

(1) Depth of Working Space. The step-back working space, measured from the enclosure front must not be less than the distances contained in Table 110.26(A)(1). Figure 110–38

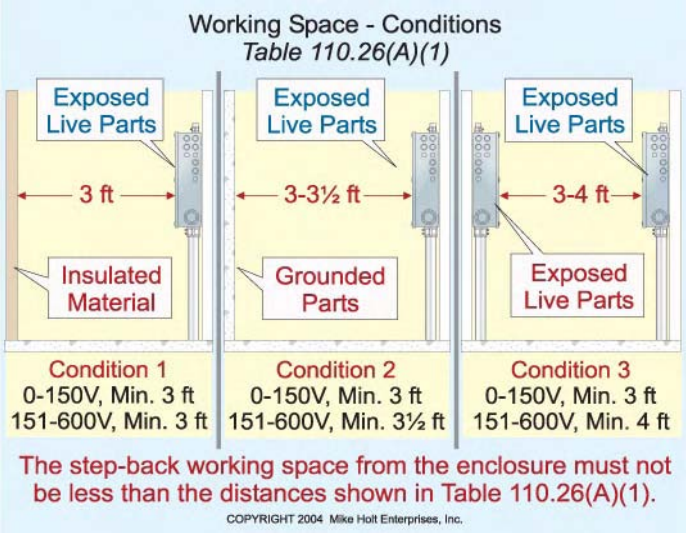

Figure 110–38

Table 110.26(A)(1) Step-Back Working Space

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

- **Condition 1**—Exposed live parts on one side of the working space and no live or grounded parts on the other side of the working space.
- **Condition 2**—Exposed live parts on one side of the working space and grounded parts on the other side of the working space. For this table, concrete, brick, or tile walls are considered grounded.
- **Condition 3**—Exposed live parts on both sides of the working space.

(a) Rear and Sides. Step-back working space isn't required for the back or sides of assemblies where all connections are accessible from the front. Figure 110–39

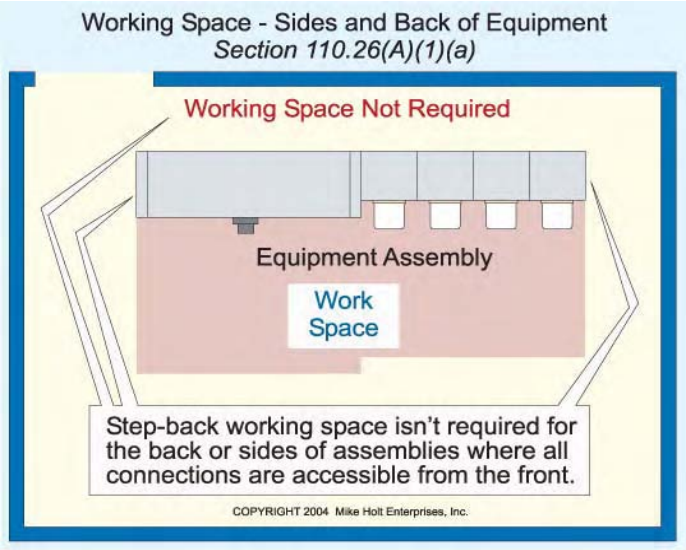

Figure 110–39

(b) Low Voltage. Where 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 smaller than the distance in Table 110.26(A)(1). Figure 110–40

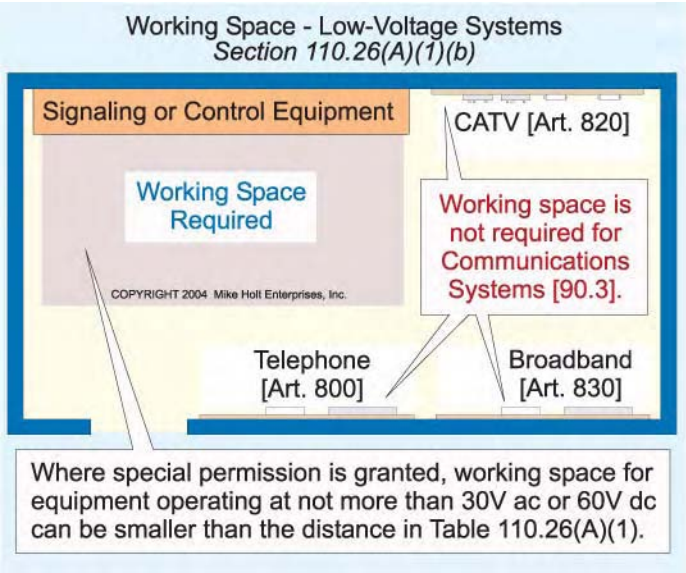

Figure 110–40

AUTHOR'S COMMENT: See Article 100 for the definition of "Special Permission."

(c) Existing Buildings. Where electrical equipment is being replaced, Condition 2 working clearance is permitted between dead-front switchboards, 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 to be open at the same time and only authorized, qualified persons will service the installation.

AUTHOR'S COMMENT: The step-back working space requirements of 110.26 do not apply to equipment included in Chapter 8 Communications Circuits [90.3]. See Figure 110–40.

(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 110–41

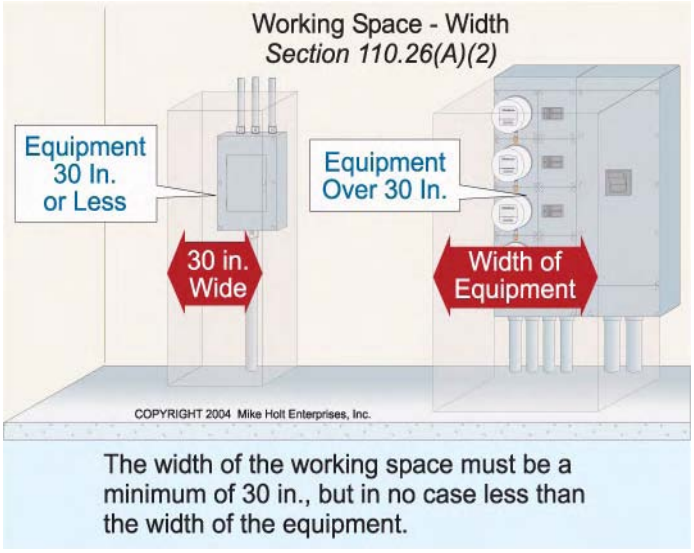

Figure 110–41

AUTHOR'S COMMENT: The width of the working space can be measured from left-to-right, from the right-to-left, or simply centered on the equipment. Figure 110–42

In all cases, the working space must be of sufficient width, depth, and height to permit all equipment doors to open 90°. Figure 110–43

AUTHOR'S COMMENT: Working space can overlap the working space for other electrical equipment.

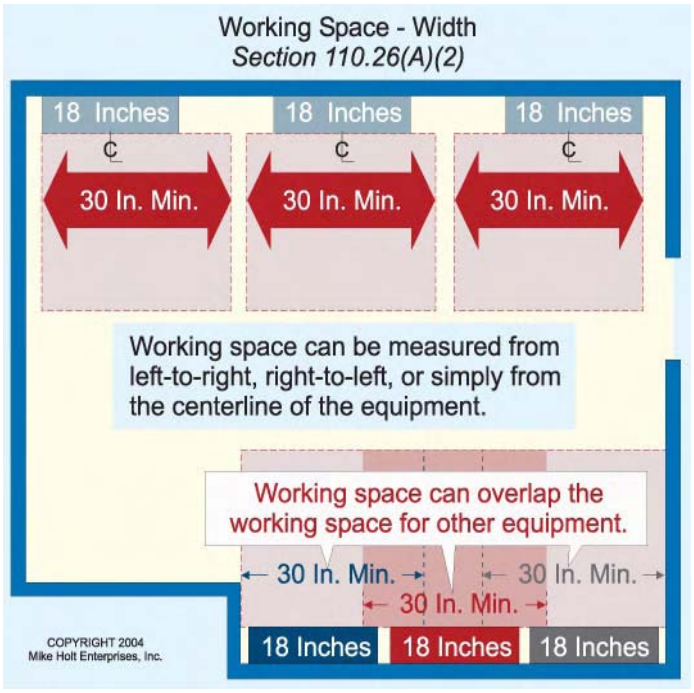

Figure 110–42

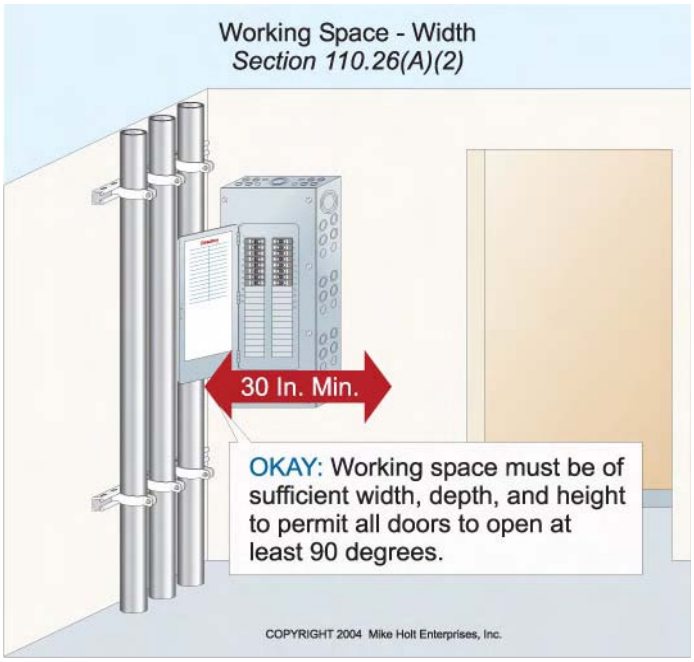

Figure 110–43

(3) Height of Working Space (Headroom). For service equipment, switchboards, panelboards, and motor control equipment, the height of working space in front of equipment must not be less than 6½ ft, measured from the grade, floor, or platform [110.26(E)].

Equipment such as raceways, cables, wireways, cabinets, panels, etc., can be located above or below electrical equipment, but it must not extend more than 6 in. into the equipment's working space. Figure 110–44

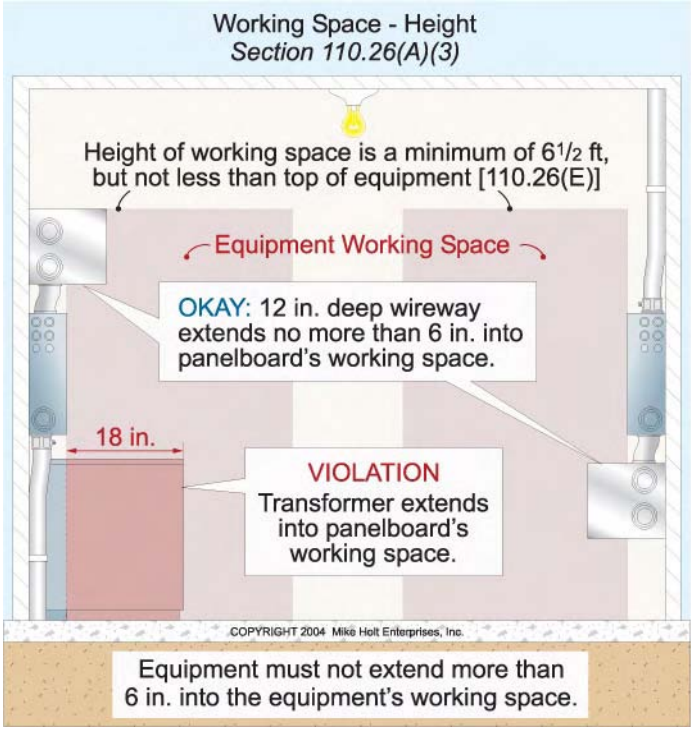

Figure 110–44

(B) Clear Working Space. The working space required by this section must be clear at all times. Therefore, this space is not permitted for storage.

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 about, around, over, or under bicycles, boxes, crates, appliances, and other impediments.* Figure 110–45

AUTHOR'S COMMENT: Signaling and communications equipment must not be installed to encroach on the working space of the electrical equipment. Figure 110–46

(C) Entrance to Working Space.

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

AUTHOR'S COMMENT: Check to see what the authority having jurisdiction considers "sufficient area."

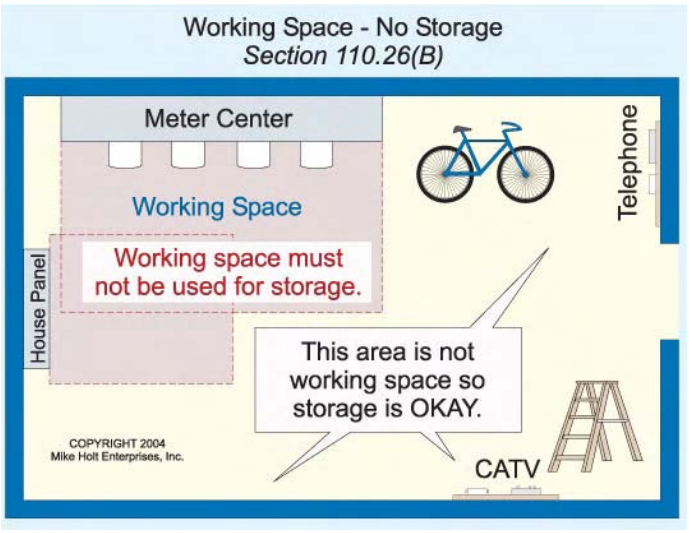

Figure 110–45

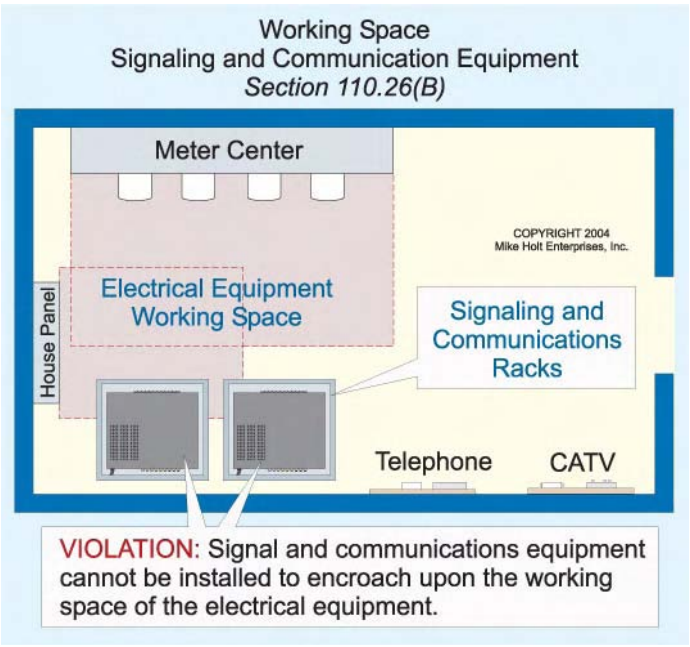

Figure 110–46

(2) Large Equipment. For equipment rated 1,200A or more, an entrance measuring not less than 24 in. wide and 6½ ft high is required at each end of the working space. Where the entrance to the working space has a door, the door must open out and be equipped with panic hardware or other devices that open under simple pressure. Figure 110–47

AUTHOR'S COMMENT: Since this requirement is in the *NEC*, the electrical contractor is responsible for ensuring that panic hardware is installed where required. Some electrical contractors are offended at being held liable for nonelectrical responsibilities, but this rule should be a little less offensive, given that it's

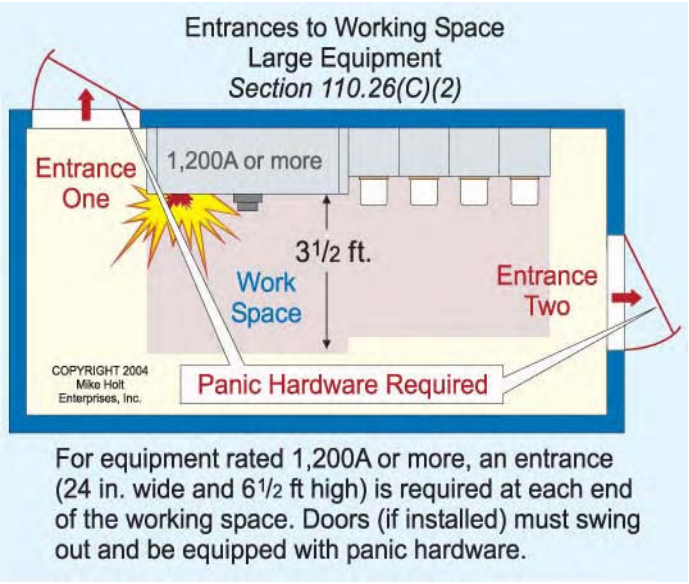

Figure 110–47

designed to save electricians' lives. 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.

A single entrance to the required working space is permitted where either of the following conditions is met.

(a) Unobstructed Exit. Only one entrance is required where the location permits a continuous and unobstructed way of exit travel.

(b) Double Workspace. Only one entrance is required where the required working space is doubled, and the equipment is located so the edge of the entrance is no closer than the required working space distance. Figure 110–48

(D) Illumination. Service equipment, switchboards, panelboards, as well as motor control centers located indoors must have illumination located in or next to the working space. Illumination must not be controlled by automatic means only. Figure 110–49

(E) Headroom. For service equipment, panelboards, switchboards, or motor control centers, the minimum working space headroom must not be less than 6½ ft. When the height of the equipment exceeds 6½ ft, the minimum headroom must not be less than the height of the equipment.

Exception: 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 Article 100 for the definition of "Dwelling Unit."

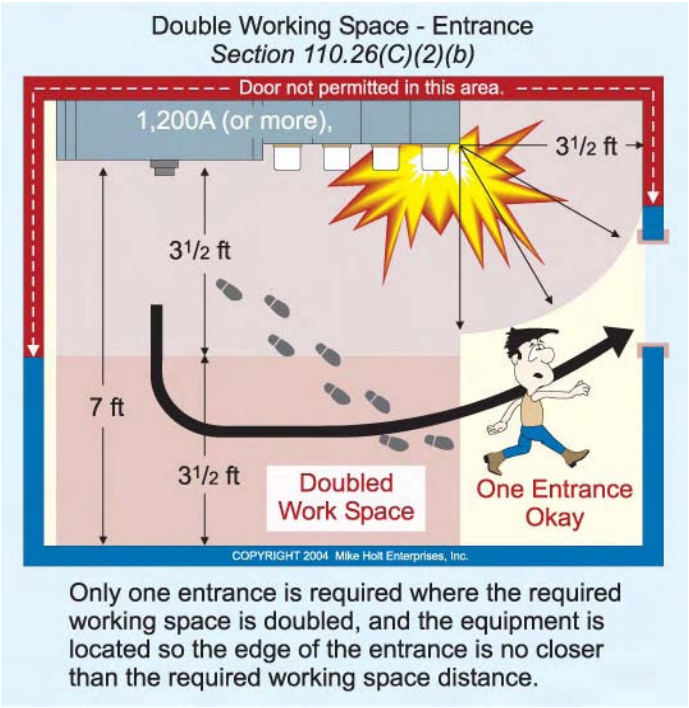

Figure 110–48

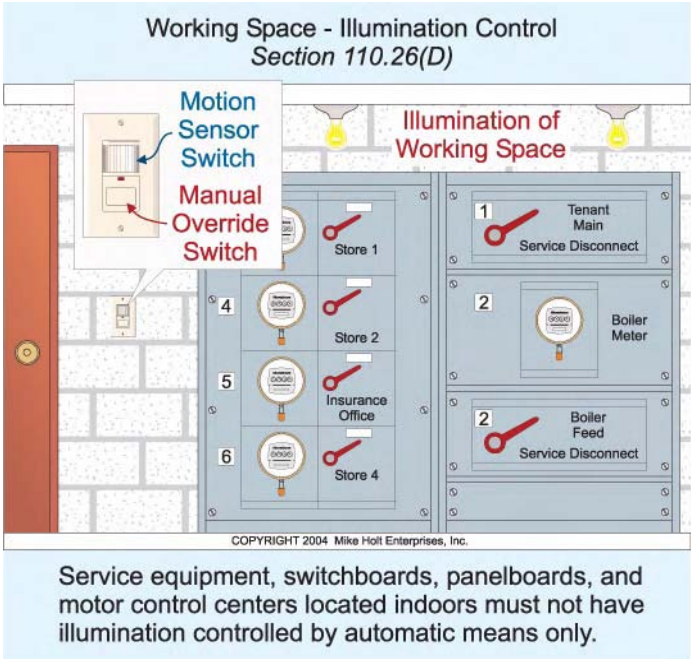

Figure 110–49

(F) Dedicated Equipment Space. Switchboards, panelboards, distribution boards, and motor control centers must comply with the following:

(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. No piping, duct, or other equipment foreign to the electrical installation can be installed in this dedicated footprint space. Figure 110–50

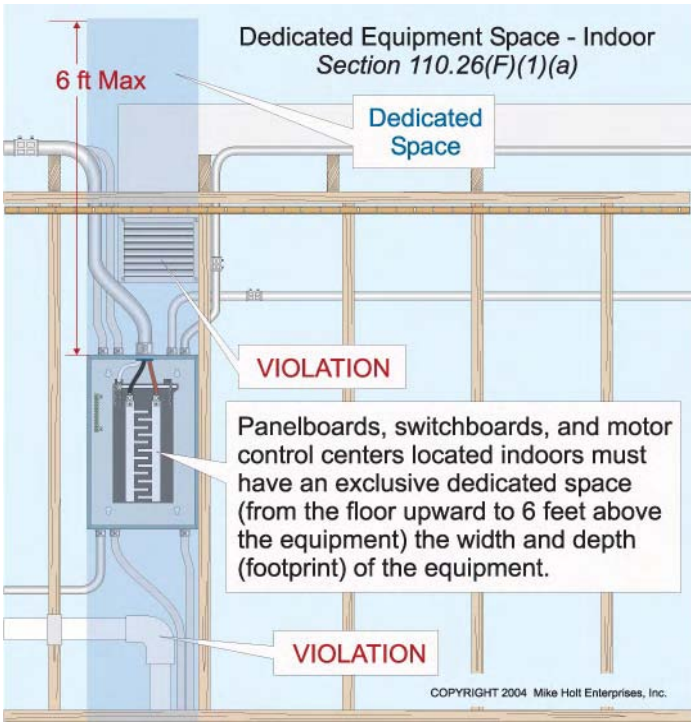

Figure 110–50

Exception: Suspended ceilings with removable panels can be within the dedicated footprint space.

> **AUTHOR'S COMMENT:** Electrical raceways and cables not associated with the dedicated space can be within the dedicated space. It isn't considered "equipment foreign to the electrical installation." See *necdigest* magazine, winter 2003, page 30. Figure 110–51

(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. Figure 110–52

(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.

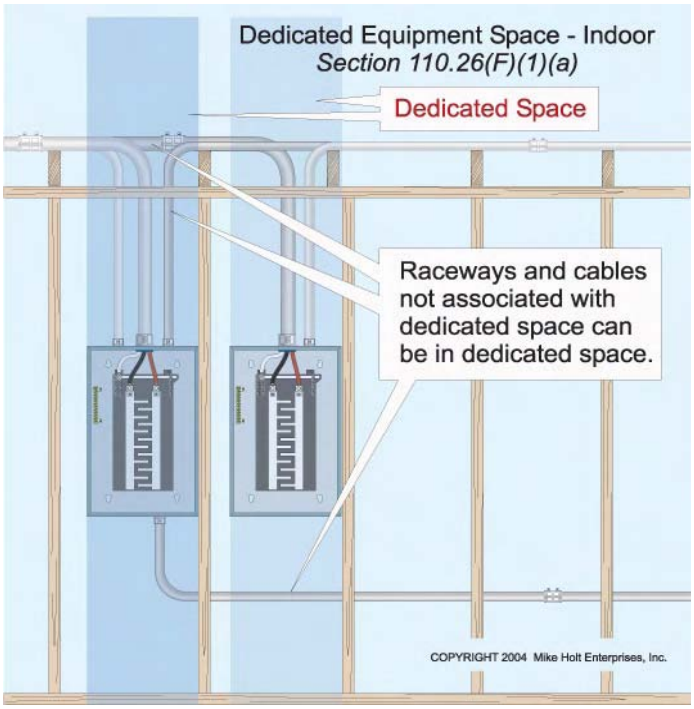

Figure 110–51

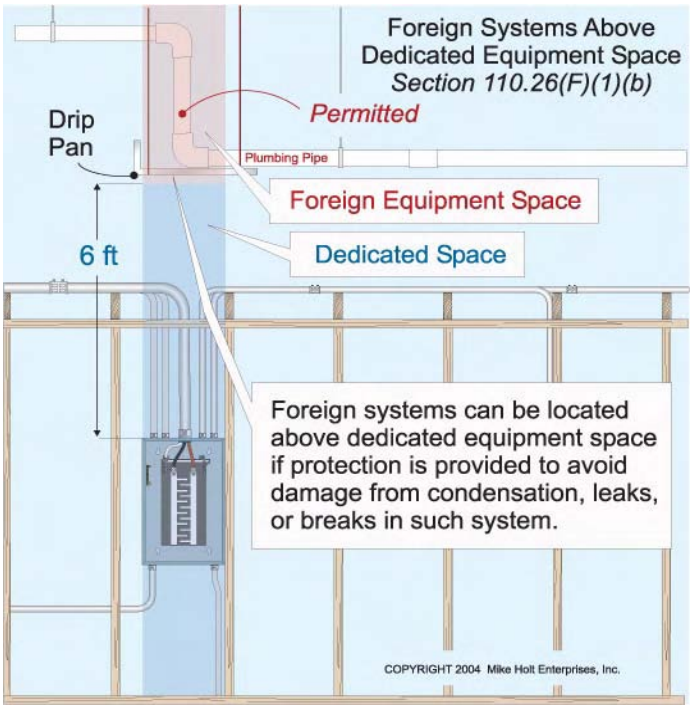

Figure 110–52

ARTICLE 200 Use and Identification of Grounded Neutral Conductors

Introduction

This Article contains requirements for identification of grounded (neutral) conductors and equipment terminals to which they connect.

200.6 Identification of the Grounded Neutral Conductor

(A) 6 AWG or Smaller. grounded neutral conductors 6 AWG and smaller must be identified by a continuous white or gray outer finish along their entire length, or by any color insulation (except green) with three white stripes, or by white or gray insulation with any color stripes (except green). Figure 200–5

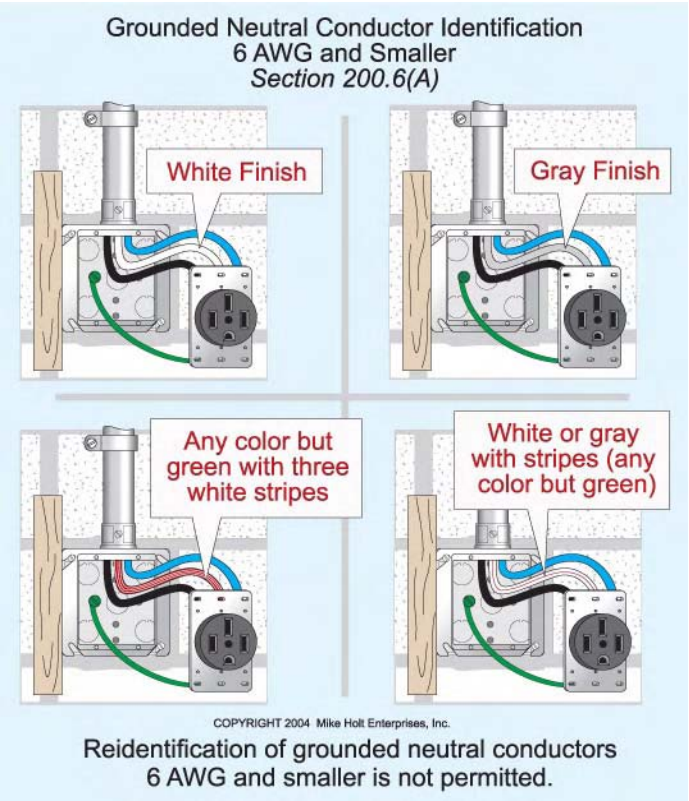

Figure 200–5

AUTHOR'S COMMENT: The use of white tape, paint, or other methods of identification isn't permitted for conductors 6 AWG or smaller. Figure 200–6

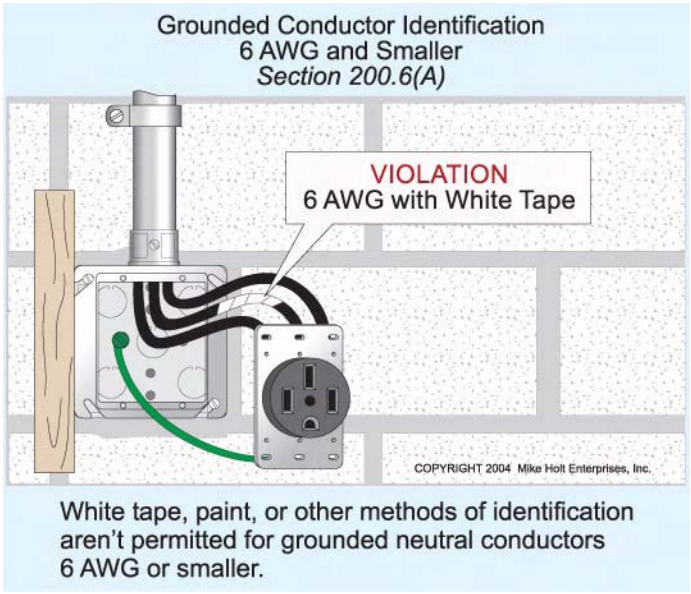

Figure 200–6

(B) Larger than 6 AWG. grounded neutral conductors larger than 6 AWG must be identified by one of the following means: Figure 200–7

(1) A continuous white or gray outer finish along its entire length

(2) Three continuous white stripes along its length

(3) White or gray tape or paint at terminations.

(D) Grounded Neutral Conductors of Different Systems. Where grounded neutral conductors of different wiring systems are installed in the same raceway, cable, or enclosure, each grounded neutral conductor must be identified to distinguish the systems by one of the following means:

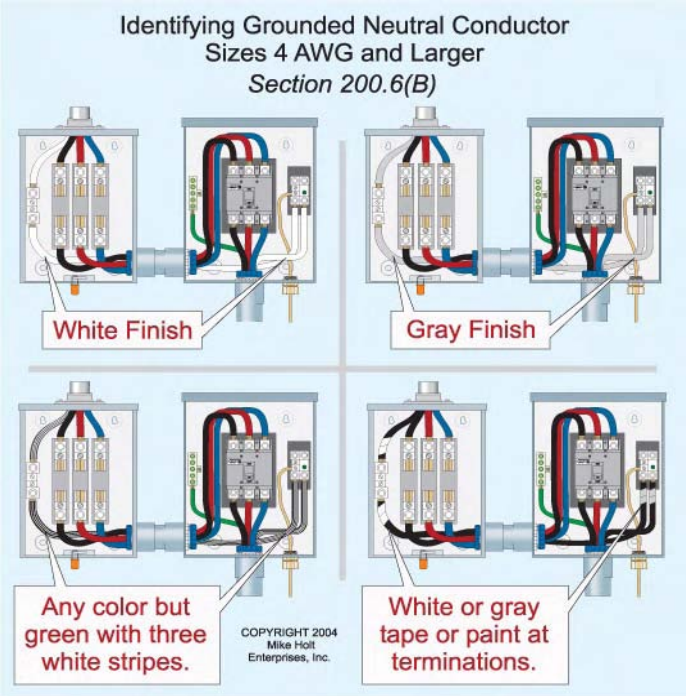

Figure 200–7

(1) One system grounded neutral conductor must have an outer covering conforming to 200.6(A) or 200.6(B). Figure 200–8

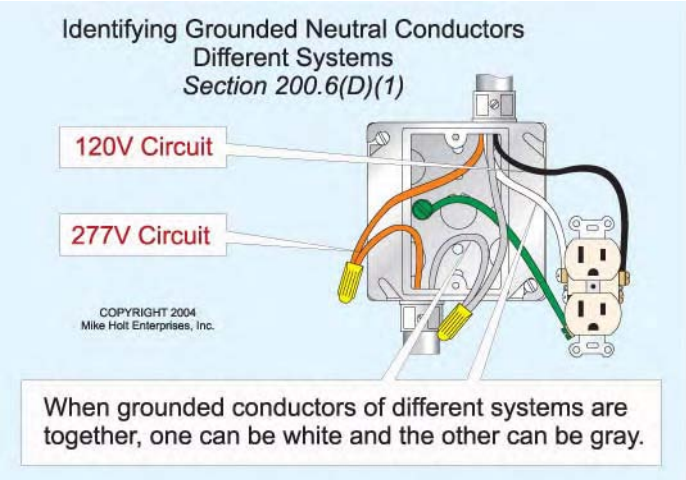

Figure 200–8

AUTHOR'S COMMENT: This means that you can use either white or gray to identify the grounded neutral conductor of a single wiring system.

(2) The grounded neutral conductor of the other system must have a different outer covering conforming to either 200.6(A) or 200.6(B). Figure 200–9

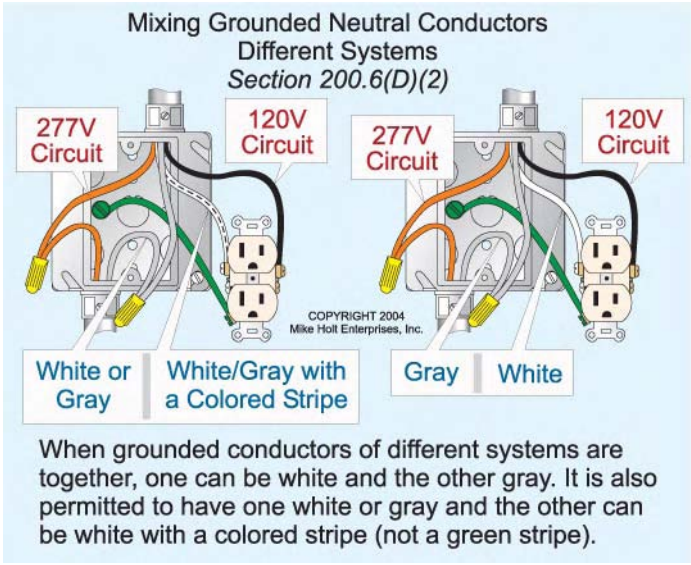

Figure 200–9

Or the grounded neutral conductor of the other system must have an outer covering of white or gray with a readily distinguishable, different colored stripe other than green running along the insulation.

(3) Other and different means of identification, as permitted by 200.6(A) or (B), that will distinguish each system grounded neutral conductor.

AUTHOR'S COMMENT: I guess this means get creative! But remember, you have to have the identification means approved by the authority having jurisdiction.

This means of identification must be permanently posted at each branch-circuit panelboard. Figure 200–10

AUTHOR'S COMMENT: Where a premise has branch circuits supplied from more than one voltage system, each ungrounded conductor must be identified by system [210.5(C)].

FPN: Care should be taken when working on existing systems because a gray insulated conductor may have been used in the past as an ungrounded (hot) conductor.

13 200.7 Use of White or Gray Color

(C) Circuits Over 50V. A conductor with white insulation can only be used for the ungrounded conductor as permitted in (1), (2), and (3) below.

(1) Cable Assembly. The white conductor within a cable can be used for the ungrounded conductor if permanently reiden-

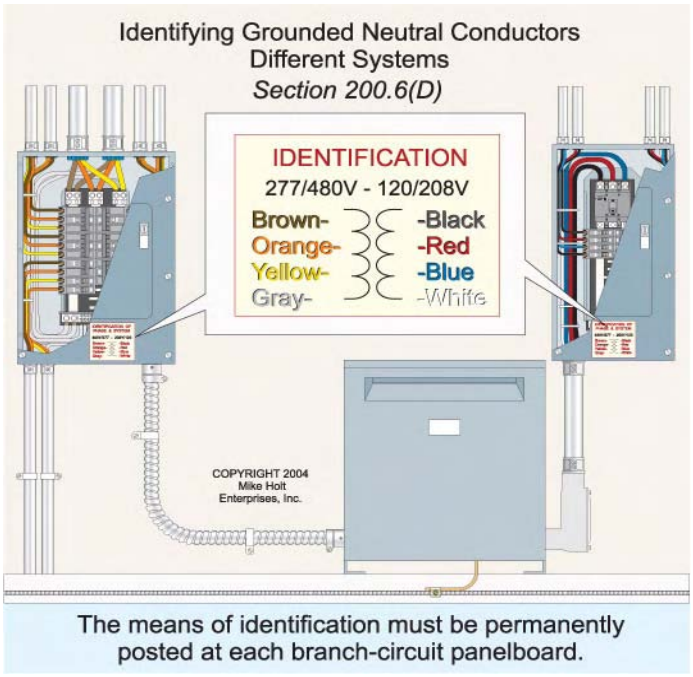

Figure 200–10

tified at each location where the conductor is visible to indicate its use as an ungrounded conductor. Identification must encircle the insulation and must be a color other than white, gray, or green. Figure 200–11

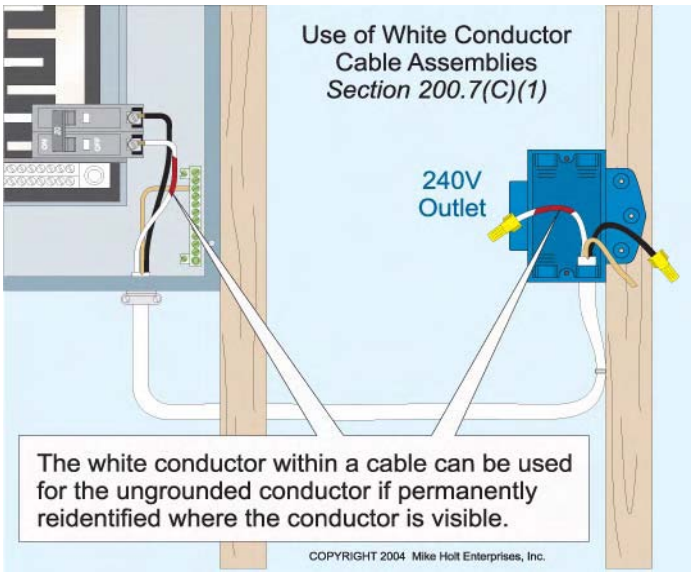

Figure 200–11

(2) Switches. The white conductor within a cable can be used for single-pole, 3-way or 4-way switch loops if permanently identified at each location where the conductor is visible to indicate its use as an ungrounded conductor. Figure 200–12

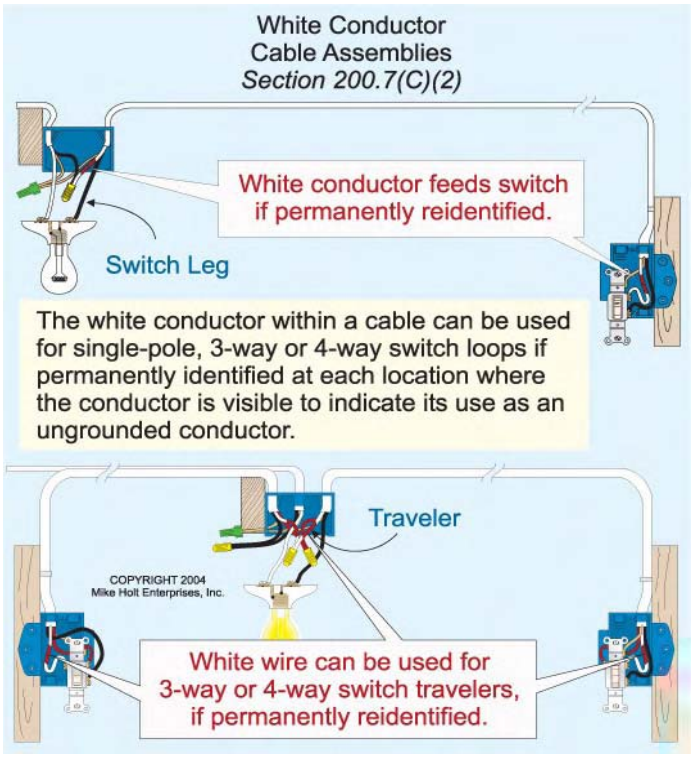

Figure 200–12

(3) Flexible Cord. The white conductor within a flexible cord can be used for the ungrounded conductor for connecting an appliance or equipment permitted by 400.7.

FPN: Care should be taken when working on existing systems because a gray insulated conductor may have been used in the past as an ungrounded (hot) conductor.

AUTHOR'S COMMENT: The *NEC* doesn't permit the use of white or gray conductor insulation for ungrounded conductors in a raceway, even if the conductors are permanently reidentified. Figure 200–13

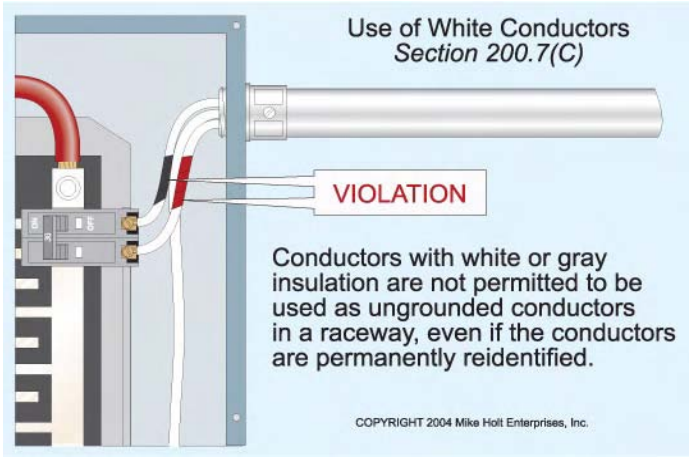

Figure 200–13

ARTICLE 210 Branch Circuits

Introduction

This Article contains requirements for branch circuits. These include conductor sizing, required branch circuits, GFCI protection of receptacles, and receptacle and lighting outlet requirements.

14 210.3 Branch-Circuit Rating

The rating of a branch circuit is determined by the rating of the branch-circuit overcurrent protection device, not the conductor size.

AUTHOR'S COMMENT: For example, the branch-circuit ampere rating of 10 THHN (rated 30A at 60°C in Table 310.16) on a 20A circuit breaker is 20A. Figure 210–2

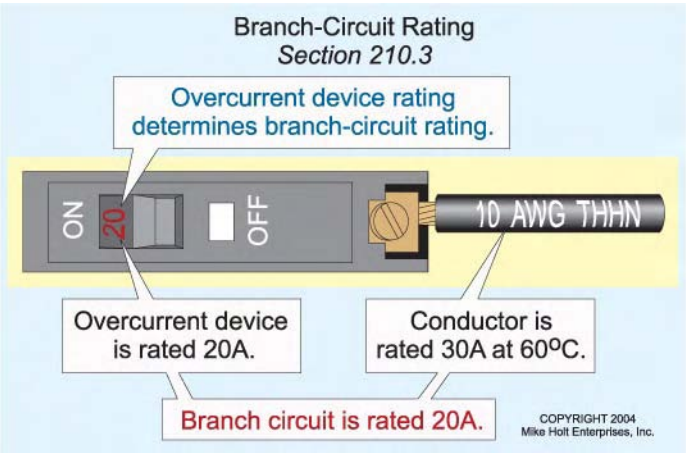

Figure 210–2

15 210.4 Multiwire Branch Circuits

(A) General. A multiwire branch circuit can be considered a single circuit or a multiple circuit.

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Multiwire Branch Circuit."
- Two small-appliance circuits are required for receptacles that serve countertops in dwelling unit kitchens [210.11(C)(1) and 210.52(B)]. One 3-wire, single-phase, 120/240V branch circuit could be used for this purpose. In such a case it's considered a multiwire branch circuit.

To prevent inductive heating and to reduce conductor impedance for fault currents, all multiwire branch-circuit conductors must originate from the same panelboard or distribution equipment.

AUTHOR'S COMMENT: For more information on inductive heating of metal parts, see 300.3(B), 300.5(I), and 300.20.

FPN: Unwanted and potentially hazardous harmonic currents can cause additional heating of the neutral conductor of a 4-wire three-phase 120/208V or 277/480V wye-connected system, which supplies nonlinear loads. To prevent fire or equipment damage from excessive harmonic neutral current, the designer should consider: (1) increasing the size of the neutral conductor, or (2) installing a separate neutral for each phase. Also see 220.61(C)(2) FPN 2, and 310.15(B)(4)(c). Figure 210–3

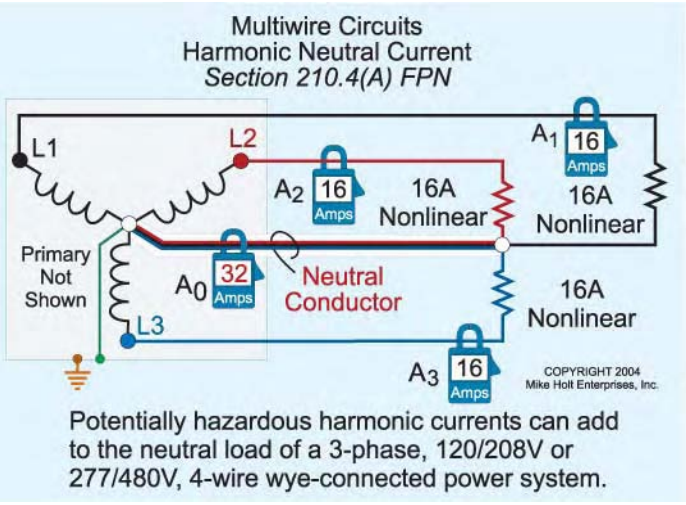

Figure 210–3

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Nonlinear Load."
- For more information, please visit www.MikeHolt.com. Click on "Technical Information" on the left side of the page, and then select "Power Quality."

(B) Devices or Equipment. Multiwire branch circuits that supply devices or equipment on the same yoke (also called a strap) must be provided with a means to disconnect simultaneously all ungrounded conductors that supply those devices or equipment at the point where the branch circuit originates. Figure 210–4

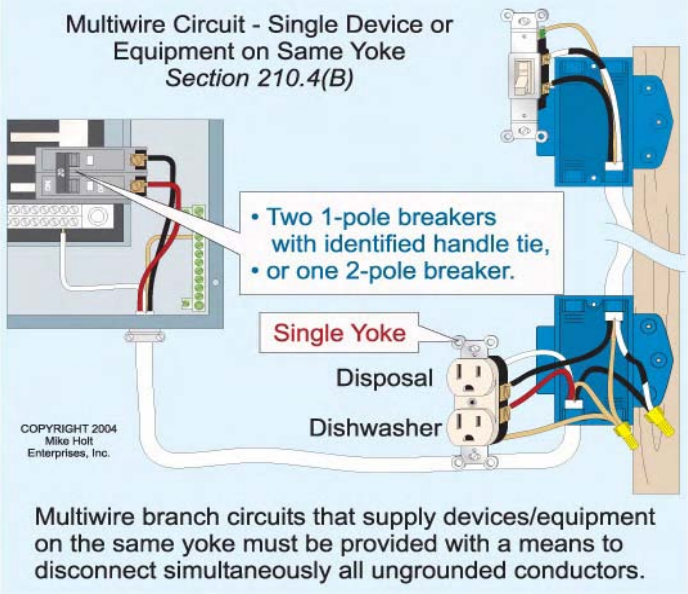

Figure 210–4

AUTHOR'S COMMENTS:

- See 210.7(B) for similar requirements for devices or equipment supplied by multiple branch circuits.
- A "yoke" is the metal mount structure for a switch, receptacle, switch and receptacle, switch and pilot light, etc. It's also known as a "strap." Figure 210–5
- Individual single-pole circuit breakers with handle ties identified for the purpose, or a breaker with common internal trip, can be used for this application [240.20(B)(1)].

CAUTION: *This rule is intended to prevent people from working on energized circuits that they thought were disconnected.*

AUTHOR'S COMMENT: Two or more branch circuits that supply devices or equipment on the same yoke must be provided with a means to disconnect simultaneously all ungrounded conductors that supply those devices or equipment [210.7(B)].

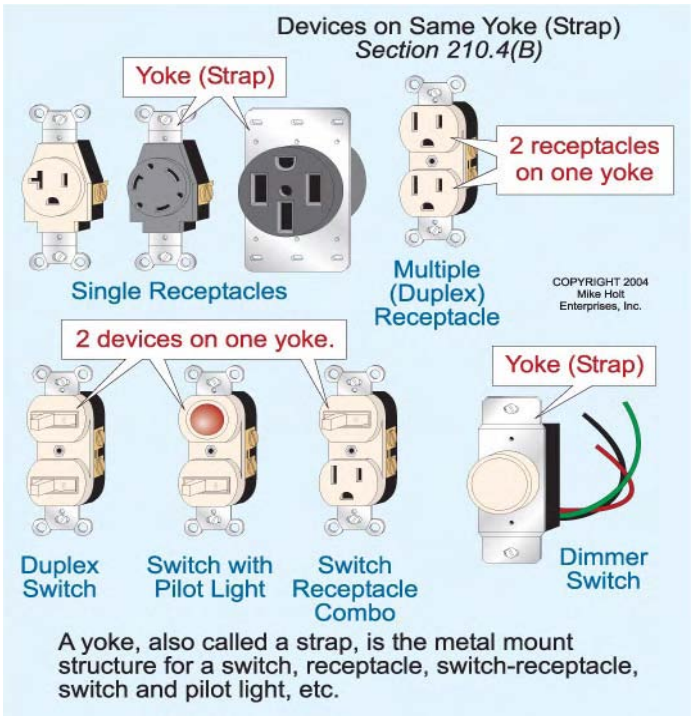

Figure 210–5

(C) Line-to-Neutral Loads. Multiwire branch circuits must supply only line-to-neutral loads.

Exception 1: A multiwire branch circuit is permitted to supply line-to-line utilization equipment, such as a range or dryer.

Exception 2: A multiwire branch circuit is permitted to supply both line-to-line and line-to-neutral loads if the circuit is protected by a device (multipole circuit breaker) that opens all ungrounded conductors of the multiwire branch circuit simultaneously (common internal trip) under a fault condition. Figure 210–6

FPN: See 300.13(B) for the requirements relating to the continuity of the grounded neutral conductor on multiwire circuits.

CAUTION: *If the continuity of the grounded neutral conductor of a multiwire circuit is interrupted (open), the resultant over- or undervoltage could cause a fire and/or destruction of electrical equipment. For details on how this occurs, see 300.13(B) in this textbook.* Figure 210–7

16 210.5 Identification for Branch Circuits

(A) Grounded Neutral Conductor. The grounded neutral conductor of a branch circuit must be identified in accordance with 200.6. Figure 210–8

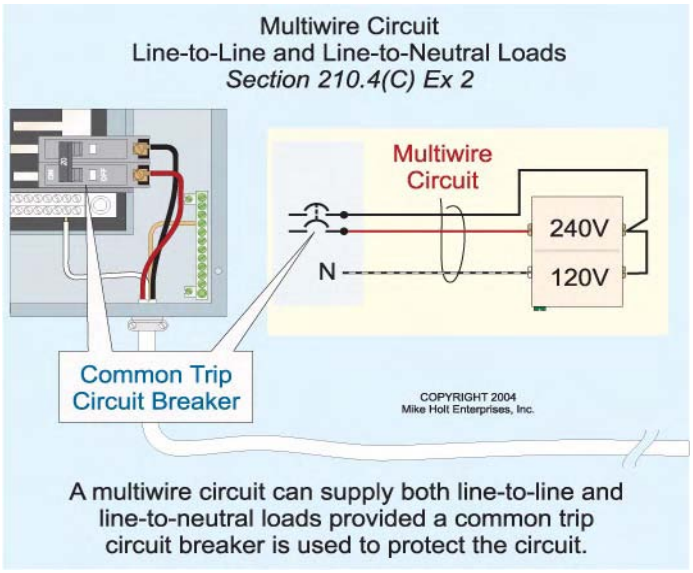

Figure 210–6

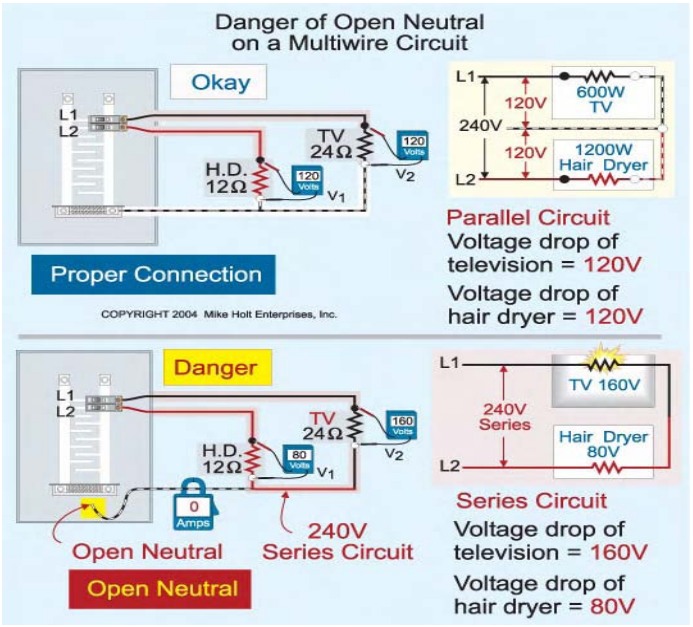

Figure 210–7

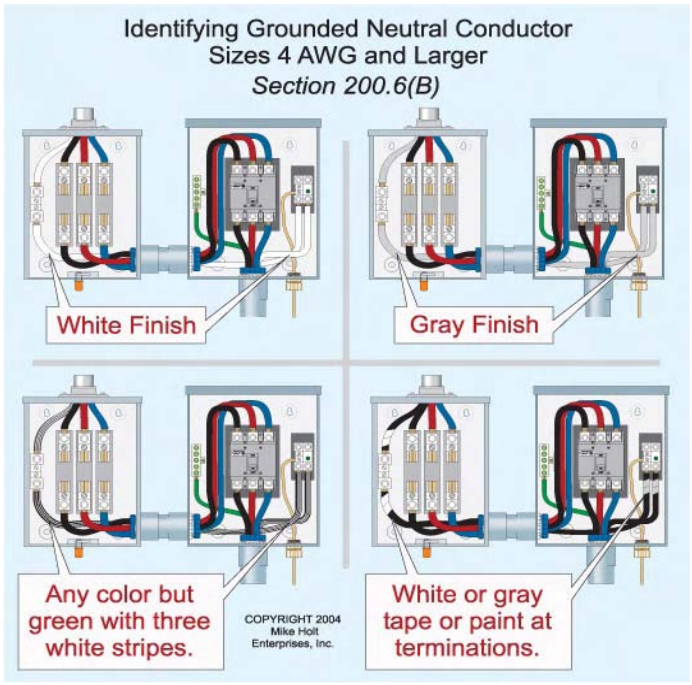

Figure 210–8

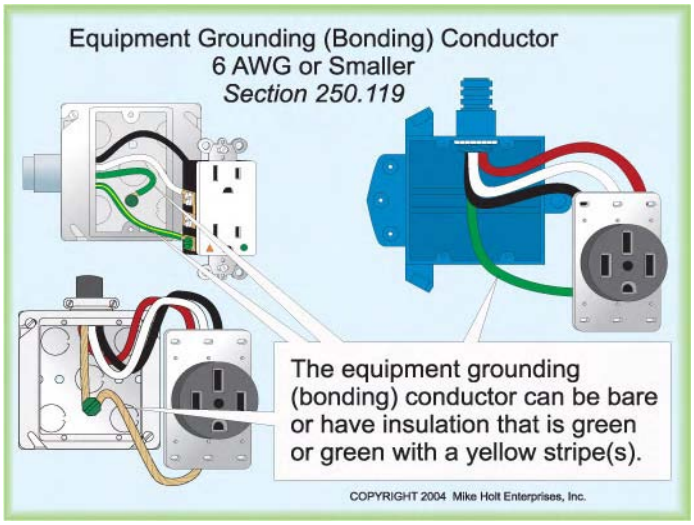

Figure 210–9

(B) Equipment Grounding (Bonding) Conductor. Equipment grounding (bonding) conductors can be bare, covered, or insulated. Insulated equipment grounding (bonding) conductors sized 6 AWG and smaller must have a continuous outer finish that is either green or green with one or more yellow stripes [250.119]. Figure 210–9

Equipment grounding (bonding) conductors larger than 6 AWG, that are insulated can be permanently reidentified with green marking at the time of installation at every point where the conductor is accessible [250.119(A)].

(C) Ungrounded Conductors. Where the premises wiring system contains branch circuits supplied from more than one voltage system, each ungrounded conductor, where accessible, must be identified by system. Identification can be by color-coding, marking tape, tagging, or other means approved by the authority having jurisdiction. Such identification must be permanently posted at each branch-circuit panelboard or branch-circuit distribution equipment. Figure 210–10

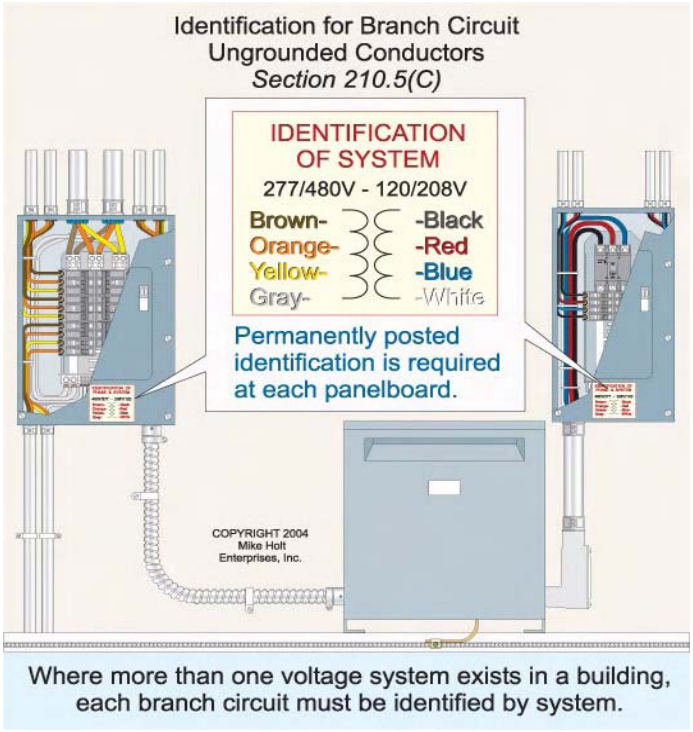

Figure 210–10

AUTHOR'S COMMENTS:

- Electricians often use the following color system for power and lighting conductor identification:
- 120/240V single-phase—black, red, and white
- 120/208V three-phase—black, red, blue, and white
- 120/240V three-phase—black, orange, blue, and white
- 277/480V three-phase—brown, orange, yellow, and gray; or, brown, purple, yellow, and gray
- Conductors with insulation that is green or green with one or more yellow stripes cannot be used for an ungrounded or grounded neutral conductor [250.119].

17 210.8 GFCI-Protected Receptacles

(A) Dwelling Units. GFCI protection is required for all 15 and 20A, 125V receptacles located in the following areas of a dwelling unit:

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "GFCI."
- Circuits are rated 120V and receptacles are rated 125V.

(1) Bathroom Area. GFCI protection is required for all 15 and 20A, 125V receptacles in the bathroom area of a dwelling unit. See 210.52(D) for acceptable locations for the required bathroom receptacle. Figure 210–13

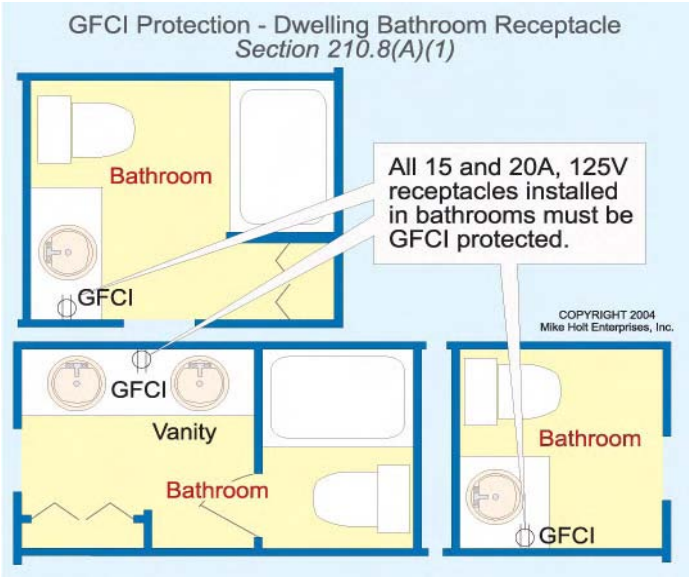

Figure 210–13

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Bathroom."
- *Code*-change proposals that would allow receptacles for dedicated equipment in the bathroom area to be exempted from the GFCI protection requirements have all been rejected because it was not in the interest of safety to allow appliances without GFCI protection in this area.

(2) Garage and Accessory Buildings. GFCI protection is required for all 15 and 20A, 125V receptacles in garages, and in grade-level portions of unfinished or finished accessory buildings used for storage or work areas of a dwelling unit. Figure 210–14

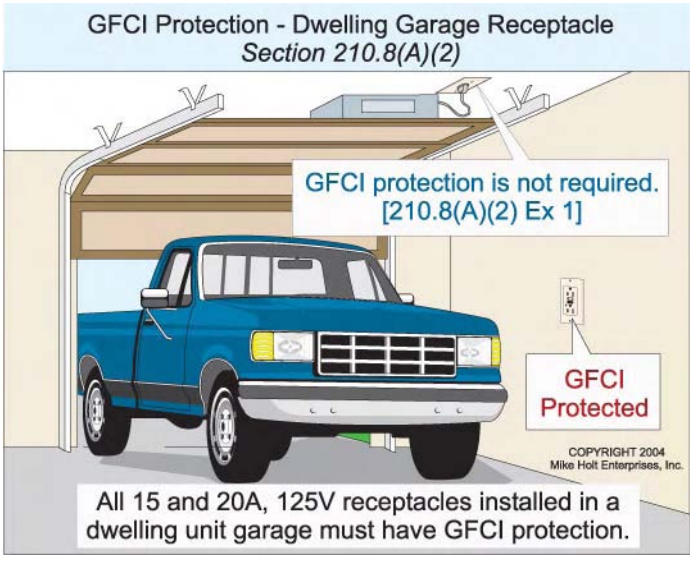

Figure 210–14

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Garage."
- A receptacle outlet is required in a dwelling unit attached garage [210.52(G)], but a receptacle outlet isn't required in an accessory building or a detached garage without power. If a 15 or 20A, 125V receptacle is installed in an accessory building, it must be GFCI protected. Figure 210–15

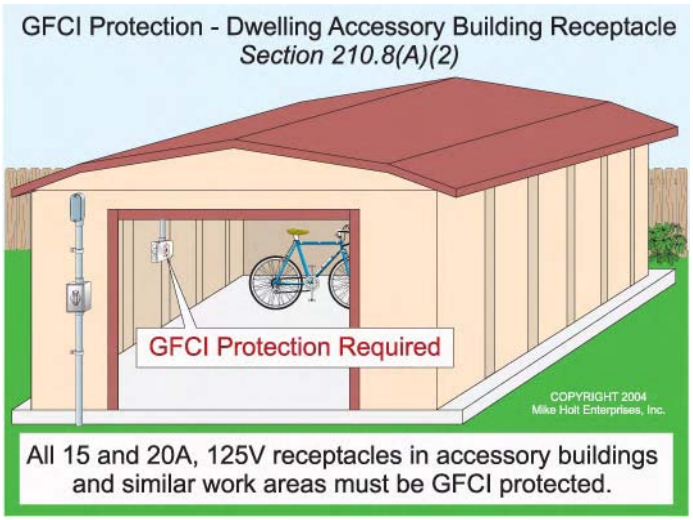

Figure 210–15

Exception 1: GFCI protection isn't required for receptacles that aren't readily accessible, such as those located in the ceiling for the garage door opener motor. See Figure 210–14.

AUTHOR'S COMMENT: See Article 100 for the definition of "Readily Accessible."

Exception 2: GFCI protection isn't required for a receptacle on a dedicated branch circuit located and identified for a specific cord-and-plug connected appliance, such as a refrigerator or freezer. Figure 210–16

Receptacles that aren't readily accessible, or those for a dedicated branch circuit for a specific cord-and-plug connected appliance, as permitted in the two exceptions above, aren't considered as meeting the requirement for a garage receptacle contained in 210.52(G).

(3) Outdoors. All 15 and 20A, 125V receptacles located outdoors of dwelling units, including receptacles installed under the eaves of roofs must be GFCI protected. Figure 210–17

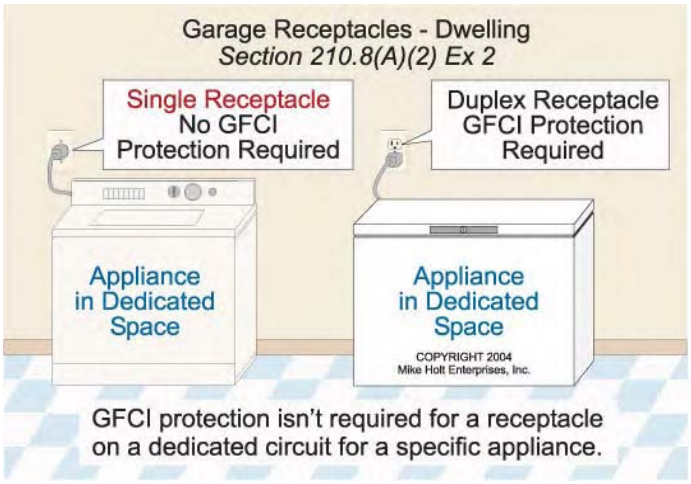

Figure 210–16

Figure 210–17

AUTHOR'S COMMENT: The ground floor units of a multifamily dwelling (one that contains three or more dwelling units) with individual exterior entrances require at least one outdoor receptacle outlet with GFCI protection. Dwelling units above ground level of a multifamily dwelling unit do not require an outdoor receptacle outlet, but if one is installed, then it must be GFCI protected [210.52(E)].

Exception: GFCI protection isn't required for a fixed electric snow-melting or deicing equipment receptacle supplied by a dedicated branch circuit, if the receptacle isn't readily accessible. See 426.28. Figure 210–18

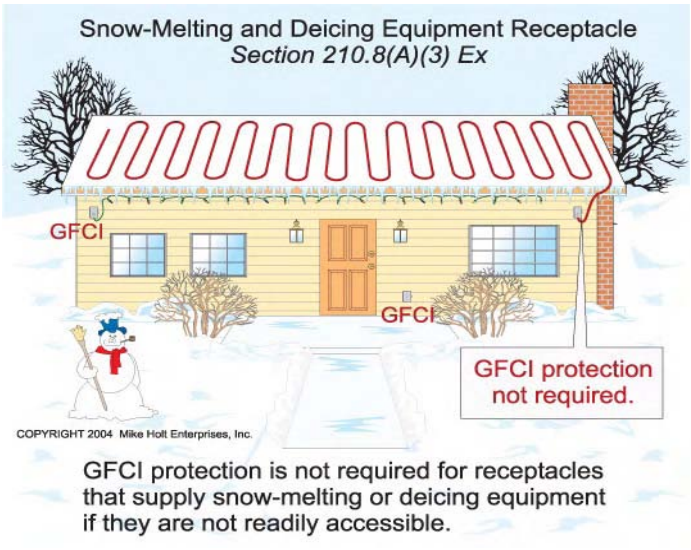

Figure 210–18

(4) Crawl Space. All 15 and 20A, 125V receptacles installed in crawl spaces at or below grade of a dwelling unit must be GFCI protected.

AUTHOR'S COMMENT: The *Code* doesn't require a receptacle to be installed in the crawl space, except when heating, air-conditioning, and refrigeration equipment is installed there [210.63].

(5) Unfinished Basement. GFCI protection is required for all 15 and 20A, 125V receptacles located in the unfinished portion of a basement not intended as a habitable room and limited to storage and work areas. Figure 210–19

Figure 210–19

AUTHOR'S COMMENT: A receptacle outlet is required in each unfinished portion of a dwelling unit basement [210.52(G)].

Exception 1: GFCI protection isn't required for receptacles that aren't readily accessible.

Exception 2: GFCI protection isn't required for a receptacle on a dedicated branch circuit located and identified for a specific cord-and-plug connected appliance.

(6) Kitchen Countertop Surface. GFCI protection is required for all 15 and 20A, 125V receptacles that serve countertop surfaces in a dwelling unit. See 210.52(C) for the location requirements of countertop receptacles. Figure 210–20

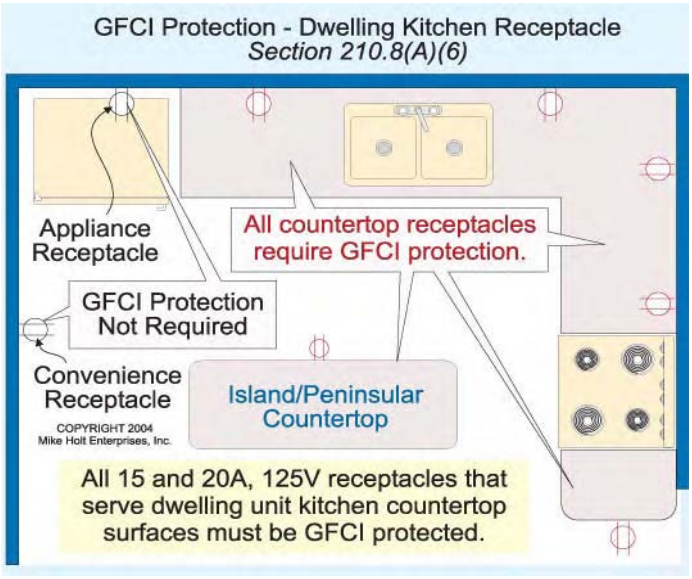

Figure 210–20

AUTHOR'S COMMENT: GFCI protection is required for all receptacles that serve the countertop surfaces, but GFCI protection isn't required for receptacles that serve built-in appliances, such as dishwashers or kitchen waste disposals.

(7) Laundry, Utility, and Wet Bar Sinks. GFCI protection is required for all 15 and 20A, 125V receptacles located within an arc measurement of 6 ft from the dwelling unit laundry, utility, and wet bar sink. Figures 210–21 and 210–22

(8) Boathouse. GFCI protection is required for all 15 and 20A, 125V receptacles located in a dwelling unit boathouse. Figure 210–23

AUTHOR'S COMMENT: The Code doesn't require a 15 or 20A, 125V receptacle to be installed in a boathouse, but if one is installed, then it must be GFCI protected.

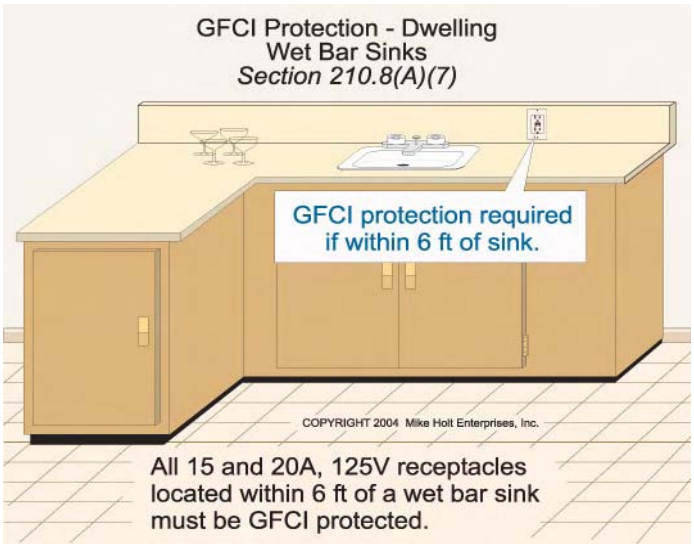

Figure 210–21

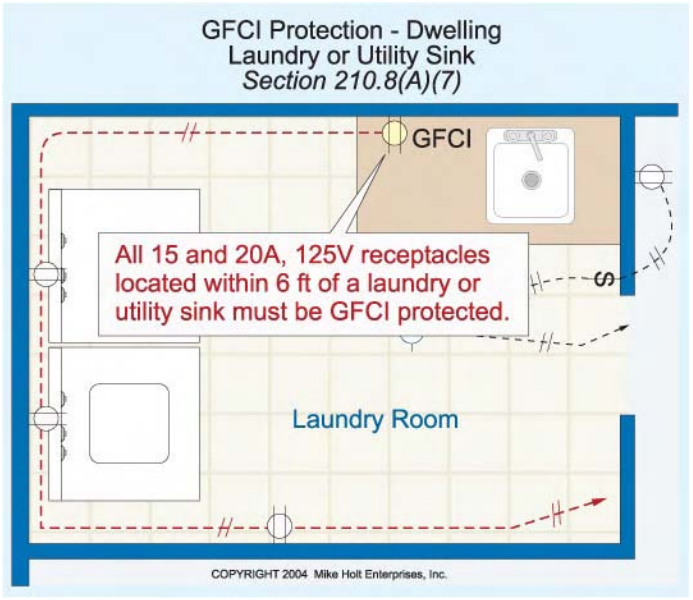

Figure 210–22

(B) Other than Dwelling Units. GFCI protection is required for all 15 and 20A, 125V receptacles installed in the following commercial/industrial locations:

(1) Bathroom. All 15 and 20A, 125V receptacles installed in commercial or industrial bathrooms must be GFCI protected. See Article 100 for the definition of a bathroom. Figure 210–24

AUTHOR'S COMMENT: A 15 or 20A, 125V receptacle isn't required in a commercial or industrial bathroom, but if one is installed, then it must be GFCI protected.

Figure 210–23

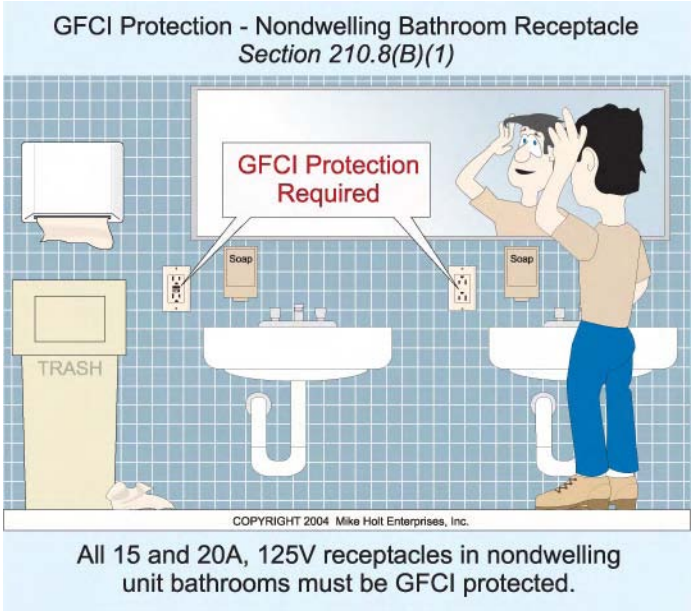

Figure 210–24

(2) Commercial and Institutional Kitchens. All 15 and 20A, 125V receptacles installed in an area with a sink and permanent facilities for food preparation and cooking (kitchens), even those that do not supply the countertop surface, must be GFCI protected. Figure 210–25

For the purposes of this section, a kitchen is defined as an area with a sink and permanent facilities for food preparation and cooking.

AUTHOR'S COMMENT: GFCI protection is not required for 15 and 20A, 125V receptacles in employee break rooms containing portable cooking appliances.

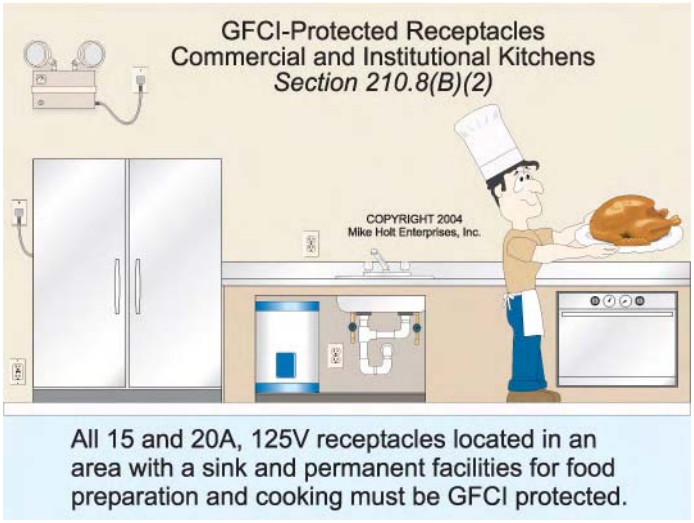

Figure 210–25

(3) Rooftops. All 15 and 20A, 125V receptacles installed on rooftops must be GFCI protected. Figure 210–26

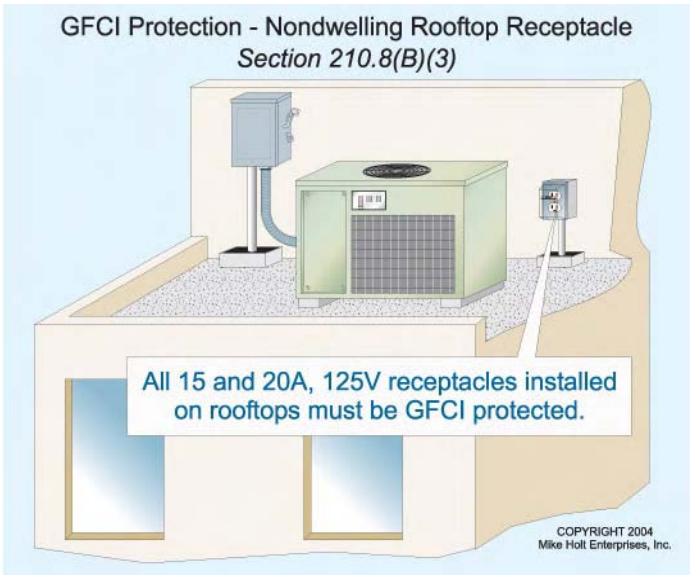

Figure 210–26

AUTHOR'S COMMENT: A 15 or 20A, 125V receptacle outlet must be installed within 25 ft of heating, air-conditioning, and refrigeration equipment [210.63].

Exception: GFCI protection isn't required for a fixed electric snow-melting or deicing equipment receptacle that isn't readily accessible. See 426.28.

(4) Outdoor Public Spaces. All 15 and 20A, 125V receptacles installed outdoors in public spaces used by, or accessible to, the public must be GFCI protected. Figure 210–27

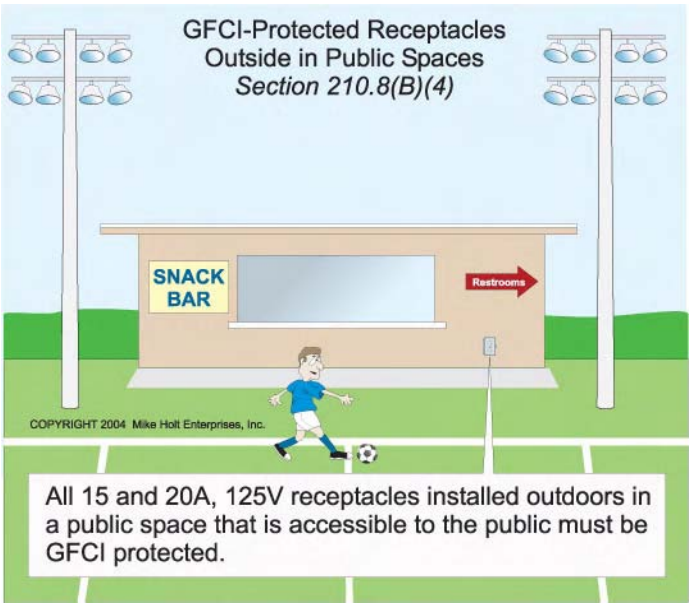

Figure 210–27

AUTHOR'S COMMENT: GFCI protection isn't required for receptacles located outdoors of commercial and industrial occupancies where the general public doesn't have access. Figure 210–28

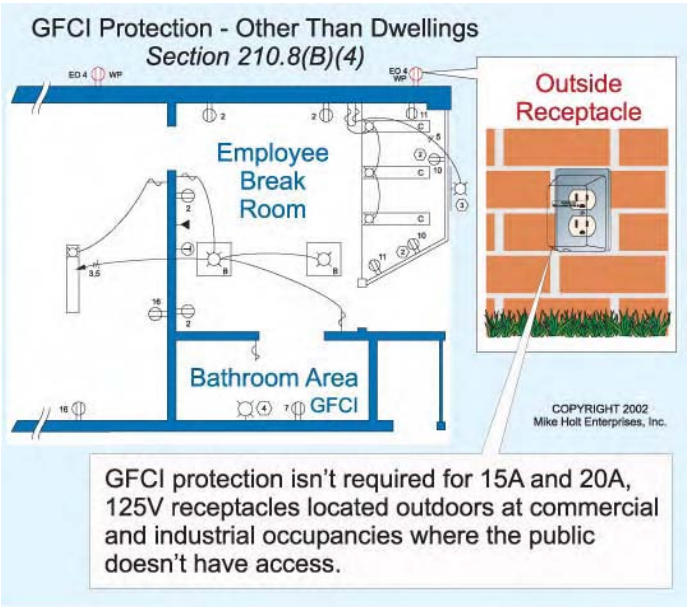

Figure 210–28

(5) Heating, Air-Conditioning, and Refrigeration Equipment. All outdoor 15 and 20A, 125V receptacles installed at an accessible location for the servicing of heating, air-conditioning, and refrigeration equipment in accordance with 210.63 must be GFCI protected. Figure 210–29

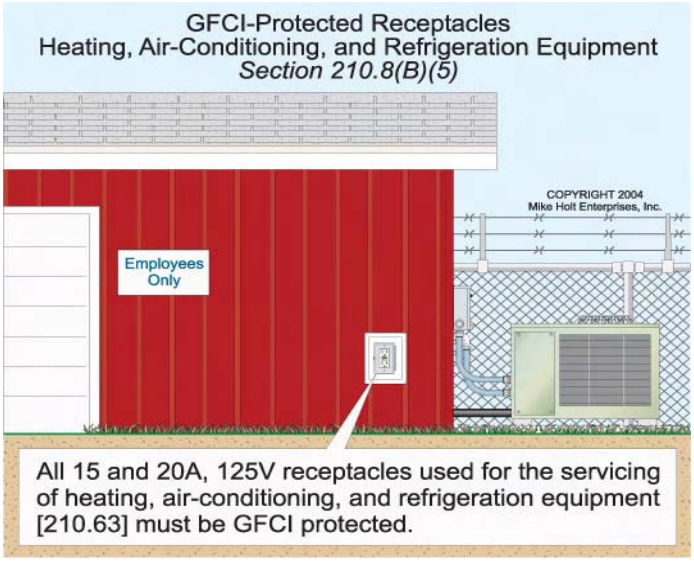

Figure 210–29

(C) Boat Hoists. GFCI protection is required for all 15 or 20A, 125V outlets that supply dwelling unit boat hoists.

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Outlet."
- This ensures GFCI protection regardless of whether the boat hoist is cord-and-plug connected or hard-wired.
- Since 1971, the *NEC* has been expanding GFCI protection requirements to include the following locations:
- Aircraft Hangars, 513.12
- Agricultural Buildings, 547.5(G)
- Carnivals, Circuses, and Fairs, 525.23
- Commercial Garages, 511.12
- Elevator Pits, 620.85
- Health Care Facilities, 517.20(A)
- Marinas and Boatyards, 555.19(B)(1)
- Portable or Mobile Signs, 600.10(C)(2)
- Swimming Pools, 680.22(A)(5)
- Temporary Installations, 590.6

18 210.12 Arc-Fault Circuit-Interrupter (AFCI) Protection

(A) AFCI Definition. An arc-fault circuit interrupter is a device intended to de-energize the circuit when it detects the current waveform characteristics that are unique to an arcing fault. Figure 210–36

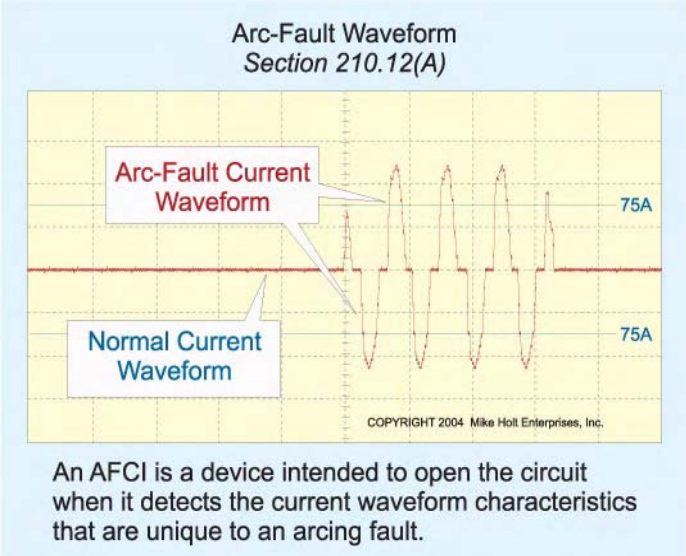

Figure 210–36

(B) Dwelling Unit Bedroom Circuits. All 15 or 20A, 120V branch circuits that supply outlets in dwelling unit bedrooms must be protected by a listed AFCI device. Figure 210–37

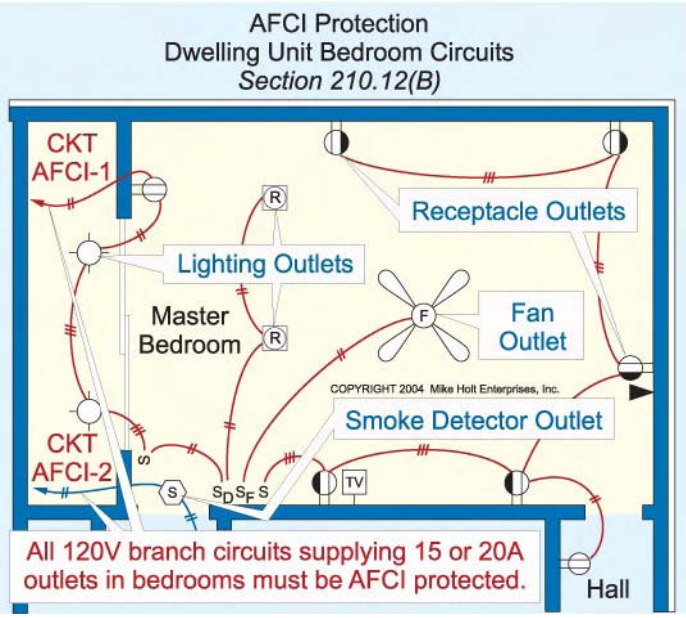

Figure 210–37

AUTHOR'S COMMENTS:

- The 120V circuit limitation means that AFCI protection isn't required for equipment rated 230V, such as a baseboard heater or room air conditioner. For more information, visit www.MikeHolt.com, click on the "Search" link and search for "AFCI."
- Smoke detectors connected to a 15 or 20A circuit must be AFCI protected if the smoke detector is located in the bedroom of a dwelling unit. The exemption from AFCI protection for the fire alarm circuit [760.21 and 760.41] doesn't apply to the smoke detector's circuit, because a smoke detector circuit isn't defined as a fire alarm circuit; it's an "alarm circuit" [See NFPA 72, *National Fire Alarm Code*].

After January 1, 2008 (basically a 2008 *NEC* requirement), AFCI protection must be provided by a combination-type AFCI protection device.

AUTHOR'S COMMENT: Combination type AFCI protection devices provide improved safety performance over existing AFCI protection devices, because the combination type is designed to detect arcs as low as 5A peak. Existing AFCI circuit breakers are designed to operate when the arcs exceed 75A peak. See UL 1699, *Standard for Arc-Fault Circuit Interrupters* (www.UL.com) for information on differences between a branch-circuit type AFCI (circuit breaker) and a combination type AFCI (receptacle).

Exception: The AFCI can be located within 6 ft of the branch-circuit overcurrent device, as measured along the branch-circuit conductors, if the circuit conductors are installed in a metal raceway or a cable with a metallic sheath.

19 210.19 Conductor Sizing

(A) Branch Circuits.

(1) Continuous and Noncontinuous Loads. Conductors must be sized no less than 125 percent of the continuous loads, plus 100 percent of the noncontinuous loads, based on the terminal temperature rating ampacities as listed in Table 310.16, before any ampacity adjustment [110.14(C)].

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Continuous Load."
- See 210.20 for the sizing requirements for the branch-circuit overcurrent protection device for continuous and noncontinuous loads.
- Circuit conductors must have sufficient ampacity, after applying adjustment factors, to carry the load, and they must be protected against overcurrent in accordance with their ampacity [210.20(A) and 240.4].

Question: *What size branch-circuit conductor is required for a 44A continuous load if the equipment terminals are rated 75ºC as permitted by 110.14(C)(1)(a)?* Figure 210–38

(a) 10 AWG (b) 8 AWG (c) 6 AWG (d) 4 AWG

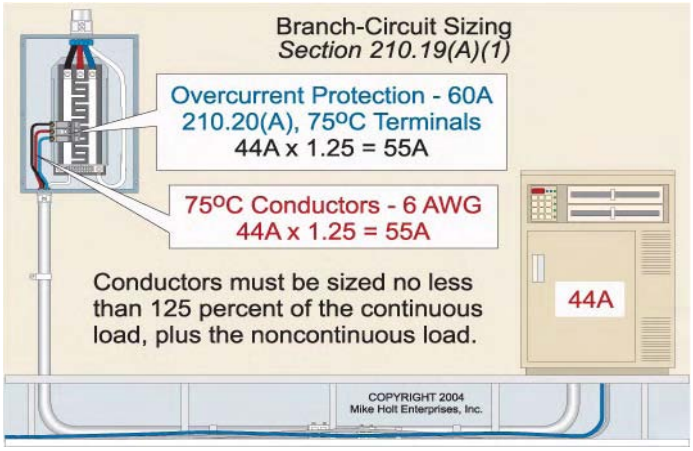

Figure 210–38

Answer: *(c) 6 AWG*

Since the load is 44A continuous, the conductor must be sized to have an ampacity not less than 55A (44A x 1.25). According to Table 310.16, 75ºC column, a 6 AWG conductor is suitable, because it has an ampere rating of 65A at 75ºC, before any conductor ampacity adjustment and/or correction.

Exception: Where the assembly and the overcurrent protection device are both listed for 100 percent continuous load operation, the branch-circuit conductors can be sized at 100 percent of the continuous load.

AUTHOR'S COMMENT: Equipment suitable for 100 percent continuous loading is rarely available in ratings under 400A.

FPN No. 4: To provide reasonable efficiency of operation of electrical equipment, branch-circuit conductors should be sized to prevent a voltage drop not to exceed three percent. In addition, the maximum total voltage drop on both feeders and branch circuits should not exceed five percent. Figures 210–39 and 210–40

AUTHOR'S COMMENT: The purpose of the *National Electrical Code* is the practical safeguarding of persons and property from hazards caused by the use of electricity. The *NEC* doesn't consider voltage drop to be a safety issue, except for fire pumps [695.7].

Calculating Conductor Voltage Drop. Conductor voltage drop can be determined by multiplying the current flowing through the circuit by the resistance of the circuit conductors: Voltage

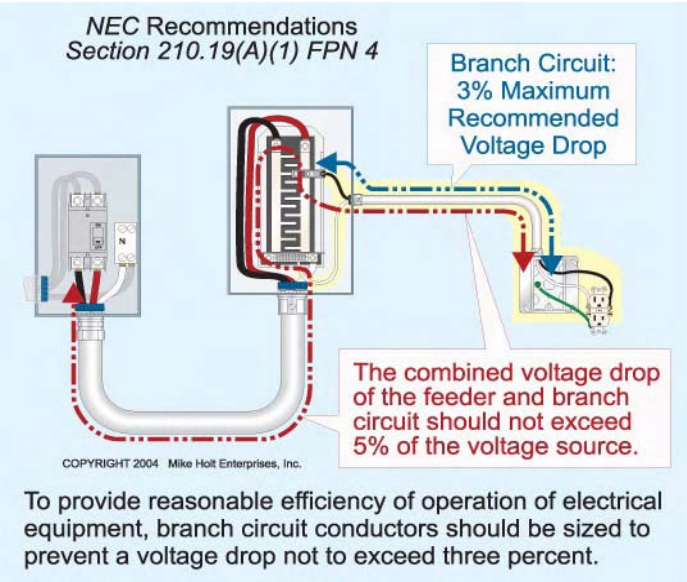

Figure 210–39

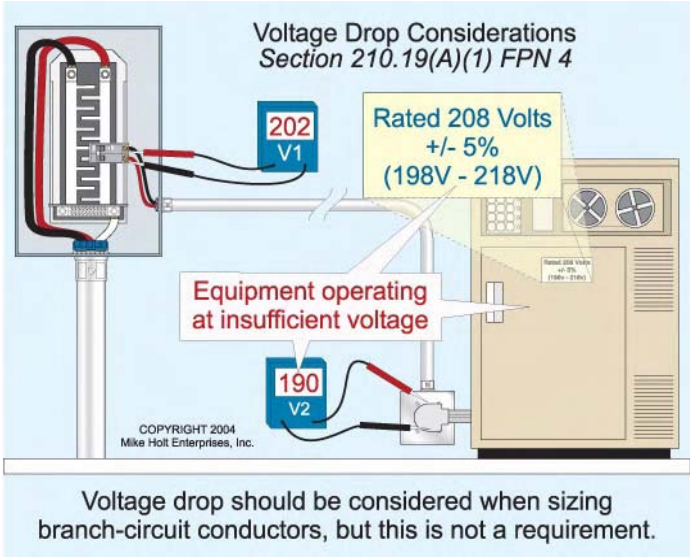

Figure 210–40

Drop = I x R. Where "I" is equal to the load in amperes and "R" is the resistance of the conductor [Chapter 9, Table 8 for direct-current circuits, or Chapter 9, Table 9 for alternating-current circuits]. For three-phase circuits, simply adjust the single-phase voltage-drop value by a multiplier of 0.866

Question: *What is the conductor voltage drop for two 12 AWG conductors that supply a single-phase 16A, 120V load located 100 ft from the power supply (200 ft of wire)?* Figure 210–41

(a) 3.2V (b) 6.4V (c) 9.6V (d) 12.8V

Answer: *(b) 6.4V*

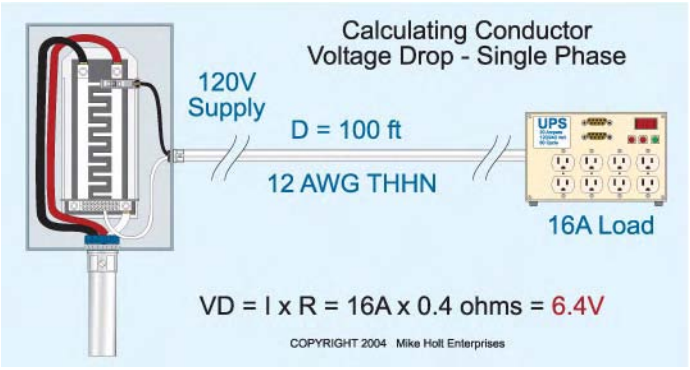

Figure 210–41

Voltage Drop = I x R
I = 16A

R = (2 ohms per 1,000 ft/1,000 ft) x 200 ft
R = 0.4 ohms, Chapter 9, Table 9

Voltage Drop = 16A x 0.4 ohms
Voltage Drop = 6.4V
Voltage Drop % = 6.4V/120V
Voltage Drop % = 5.3%

The 5.3 percent voltage drop exceeds the NEC*'s recommendations of three percent, but this isn't a violation of the* Code.

(2) Multioutlet Branch Circuits. Branch-circuit conductors that supply more than one receptacle for cord-and-plug connected portable loads must have an ampacity not less than the rating of the circuit [210.3 and 240.4(D)].

(3) Household Ranges and Cooking Appliances. Branch-circuit conductors that supply household ranges, wall-mounted ovens or counter-mounted cooking units must have an ampacity not less than the rating of the branch circuit and not less than the maximum load to be served. For ranges of 8¾ kW or more rating, the minimum branch-circuit ampere rating must be 40A.

Exception 1: Tap conductors for electric ranges, wall-mounted electric ovens and counter-mounted electric cooking units from a 50A branch circuit must have an ampacity not less than 20A and must have sufficient ampacity for the load to be served. These tap conductors include any conductors that are a part of the lead (pigtail) supplied with the appliance that are smaller than the branch-circuit conductors. The taps must not be longer than necessary for servicing the appliance.

(4) Other Loads. Branch-circuit conductors must have an ampacity sufficient for the loads served and must not be smaller than 14 AWG.

Exception 1: Tap conductors must have an ampacity not less than 15A for circuits rated less than 40A and not less than 20A for circuits rated at 40 or 50A for the following loads:

(c) Individual outlets, other than receptacle outlets, with taps not over 18 in. long.

AUTHOR'S COMMENT: Branch-circuit tap conductors aren't permitted for receptacle outlets. Figure 210–42

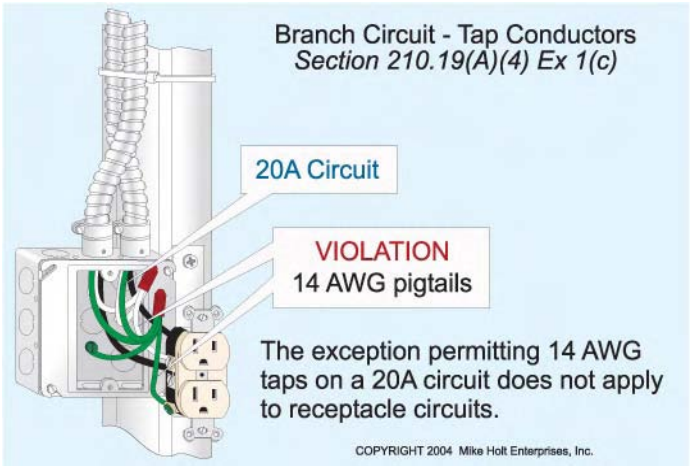

Figure 210–42

20 210.20 Overcurrent Protection

(A) Continuous and Noncontinuous Loads. Branch-circuit overcurrent protection devices must have an ampacity not less than 125 percent of the continuous loads, plus 100 percent of the noncontinuous loads.

AUTHOR'S COMMENT: See 210.19(A)(1) for branch-circuit conductor sizing requirements.

Exception; Where the assembly and the overcurrent protection devices are both listed for 100 percent continuous load operation, the branch-circuit protection device can be sized at 100 percent of the continuous load.

AUTHOR'S COMMENT: Equipment suitable for 100 percent continuous loading is rarely available in ratings under 400A.

(B) Conductor Protection. Branch-circuit conductors must be protected against overcurrent in accordance with 240.4.

(C) Equipment Protection. Branch-circuit equipment must be protected in accordance with 240.3.

21 210.21 Outlet Device Rating

(A) Lampholder Ratings. Lampholders connected to a branch circuit rated over 20A must be of the heavy-duty type.

WARNING: *Fluorescent lampholders aren't rated heavy duty, so fluorescent luminaires cannot be installed on circuits rated over 20A.*

(B) Receptacle Ratings and Loadings.

(1) Single Receptacle. A single receptacle on an individual branch circuit must have an ampacity not less than the rating of the overcurrent protection device. Figure 210–43

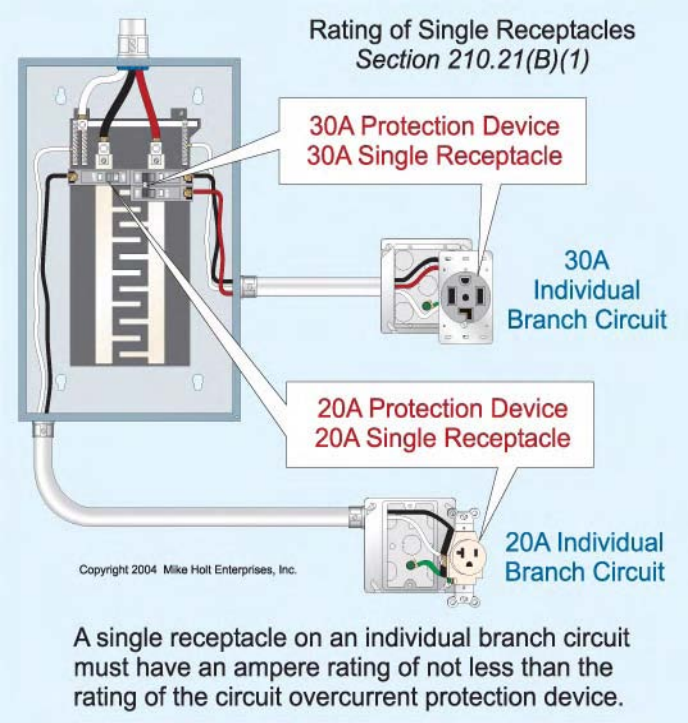

Figure 210–43

AUTHOR'S COMMENT: A single receptacle has only one contact device on its yoke [Article 100]. This means a duplex receptacle is considered two receptacles.

(2) Multiple Receptacle Loading. Where connected to a branch circuit that supplies two or more receptacles, the total cord-and-plug connected load must not exceed 80 percent of the receptacle rating.

AUTHOR'S COMMENT: A duplex receptacle has two contact devices on the same yoke [Article 100]. This means that even one duplex receptacle on a circuit makes that circuit a multioutlet branch circuit.

(3) Multiple Receptacle Rating. Where connected to a branch circuit that supplies two or more receptacles, receptacles must have an ampere rating in accordance with the values listed in Table 210.21(B)(3). Figure 210–44

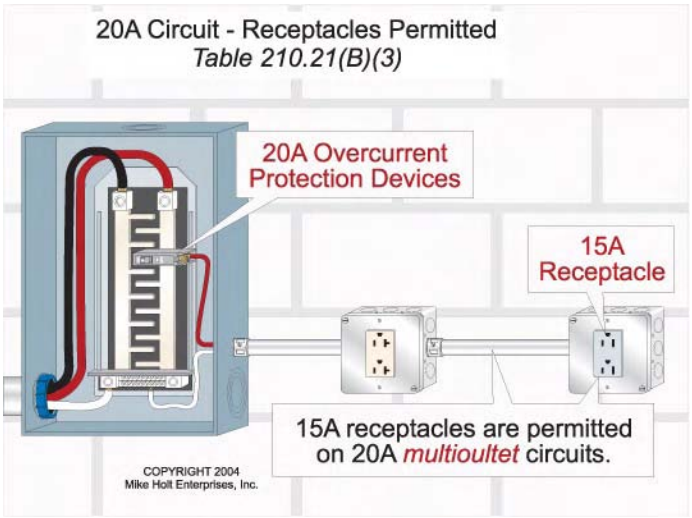

Figure 210–44

Table 210.21(B)(3) Receptacle Ratings

Circuit Rating	Receptacle Rating
15A	15A
20A	15 or 20A
30A	30A
40A	40 or 50A
50A	50A

22 210.52 Dwelling Unit Receptacle Outlet Requirements

This section contains the requirements for 15 and 20A, 125V receptacle outlets for dwelling units.

AUTHOR'S COMMENT: Circuits are rated 120V and receptacles are rated 125V.

Receptacle outlets that are part of a luminaire or appliance, or are located within cabinets or cupboards, or are located more than 5½ ft above the floor are not permitted to meet the requirements of this section.

(A) General Requirements—Dwelling Unit. A receptacle outlet must be installed in every kitchen, family room, dining room, living room, parlor, library, den, bedroom, recreation room, and similar room or area in accordance with (1), (2), or (3): Figure 210–49

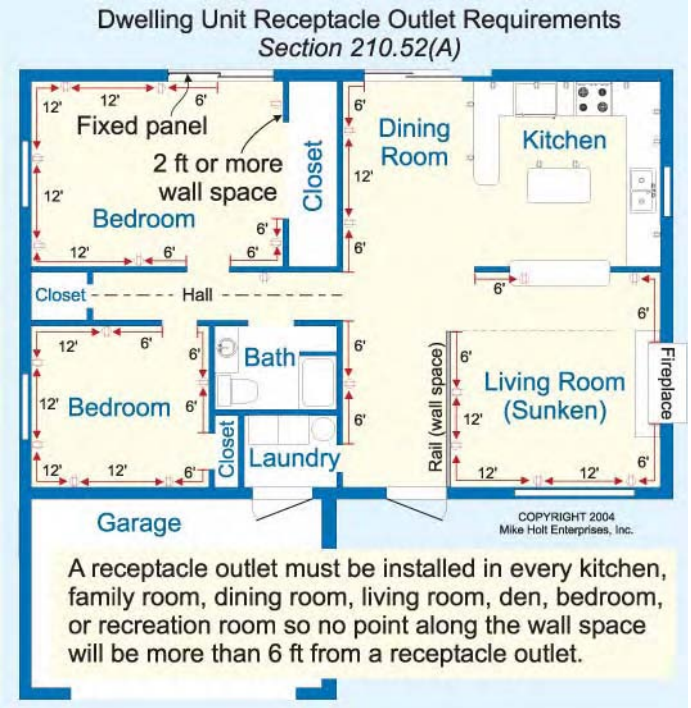

Figure 210–49

(1) Receptacle Placement. A receptacle outlet must be installed so no point along the wall space will be more than 6 ft, measured horizontally, from a receptacle outlet.

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 travel across openings, such as doorways or fireplaces.

(2) Definition of Wall Space.

(1) Any space 2 ft or more in width, unbroken along the floor line by doorways, fireplaces, and similar openings.

(2) The space occupied by fixed panels in exterior walls.

(3) The space occupied by fixed room dividers, such as free-standing bar-type counters or railings.

(3) Floor Receptacle Outlets. Floor receptacle outlets cannot be counted as the required receptacle wall outlet if located more than 18 in. from the wall. Figure 210–50

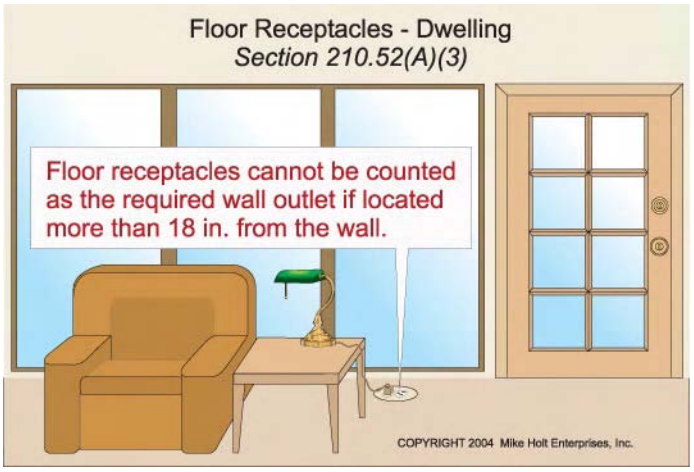

Figure 210–50

(B) Small-Appliance Circuit—Dwelling Unit.

(1) Receptacle Outlets. The 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 210–51

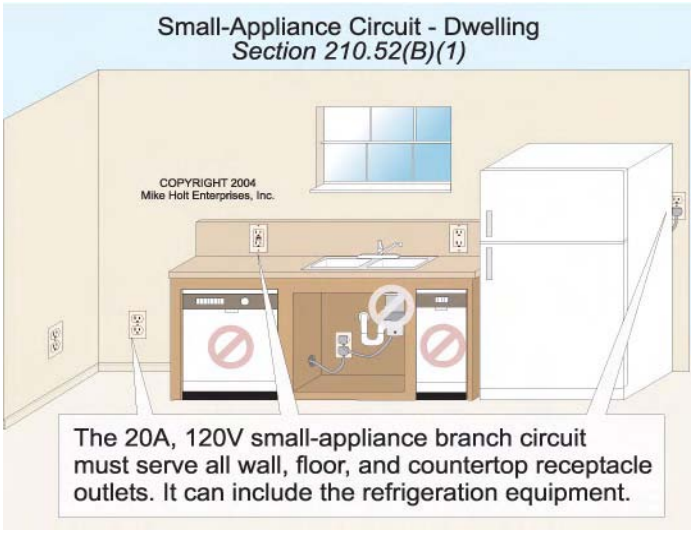

Figure 210–51

Exception 2: The receptacle outlet for refrigeration equipment can be supplied from an individual branch circuit rated 15A or greater.

(2) Not Supply Other Outlets. The 20A, 120V small-appliance circuits [210.11(C)(1)] cannot be used to supply any other outlet, including outlets for luminaires or appliances.

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

Exception 2: A receptacle can be connected to the small-appliance circuit to supply a gas-fired range, oven, or counter-mounted cooking unit. Figure 210–52

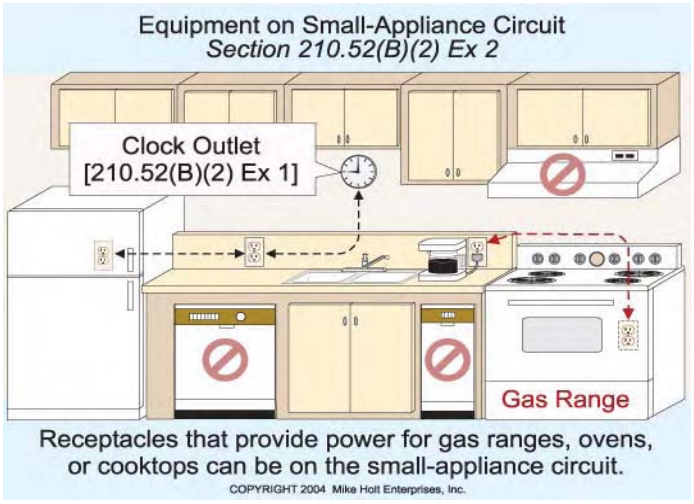

Figure 210–52

(3) Kitchen Countertop Receptacles. Kitchen countertop receptacles, as required by 210.52(C) for dwelling units, must be supplied by not less than two 20A, 120V small-appliance branch circuits [210.11(C)(1)]. Either or both of these circuits are permitted to supply receptacle outlets in the same kitchen, pantry, breakfast room, or dining room of the dwelling unit [210.52(B)(1)]. See 210.11(C)(1).

(C) Countertop Receptacle—Dwelling Unit. In kitchens and dining rooms of dwelling units, receptacle outlets for countertop spaces must be installed according to (1) through (5) below.

AUTHOR'S COMMENT: GFCI protection is required for all 15 and 20A, 125V receptacles that supply kitchen countertop appliances [210.8(A)(6)].

(1) Wall Counter Space. A receptacle outlet must be installed for each kitchen and dining area countertop wall space that is 1 ft or wider, and receptacles must be placed so no point along the countertop wall space is more than 2 ft, measured horizontally from a receptacle outlet. Figure 210–53

Exception: A receptacle outlet isn't required on a wall directly behind a range or sink as shown in Figure 210–54

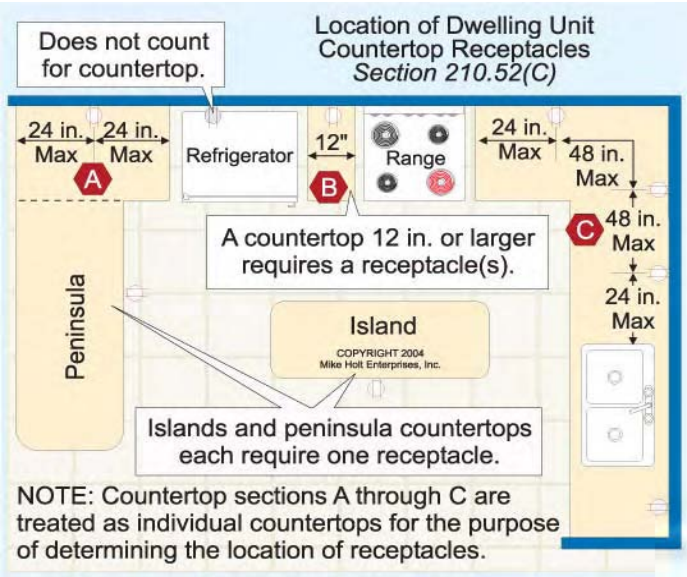

Figure 210–53

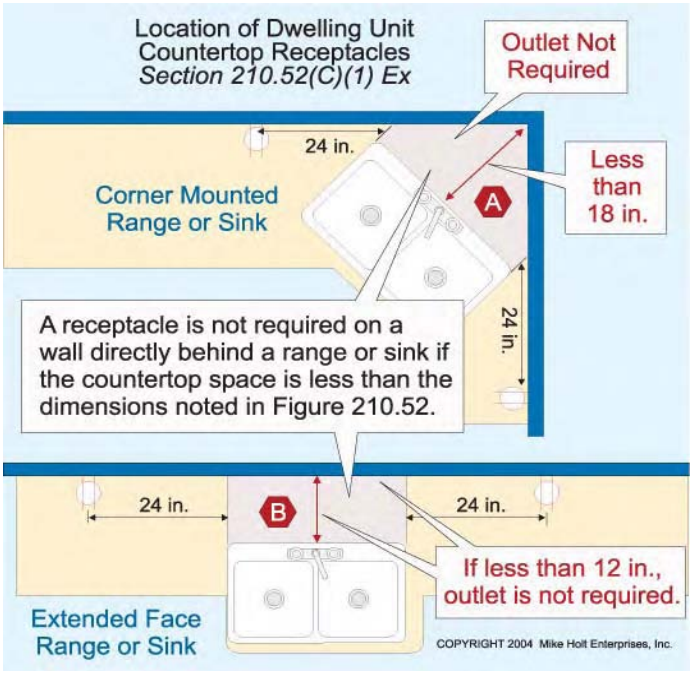

Figure 210–54

AUTHOR'S COMMENT: If the countertop space behind a range or sink is larger that the dimensions noted in Figure 210.52 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.

(2) Island Countertop Space. One receptacle outlet must be installed at each island countertop space with a long dimension of 2 ft or greater, and a short dimension of 1 ft or greater. When breaks occur in countertop spaces for appliances, sinks, etc., and the width of the counter space behind the appliance or sink is less than 1 ft, each countertop space is considered as a separate island for determining receptacle placement [210.52(C)(4)]. Figure 210–55

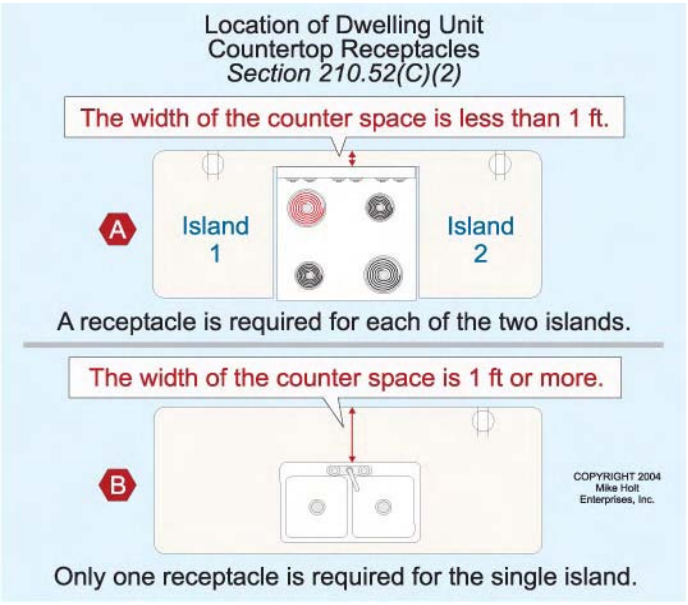

Figure 210–55

(3) Peninsular Countertop Space. One receptacle outlet must be installed at each peninsular countertop with a long dimension of 2 ft or greater, and a short dimension of 1 ft or greater, measured from the connecting edge.

(4) Separate Countertop Spaces. When breaks occur in countertop spaces for appliances, sinks, etc., each countertop space is considered as a separate countertop for determining receptacle placement.

(5) Receptacle Location. Receptacle outlets required by 210.52(C)(1) for the countertop space must be located above, but not more than 20 in. above, the counter surface. Figure 210–56

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 are not permitted to be used as the required counter surface receptacles.

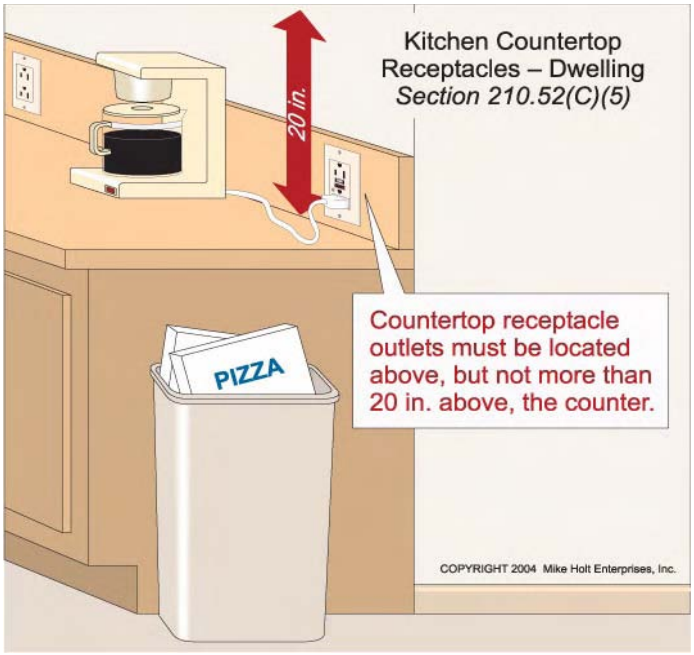

Figure 210–56

AUTHOR'S COMMENT: An "appliance garage" is an enclosed area on the counter surface where an appliance can be stored and hidden from view when not in use. If a receptacle is installed inside an appliance garage, it cannot count as a required countertop surface receptacle outlet.

Question: *Can a receptacle installed inside an appliance garage be connected to the small-appliance circuit?*

Answer: *This is a judgment call by the authority having jurisdiction, but receptacles for garbage disposals, dishwashers, compactors, etc., cannot be on the 20A, 120V small-appliance circuits [210.52(B)(2)].*

Exception: The receptacle outlet for the countertop space can be installed below the countertop where no wall space is available, such as an island or peninsular counter. Under these conditions, the required receptacle(s) must be located no more than 1 ft below the countertop surface and no more than 6 in. from the counter's edge, measured horizontally. Figure 210–57

(D) Bathrooms—Dwelling Unit. In dwelling units, not less than one 15 or 20A, 125V receptacle outlet must be installed within an arc measurement of 3 ft from the outside edge of each bathroom basin. The receptacle outlet must be located on a wall or partition that is adjacent to the basin counter surface. See 210.11(C)(3). Figure 210–58

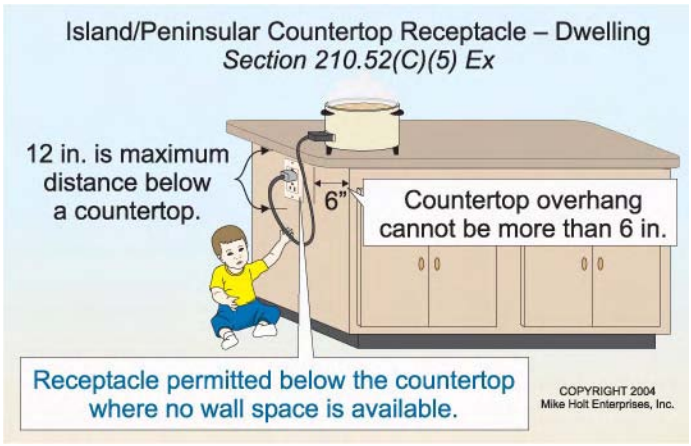

Figure 210–57

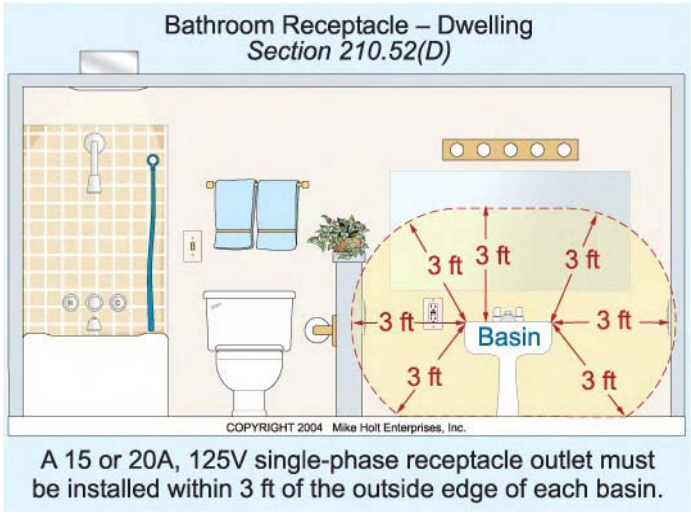

Figure 210–58

AUTHOR'S COMMENTS:

- One receptacle outlet could be located between two basins to meet the requirement, but only if the receptacle outlet is located within 3 ft of the outside edge of each basin. Figure 210–59
- The bathroom receptacles must be GFCI protected [210.8(A)(1)].

Exception: The required bathroom receptacle can be installed on the face or side of the basin cabinet not more than 12 in. below the countertop surface. Figure 210–60

(E) Outdoor Receptacle—Dwelling Units.

One-Family Dwelling Unit. Two GFCI-protected receptacle outlets accessible at grade level must be installed outdoors for each one-family dwelling unit, one at the front and one at the back of the dwelling unit, no more than 6½ ft above grade. Figure 210–61

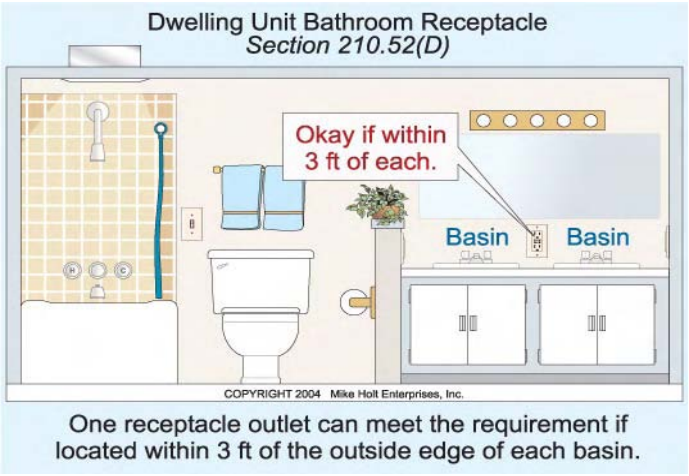

Figure 210–59

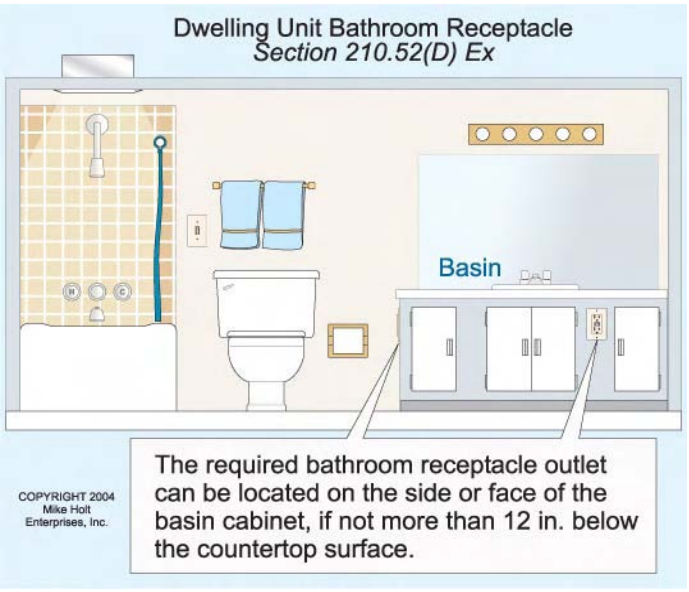

Figure 210–60

AUTHOR'S COMMENT: These receptacles must be GFCI protected [210.8(A)(3)].

Two-Family Dwelling Unit. Each dwelling unit of a two-family dwelling that is at grade level must have two GFCI-protected [210.8(A)(3)] receptacle outlets accessible at grade level installed outdoors for each dwelling unit, one at the front and one at the back of each dwelling, no more than 6½ ft above grade.

AUTHOR'S COMMENT: A receptacle is not required to be located outdoors for dwelling units above grade level, but if installed outdoors, they must be GFCI protected [210.8(A)(3)].

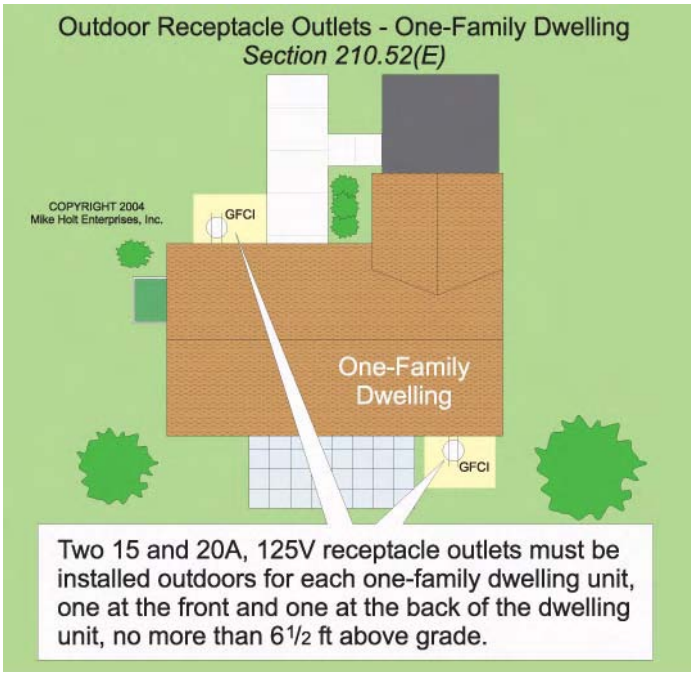

Figure 210–61

Multifamily Dwelling Unit Building. Each dwelling unit of a multifamily dwelling that has an individual entrance at grade level must have at least one GFCI-protected receptacle outlet accessible from grade level located not more than 6½ ft above grade. Figure 210-62

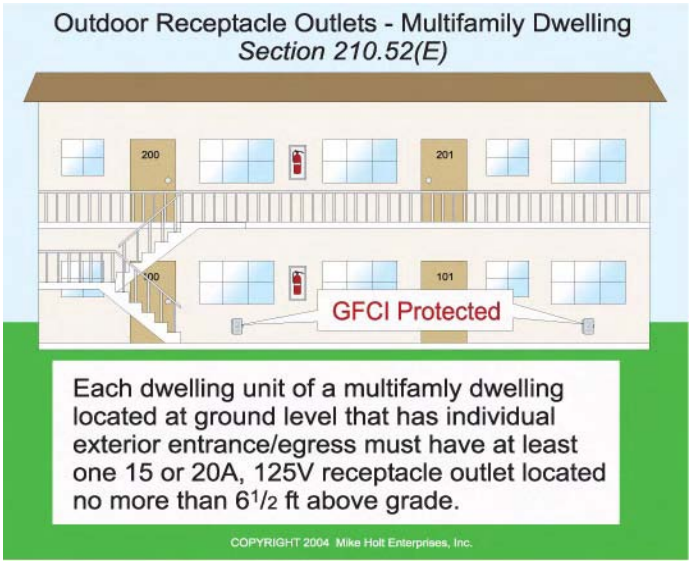

Figure 210–62

AUTHOR'S COMMENTS:

- See Article 100 for the definition of "Multifamily Dwelling."
- The 2005 *NEC* doesn't specify the rating of the required receptacle, but all 15 or 20A, 125V receptacles located outdoors of a dwelling unit must be GFCI protected [210.8(A)(3)].

(F) Laundry Area Receptacle—Dwelling Unit. Each dwelling unit must have not less than one 15 or 20A, 125V receptacle installed in the laundry area. This receptacle(s) must be supplied by the 20A, 120V laundry branch circuit, which must not supply any other outlets [210.11(C)(2)]. Figure 210–63

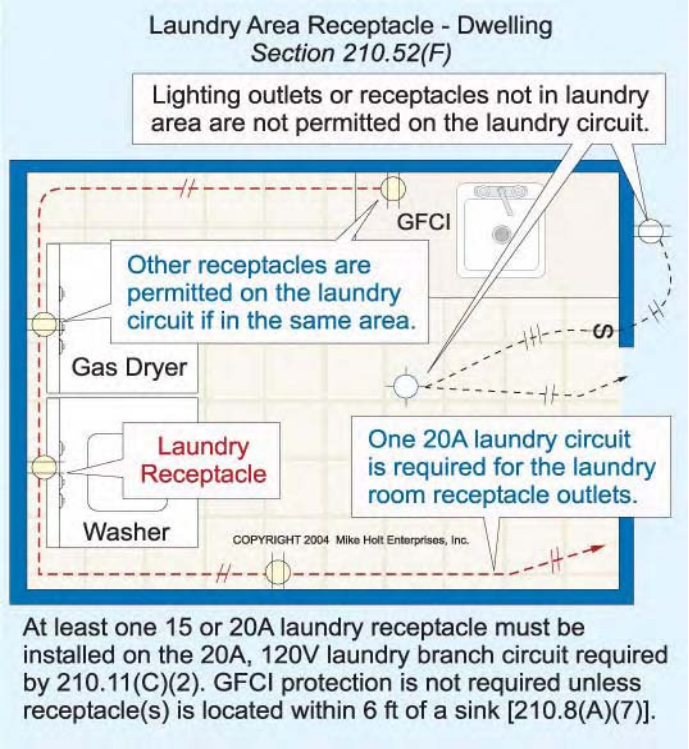

Figure 210–63

AUTHOR'S COMMENT: All receptacles located within 6 ft of a laundry room sink require GFCI protection [210.8(A)(7)].

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

(G) Garage and Basement Receptacles—Dwelling Unit. For a one-family dwelling, not less than one 15 or 20A, 125V receptacle outlet, in addition to any provided for laundry equipment, must be installed in each basement, each attached garage, and each detached garage with electric power. Figure 210–64

AUTHOR'S COMMENT: The required garage and basement receptacles must be GFCI protected in accordance with 210.8(A)(2) for garages and 210.8(A)(5) for unfinished basements.

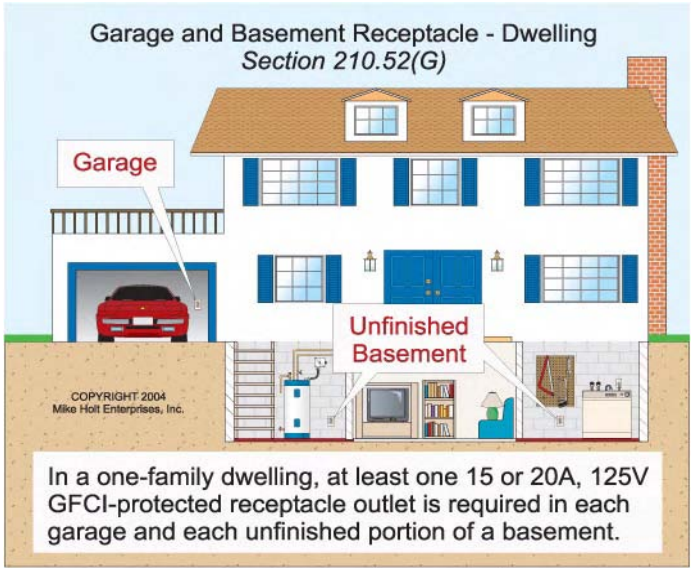

Figure 210–64

Where a portion of the basement is finished into one or more habitable rooms, each separate unfinished portion must have a 15 or 20A, 125V receptacle outlet installed.

AUTHOR'S COMMENT: The purpose is to prevent an extension cord from a non-GFCI-protected receptacle to be used to supply power to loads in the unfinished portion of the basement. See Figure 210–64.

(H) Hallway Receptacle—Dwelling Unit. One 15 or 20A, 125V receptacle outlet must be installed in each hallway that is at least 10 ft long, measured along the centerline of the hall without passing through a doorway. Figure 210–65

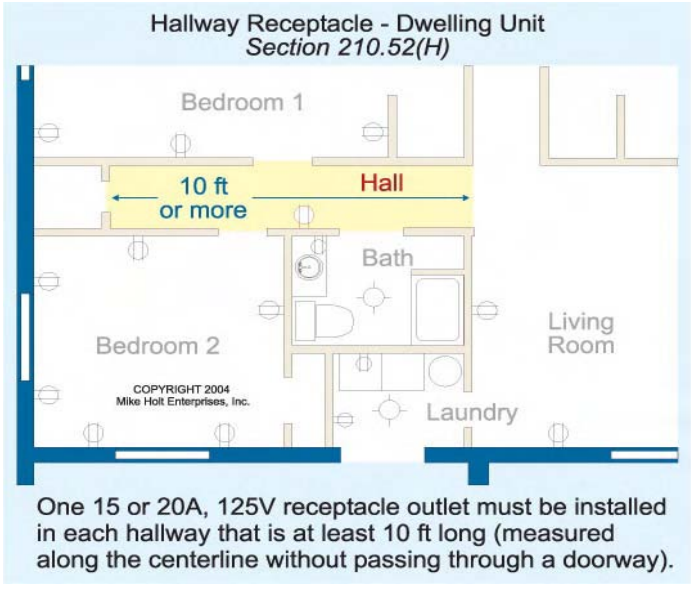

Figure 210–65

ARTICLE 225 Outside Wiring

Introduction

This Article contains installation requirements for equipment, including conductors located outdoors, on or between buildings, poles, and other structures on the premises.

23 225.18 Clearances

Overhead conductor spans must maintain the following vertical clearances:

(1) 10 ft above finished grade, sidewalks, platforms, or projections from which they might be accessible to pedestrians for 120V, 120/208V, 120/240V, or 240V circuits.

(2) 12 ft above residential property and driveways, and those commercial areas not subject to truck traffic for 120V, 120/208V, 120/240V, 240V, 277V, 277/480V, or 480V circuits.

(4) 18 ft over public streets, alleys, roads, parking areas subject to truck traffic, driveways on other than residential property, and other areas traversed by vehicles (such as those used for cultivation, grazing, forestry, and orchards).

AUTHOR'S COMMENT: Overhead conductors not under the exclusive control of the electric utility located above pools, outdoor spas, outdoor hot tubs, diving structures, observation stands, towers, or platforms must be installed in accordance with the clearance requirements in 680.8.

24 225.30. Number of Supplies

Where more than one building or structure is on the same property, each building or structure must be served by no more than one feeder or branch circuit, except as permitted in (A) through (E).

For the purpose of this section, a multiwire branch circuit is considered a single circuit.

(A) Special Conditions. Additional circuits are permitted for:

(1) Fire pumps

(2) Emergency systems

(3) Legally required standby systems

(4) Optional standby systems

(5) Parallel power production systems

(6) Systems designed for connection to multiple sources of supply for the purpose of enhanced reliability.

AUTHOR'S COMMENT: To minimize the possibility of accidental interruption, the disconnecting means for the fire pump or standby power must be located remotely away from the normal power disconnect [225.34(B)].

(B) Special Occupancies. By special permission, additional feeders are permitted for:

(1) Multiple-occupancy buildings where there's no available space for supply equipment accessible to all occupants, or

(2) A building or structure that is so large that two or more feeder supplies are necessary.

(C) Capacity Requirements. Additional feeders are permitted for a building or structure where the capacity requirements exceed 2,000A.

(D) Different Characteristics. Additional feeders or branch circuits are permitted for different voltages, frequencies, or uses, such as control of outside lighting from multiple locations.

(E) Documented Switching Procedures. Additional feeders are permitted where documented safe switching procedures are established and maintained for disconnection.

25 225.31 Disconnecting Means

A disconnect is required for all conductors that enter or pass through a building or structure.