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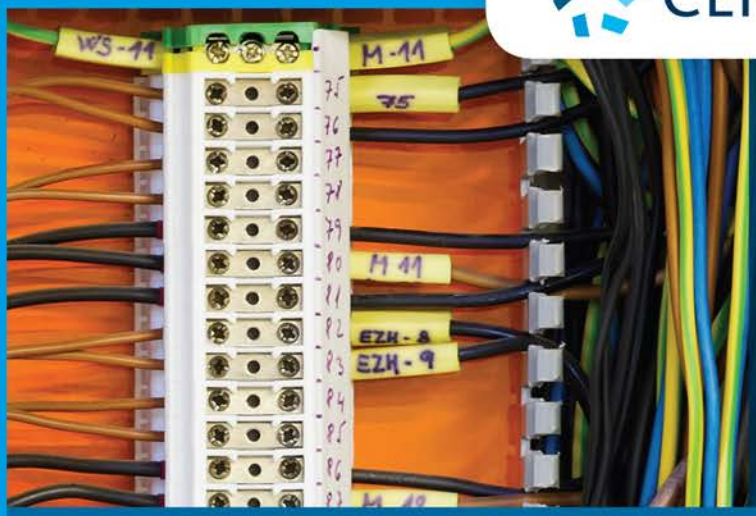

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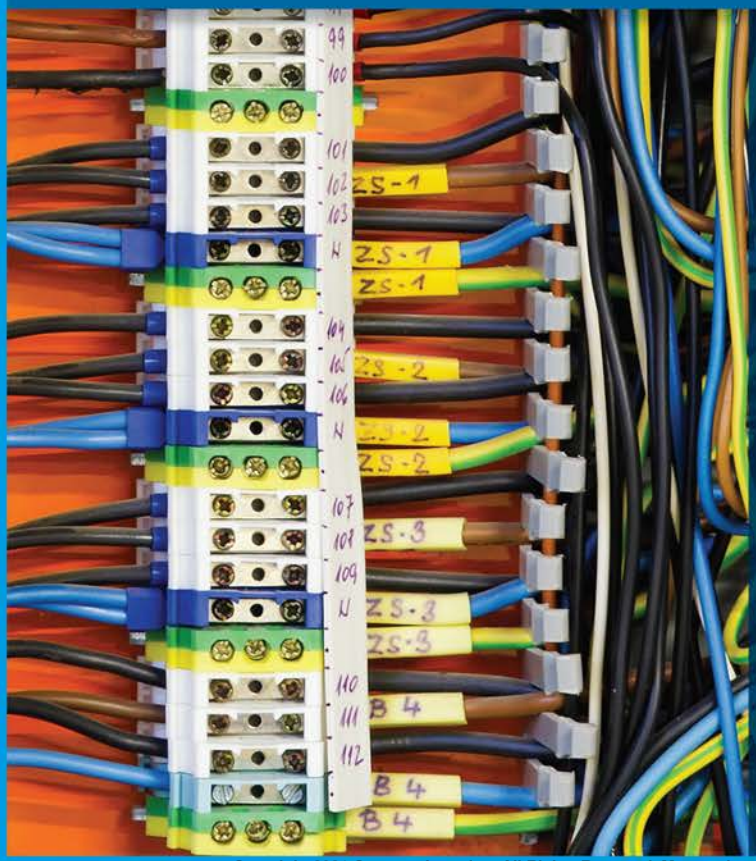

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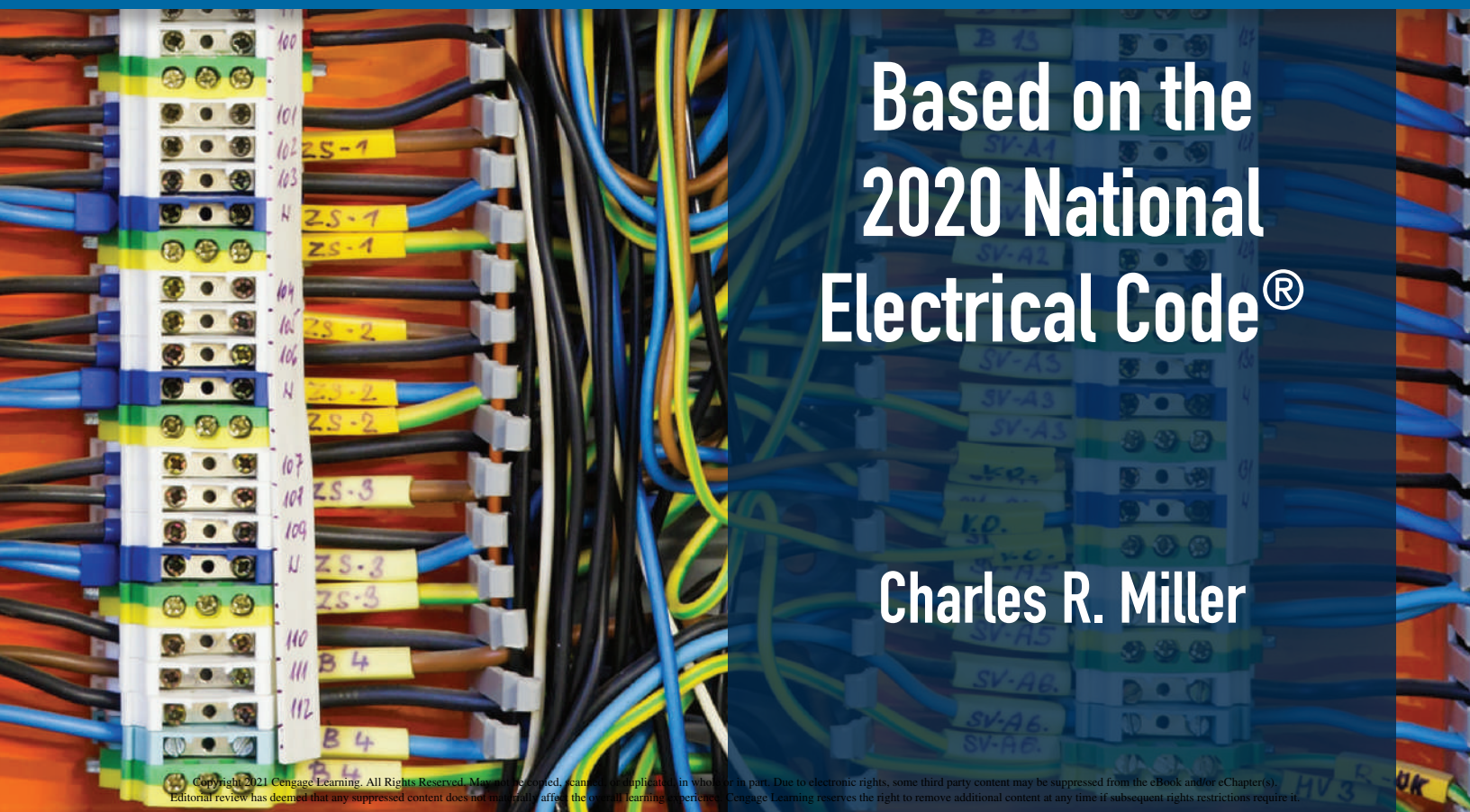

Based on the 2020 National Electrical Code®

Charles R. Miller

Illustrated Guide to the National Electrical Code® Based on the 2020 National Electrical Code®, 8th Edition
Charles R. Miller

SVP, Higher Education & Skills Product: Erin Joyner

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Director, Learning Design: Rebecca von Gillern

Senior Manager, Learning Design: Leigh Hefferon

Learning Designer: Elizabeth Berry

Marketing Director: Sean Chamberland

Marketing Manager: Scott Chrysler

Director, Content Creation: Juliet Steiner

Content Creation Manager: Alexis Ferraro

Content Manager: Jenn Alverson

Senior Digital Delivery Lead: Elizabeth Cranston

Art Director: Jack Pendleton

Text Designer: Erin Griffin

Cover Designer: Erin Griffin

Cover image(s): Lubos Chlubny/ShutterStock.com

Library of Congress Control Number: 2020902054

ISBN: 978-0-3573-7152-7

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Printed in the United States of America
Print Number: 01 Print Year: 2020

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Preface

Illustrated Guide to the National Electrical Code offers an exciting new approach to understanding and applying the provisions of the *National Electrical Code*.* Unlike the *Code*, this text gathers and presents detailed information in a format, such as one-family or multifamily dwellings, based on "type of occupancy." *Code* specifications applicable to a given type of occupancy are logically organized in easy-to-read units and graphically enhanced by numerous technical illustrations. Going an extra step, the occupancy-specific material is subdivided into specific rooms and areas. Information relevant to more than one type of occupancy is organized into independent units for easier reference. For instance, items such as raceways and conductors are covered in Unit 5 but are related to every type of occupancy.

Students who wish to acquire a comprehensive grasp of all electrical codes will want to study this text section by section and unit by unit. Practicing electricians who have specialized in one type of occupancy and who wish to understand an unfamiliar segment may want to focus on those new areas. For example, an electrician who has been wiring commercial facilities for a number of years wants to wire a new house. Being unfamiliar with the codes concerning residential wiring, this individual can turn to Section 2, "One-Family Dwellings." Here, everything from receptacle placement to the placement of the service point is explained. Section 2 is made up of four units: Units 6 through 9. Unit 6, "General Provisions," contains general requirements for one-family dwellings, both interior and exterior. Unit 7, "Specific Provisions," addresses more complex issues, requiring additional provisions for specific areas such as kitchens, hallways, clothes closets, bathrooms, garages, basements, etc. Unit 8, "Load Calculations," simplifies the standard as well as optional load calculation methods for one-family dwellings. Unit 9, "Services and Electrical Equipment," is divided into five subheadings: Service-Entrance Wiring Methods, Service and Outside Wiring Clearances, Working Space around Equipment, Service Equipment and Panelboards, and Grounding.

The "what," "when," "where" adoption of the provisions of the *NEC* is under the discretionary control of state and local jurisdictions. State and local jurisdictions also have the liberty of appending additional codes, which in many cases may be more stringent than those outlined by the *NEC*. The *Code* may be adopted in whole or in part. For example, while some local codes do not allow the use of nonmetallic-sheathed cable for residential or commercial wiring, others allow its use in residential but not in commercial wiring applications. To ensure compliance, obtain a copy of any additional rules and regulations for your area.

This guide's objective is to provide the information needed to complete your project—without the necessity of learning the *NEC* from cover to cover. *Illustrated Guide to the National Electrical Code* will bring your project to life as quickly and as accurately as any text on the market today. In the electrical field, as in any career, the learning experience never ends. Whether you are an electrician's apprentice, a master electrician, or an electrical inspector, *Illustrated Guide to the National Electrical Code* has something for you. We believe you will find it to be a valuable addition to your reference library. In fact, you may want to include it in your toolbox or briefcase!

Take note that this guidebook was completed after all the normal steps in the National Fire Protection Association (NFPA) 70 review cycle—Public Input, First Draft Report, Public Comment, Second Draft Report, reviews by Technical Correlating Committee, NFPA Annual Meeting, and ANSI Standards Council—and before the actual publication of the 2020 edition of the *NEC*. Every effort has been

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made to be technically correct, but there is always the possibility of typographical errors or appeals made to the NFPA Board of Directors after the normal review cycle that could change the appearance or substance of the *Code.*

If changes do occur after the printing of this book, they will be included on the Instructor Companion Site and will be incorporated into the guidebook in its next printing.

Note also that the *Code* has a standard method to introduce changes between review cycles, called "Tentative Interim Amendment," or TIA. These TIAs and correction of typographical errors can be downloaded from the NFPA Web site, www.nfpa.org, to make your copy of the *Code* current.

SUPPLEMENTS:

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MindTap is a personalized teaching experience with relevant assignments that guide students to analyze, apply, and improve thinking, allowing you to measure skills and outcomes with ease.

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An Instructor Companion website containing supplementary material is available online via www.cengage.com/login. This site contains an Instructor Guide, an image gallery of text figures, unit presentations done in PowerPoint, and testing powered by Cognero.

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ABOUT THE AUTHOR

For eighteen years, Charles R. Miller owned and operated a successful commercial electrical contracting company (Lighthouse Electric Co., Inc.) in Nashville, Tennessee. Throughout those years, he prided himself on solving problems abandoned by less-skilled or less-dedicated technicians. In 1988, he began operating a second company, dedicated to electrical-related training and known as Lighthouse Educational Services. Mr. Miller teaches custom-tailored classes and seminars covering various aspects of the *National Electrical Code* and NFPA 70E. Countless numbers of students have taken advantage of his extensive experience in electrical

contracting; regulatory exams (current electrical codes); electrical-related business and law; and electrical safety–related work practices. Class and seminar attendees have included individuals employed by companies such as Ford, Textron, the Aerostructures Corporation, Aladdin Industries, Lorillard Tobacco Company, Smith & Wesson, McKee Foods, Lockheed Martin, and Goodyear; by academic institutions such as Tennessee State University, Vanderbilt University, and Purdue University; and by governmental agencies including the National Aeronautics and Space Administration (NASA).

In 1999, Charles started writing and illustrating the "Code In Focus" column in *Electrical Contractor* magazine. His attention-to-detail illustrations and writing style make this one of the top, if not the top, read columns in the monthly magazine. Charles Miller started writing for NFPA in 2003. Titles include *Pocket Guide to Residential Electrical Installations, Pocket Guide to Commercial and Industrial Electrical Installations, NFPA's Electrical References, NFPA's Pocket Electrical References, Electrician's Exam Prep Manual, and Ugly's Electrical Safety and NFPA 70E.* Besides teaching, writing, and illustrating, Charles cohosted a home improvement radio talk show in Nashville, Tennessee, for more than three years.

Charles Miller has dedicated over 5000 hours to making *Illustrated Guide to the National Electrical Code* a reality. His unsurpassed attention to detail is evident on every page. Since this book's inception, every day's waking hours have been consumed with careful planning and execution of content and design. His unwavering commitment to quality, from the first page in Unit 1 to the last page in Unit 19, has produced a technically superior, quintessentially user-friendly guide.

Acknowledgments

I would like to say "thank you" to my children, Christin and Adam, for being patient and understanding during the extremely long hours and endless days working on this text. My mother, Evelyn Miller, gets a special "thank you" and "I love you" for a lifetime of support and encouragement. She called every day to check on me and quite often sent encouraging greeting cards that always came at just the right time. "Thank you" to my wife, Linda, for all your love and support as I spend long hours writing and illustrating. I would like to say thank you to my friend Daniel Sandefur for helping me revise *Illustrated Guide to the National Electrical Code*. With the countless hours Daniel spent working on this text, we have the best edition yet.

I also would like to thank the entire Cengage project team, comprising all those listed on the copyright page at the front of this book.

Last, but not least, the author and Cengage would like to thank the following reviewers for their contributions:

Jamil AL-Nouman
New Mexico State University

Matthew G. Alexander
Central Piedmont Community College

Thomas V Kennedy
Milwaukee Area Technical College

Heidi Peterson
Milwaukee Area Technical College

Jim Webb
College of Western Idaho

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SECTION 1

FOUNDATIONAL PROVISIONS

UNIT 1

Introduction to the *National Electrical Code®*

OBJECTIVES

After studying this unit, the student should be able to:

- relate a brief account of electricity in its infancy.
- identify the catalyst that brought about the *National Electric Code®* (*NEC*).
- explain how the *NEC* began and its purpose.
- explain how changes to the *Code* evolve.
- summarize the terminology, presentation, and format of the *NEC*.
- explain what type of information is found in the *NEC* (its layout).
- explain why the *NEC* is concerned with equipment and material standards.
- identify various trademark logos that denote listed and labeled products.
- describe role of nationally recognized testing laboratories (NRTL) and the National Electrical Manufacturers Association (NEMA) as well as the expanded role of the National Fire Protection Association (NFPA).
- explain this book's layout, text conventions, and illustration methods.
- describe how to study the *Illustrated Guide to the NEC*.
- recall that electrical requirements in addition to the *NEC* may exist, and if so, that compliance is required be aware that electrical requirements in addition to the *NEC* may exist, and if so, that compliance is required.

THE *NATIONAL ELECTRICAL CODE*

Just as an extensive education is required for doctors to perform the duties of their chosen field, a working knowledge of the *NEC* is a necessity for anyone practicing a profession in the electrical industry. The *NEC* provides the standards by which all electrical installations are judged. Although other requirements, such as local ordinances and manufacturer instructions, must be applied, the *NEC* is the foundation on which successful installations are built. It is the most widely recognized and used compilation of technical rules for the installation and operation of electrical systems in the world today. Because of its widespread effect on the industry, it is important to understand the history of the *NEC*.

The Beginning

In 1882, New York City was home to the first central-station electric generating plant developed by Thomas A. Edison. The Pearl Street Station began operation at 3:00 P.M. on Monday, September 4. Fifty-nine customers had reluctantly consented to have their houses wired on the promise of three free months of electric light. They were given the option of discarding the service if it proved to be unsatisfactory. But this new way of lighting was more than satisfactory . . . it was a sensation. The number of customers tripled in only four months. And, as they say, the rest is history. The new industry swept the nation: New construction included the installation of electricity, and property owners demanded that existing structures be updated as well. New materials and equipment were developed and manufactured, and methods for installing and connecting these items to the electrical source were devised. For more than a decade, manufacturers, architects, engineers, inventors, electricians, and others worked independently to develop their contributions to the new technology. By 1895, there were as many as five different electric installation codes in use, and no single set of codes was accepted by all. To further complicate matters, there was an unexpected hazard darkening the prospects of this new industry.

Purpose and History of the *NEC*

Electrically caused fires were becoming commonplace and, by 1897, the problem was reaching epidemic proportions. A diverse group of knowledgeable, concerned individuals assembled to address this critical issue. The need for standardization was apparent. The consensus of more than 1200 individuals produced the first set of nationally adopted rules to govern electrical installations and operations—the *National Electrical Code*. The original Code document was developed as a result of the united efforts of various insurance, electrical, architectural, and allied interests.

The *NEC* states its purpose as . . . *the practical safeguarding of persons and property from hazards arising from the use of electricity*. This objective has remained constant throughout the *NEC*'s existence, and the principles it contains continue to grow and change with the dynamic electrical industry.

Code Changes

The *NEC* is regularly revised to reflect the evolution of products, materials, and installation techniques. Since 1911, the National Fire Protection Association (NFPA) of Quincy, Massachusetts, has been responsible for the maintenance and publication of the *NEC*. NFPA is responsible for the maintenance and publication of over three-hundred codes, standards, recommended practices, and guides. The 2020 edition, which contains hundreds of reworded, as well as new, regulations, represents the diligent work of eighteen code-making panels and the technical correlating committee, composed strictly of volunteers from all professions within the electrical industry. The *National Electrical Code* has been revised every three years since 1975.

These panels are complemented by a host of private individuals who submit proposals or comment on proposals already submitted for changes to the *NEC*. Anyone who wishes to participate can contact the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471, and request a free booklet, "The NFPA Standards-Making System." The current edition of the *NEC* provides information in the back of the book for submitting public inputs and public comments for changes to the next edition, a copy of which is reproduced on the next page for your reference.

Now let us examine what is inside the *NEC* and how we can go about understanding it.

Submitting Public Input/Public Comment Through the Online Submission System

Following publication of the current edition of an NFPA standard, the development of the next edition begins and the standard is open for Public Input.

Submit a Public Input

NFPA accepts Public Input on documents through our online submission system at www.nfpa.org. To use the online submission system:

- Choose a document from the List of NFPA codes & standards or filter by Development Stage for "codes accepting public input."
- Once you are on the document page, select the "Next Edition" tab.
- Choose the link "The next edition of this standard is now open for Public Input." You will be asked to sign in or create a free online account with NFPA before using this system.
- Follow the online instructions to submit your Public Input (see www.nfpa.org/publicinput for detailed instructions).
- Once a Public Input is saved or submitted in the system, it can be located on the "My Profile" page by selecting the "My Public Inputs/Comments/NITMAMs" section.

Submit a Public Comment

Once the First Draft Report becomes available there is a Public Comment period. Any objections or further related changes to the content of the First Draft must be submitted at the Comment Stage. To submit a Public Comment follow the same steps as previously explained for the submission of Public Input.

NEC Terminology, Presentation, and Format

Tables present a requirement's multiple application possibilities.

Table 210.21(B)(3) Receptacle Ratings for Various Size Circuits

Circuit Rating (Amperes)	Receptacle Rating (Amperes)
15	Not over 15
20	15 or 20
30	30
40	40 or 50
50	50

Diagrams, or figures, are used to further clarify *NEC* applications.

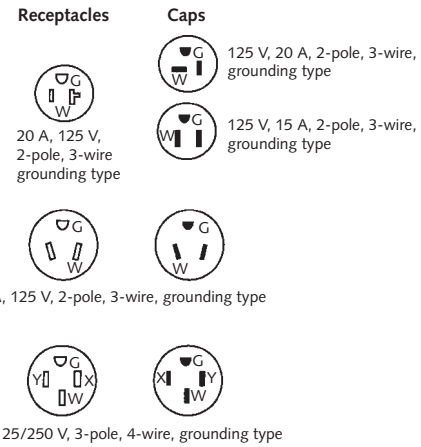


Figure 551.46(C)(1) Configurations for grounding-type receptacles and attachment plug caps used for recreational vehicle supply cords and recreational vehicle lots.

Formal Interpretations

Section 90.6 states: *To promote uniformity of interpretation and application of the provisions of this Code, formal interpretation procedures have been established and are found in the NFPA Regulations Governing Committee Projects.* (The NFPA Regulations Governing Committee Projects are in the NFPA Directory. Contact NFPA for a copy of this annual publication.)

Dictionary-style header—The left header shows the first section referenced, and the right header shows the last section referenced.

Informational Notes contain explanatory material such as references to other standards, references to related sections of the *Code*, or information related to a *Code* rule. These are informational only and do not require compliance »*90.5(C)*«.

Parts (subheadings) are used to break down articles into simpler topics. (Not all articles have subheadings.)

Sections are numerical listings where the *Code* requirements are located.

Δ This icon indicates text deletions and figure / table revisions.

Exceptions appear in *italics* and explain when and where a specific rule does not apply.

N This icon indicates new sections or new articles. These sections could be new or just moved from other sections.

• **Bullets** (solid black circles) indicate areas where one or more complete paragraphs have been deleted or moved since the last edition.

NFPA document number followed by a page number.

(E) Raceway Fittings. Raceway fittings used to support a luminaire(s) shall be capable of supporting the weight of the complete fixture assembly and lamp(s).

(F) Busways. Luminaires shall be permitted to be connected to busways in accordance with 368.17(C).

(G) Trees. Outdoor luminaires and associated equipment shall be permitted to be supported by trees.

Informational Note No. 1: See 225.26 for restrictions for support of overhead conductors.

Informational Note No. 2: See 300.5(D) for protection of conductors.

Part V. Grounding

410.40 General. Luminaires and lighting equipment shall be connected to an equipment grounding conductor as required in Article 250 and Part V of this article.

410.42 Luminaire(s) with Exposed Conductive Parts. Exposed conductive parts that are accessible to unqualified persons shall be connected to an equipment grounding conductor or be separated from all live parts and other conducting surfaces by a listed system of double insulation.

Small isolated parts, such as mounting screws, clips, and decorative bands on glass spaced at least 38 mm (1½ in.) from lamp terminals, shall not require connection to an equipment grounding conductor.

Portable luminaires with a polarized attachment plug shall not require connection to an equipment grounding conductor.

Δ **410.44 Methods of Grounding.** Luminaires and equipment shall be mechanically connected to an equipment grounding conductor as specified in 250.118 and sized in accordance with 250.122.

Exception No. 1: Replacement luminaires shall be permitted to connect an equipment grounding conductor in the same manner as replacement receptacles in compliance with 250.130(C). The luminaire shall then comply with 410.42.

Exception No. 2: Where no equipment grounding conductor exists at the outlet, replacement luminaires that are GFCI protected or do not have exposed conductive parts shall not be required to be connected to an equipment grounding conductor.

•*N* **410.46 Equipment Grounding Conductor Attachment.** Luminaires with exposed metal parts shall be provided with a means for connecting an equipment grounding conductor.

Part VI. Wiring of Luminaires

410.48 Luminaire Wiring — General. Wiring on or within luminaires shall be neatly arranged and shall not be exposed to physical damage. Excess wiring shall be avoided. Conductors shall be arranged so that they are not subjected to temperatures above those for which they are rated.

410.50 Polarization of Luminaires. Luminaires shall be wired so that the screw shells of lampholders are connected to the same luminaire or circuit conductor or terminal. The grounded conductor, where connected to a screw shell lampholder, shall be connected to the screw shell.

•

 Shaded text = Revisions. Δ =Text del

CAUTION

Be advised that the local authority having jurisdiction has the ability to amend the *Code* requirements. Consult the proper authority to obtain applicable guidelines.

Normal black letters are used for basic *Code* definitions and explanations.

Mandatory rules use the terms "shall" or "shall not" and require compliance »*90.5(A)*«.

Highlighted text within sections indicates changes, other than editorial, since the last *NEC* edition. The letter N with gray shading is placed in outside margins to identify new sections and for new articles.

Permissive rules contain the phrases "shall be permitted" or "shall not be required." These phrases normally describe options or alternative methods. Compliance is discretionary »*90.5(B)*«.

The *NEC* Layout

The table of contents in the *NEC* provides a breakdown of the information found in the book. Chapters 1 through 4 contain the most-often used articles in the *Code,* because they include general, or basic, provisions. Chapter 1, while relatively brief, includes definitions essential to the proper application of the *NEC*. It also includes an introduction and a variety of general requirements for electrical installations. More general requirements are found in Chapters 2, 3, and 4, addressing Wiring and Protection, Wiring Methods and Materials, and Equipment for General Use. Chapters 1 through 4 apply generally to all electrical installations.

Chapter 1 – General

Chapter 2 – Wiring and Protection

Chapter 3 – Wiring Methods and Materials

Chapter 4 – Equipment for General Use

Special issues are covered in Chapters 5 through 7. Chapter 5 contains information on Special Occupancies; Chapter 6, Special Equipment; and Chapter 7, Special Conditions. The contents of these chapters supplement or modify the general rules found in the first four chapters, as well as the rules found in Chapters 5, 6, and 7.

Chapter 5 – Special Occupancies

Chapter 6 – Special Equipment

Chapter 7 – Special Conditions

Chapter 8 is not subject to the requirements of Chapters 1 through 7 unless the requirements are specifically referenced in Chapter 8.

Chapter 8 – Communications Systems

The final chapter, Chapter 9, contains tables and examples. Provisions in this chapter are applicable as referenced. Each chapter contains one or more articles, and each article contains sections. Sections may be further subdivided by the use of lettered or numbered paragraphs.

Chapter 9 – Tables

Informative Annexes A through J

Informative Annex A through Informative Annex J follow Chapter 9. Non-mandatory information relative to the use of the *NEC* is provided in the informative annexes. Because nothing in the annexes is enforceable as requirements in the *NEC*, the annexes are like Informational Notes. The *Code* is completed by an index.

Informative Annexes A through J

WIRING SYSTEM PRODUCT STANDARDS

In addition to installation rules, the *NEC* is concerned with the type and quality of electrical wiring system materials. Two terms are synonymous with acceptability in this area: **labeled** and **listed.** Their definitions, found in *Article 100*, are very similar. Similarities within these definitions include: (1) an organization that is responsible for providing the listing or labeling, (2) that these organizations must be acceptable to the authority having jurisdiction, (3) that both are concerned with the evaluation of products, and (4) that both maintain periodic inspection of the production (or manufacturing) of the equipment or materials which have been listed or labeled. A manufacturer of labeled equipment (or material) must continue to comply with the appropriate standards (or performance) under which the labeling was granted. "Listed" also means that the equipment, materials, or services meet appropriate designated standards or have been tested and found suitable for a specified purpose. This information is compiled and published by the organization. The Informational Note under "Listed" states that each organization may have different means for identifying listed equipment. In fact, some do not recognize equipment as listed unless it is also labeled. Listed or labeled equipment must be installed and used as instructed »*110.3(B)*«.

The organizations described in the following directly affect the *Code* as it relates to equipment and material acceptability and play a role in developing and maintaining the standards set forth in the *NEC.*

Nationally Recognized Testing Laboratories

Prior to 1989, there were only two organizations perceived as capable of providing safety certification of products that would be used nationwide. Because there were only two, innovative technology was slow to be tested and approved. When Congress created the Occupational Safety and Health Administration (OSHA) in the early 1970s, OSHA was directed to establish safety regulations for the workplace and for the monitoring of those regulations. OSHA adopted an explanation from the *NEC* and included it in the *Code of Federal Regulations.* In part, it reads: "an installation or equipment is acceptable to the Assistant Secretary of Labor . . . if it is acceptable or certified, or listed, or labeled, or otherwise determined to be safe by a nationally recognized testing laboratory. . ." Informative Annex A in the back of the *National Electrical Code* provides a list of product safety standards used for product listing where that listing is required by the *NEC.*

Testing by a nationally recognized testing laboratory (NRTL) was specified in the Code of Federal Regulations, but requirements for becoming an NRTL had not yet been identified. Although OSHA introduced "Accreditation of Testing Laboratories" in 1973, the process through which a laboratory would receive accreditation was still missing. Cooperative efforts produced the OSHA regulation finalized in 1988, and called "OSHA Recognition Process for Nationally Recognized Testing Laboratories."

OSHA's NRTL program greatly benefits manufacturers by providing a system that certifies that a product meets national safety standards. Just as important, the door was opened for a greater number of laboratories to provide certification, and manufacturers are now better able to meet the demands of today's highly competitive market.

The aim of NRTLs is to ensure that electrical products properly safeguard against reasonable, identifiable risks. An extensive network of field personnel conduct unannounced inspections at manufacturing facilities that use the laboratory's "seal of approval." Some of the better-known trademarks of testing laboratories are shown below:

Source Interek.

Source MET Laboratories, Inc.

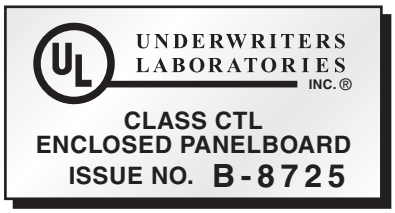
Source Underwriters Laboratories, Inc.

Source Antietam Compliance Company.

Source FM Global.

Source Interek.

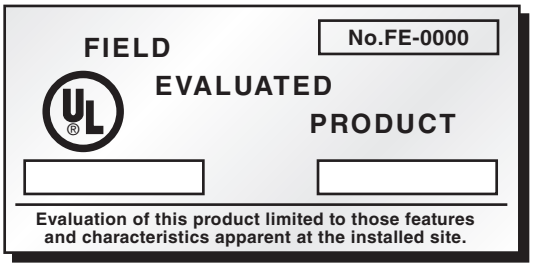
Some of the labels that appear on evaluated and certified electrical products, such as the ones that follow, carry the trademarks of the testing laboratory or the laboratory's standards being used for comparison.



Source Underwriters Laboratories, LLC.

Source Underwriters Laboratories, LLC.

Source Interek.



Source Underwriters Laboratories, LLC.

MET Laboratories

MET Laboratories, Inc., working with the Department of Labor as well as other agencies, served as a working example for the accreditation process for independent testing laboratories. In fact, MET became the first U.S. laboratory to successfully complete the process (1989), and thus became the first NRTL licensed by OSHA.

MET field inspectors interact with local electrical inspectors throughout the country to ensure product acceptance by all federal and state regulatory officials. The MET label is accepted by all fifty states, the federal government, and major retailers.

Underwriters Laboratories, Inc.

Prior to the formalization of NRTLs in 1989, electrical product standards were primarily written by Underwriters Laboratories, Inc. (UL), who also performed certification testing. Standards written by UL are still widely used. The appearance of the UL logo on a label indicates that the product complies with the UL standard. It does not mean, necessarily, that UL did the product testing. Although one of many NRTLs, Underwriters Laboratories is perhaps the most widely recognized and respected testing laboratory in operation today. Founded in 1894, UL is a not-for-profit corporation whose mission is to bring safer products to the marketplace and to serve the public through rigorous product safety testing. This organization offers a wide range of services, which include, but are not limited to, product listing, classification, component recognition, field certification, field engineering, facility registration, inspection, fact-finding, and research. As one can see from this list, UL plays a major role in guiding the safety of the electrical industry.

Intertek Testing Services

Select laboratories of Intertek Testing Services (ITS) have passed OSHA's stringent NRTL accreditation procedures and thereby have earned the right to issue product approvals and list products using the familiar ETL listed and CE marks. ITS has been conducting performance and reliability tests to nearly 200 safety standards applicable to workplace-related products since 1896. Intertek's comprehensive program includes testing, listing, labeling, and quarterly follow-up inspections. While recognized internationally by its many listed marks, the ETL listed mark is accepted throughout the United States, by all jurisdictions for electrical products, when denoting compliance with nationally recognized standards such as Wyle Laboratories (WL), International Electrotechnical Commission (IEC), UL, Canadian Standards Association (CSA), and FM Approvals (FM).

National Electrical Manufacturers Association

Founded in 1926, National Electrical Manufacturers Association (NEMA) comprises companies that manufacture equipment for all facets of electrical application, from generation through utilization. Its expansive objectives include product quality maintenance and improvement, safety standards for product manufacture and usage, and a variety of product standards, such as ratings and performance. NEMA contributes to the development of the *National Electrical Safety Code* as well as the *NEC.*

National Fire Protection Association

The NFPA, more than a century old, dedicates itself to safety standards, gathering statistical data, conducting research, providing crucial information on fire protection, prevention, and suppression methods, and much more. Boasting an internationally diverse membership of more than 75,000, this leading nonprofit organization publishes over 300 widely recognized consensus codes, standards, recommended practices, and guides including the *NEC.* Its primary pursuit is to protect lives and property from the often catastrophic hazards of fire.

THIS BOOK

The *Illustrated Guide to the NEC* is designed to teach through visualization. If a picture is truly worth a thousand words, this book should provide a more in-depth look at the *National Electrical Code* than can be found in any other single publication. Its highly detailed illustrations are complemented with concise, easy-to-understand written information. Not intended as a how-to book, the *Illustrated Guide to the NEC* instead strives to translate difficult material into simpler, straightforward principles. Once the reader understands how the *Code* translates in a specific area, the same techniques can be applied throughout.

Its Layout

Not only is the presentation of material in this text different from others on the market, but the organization of information also offers a new approach. After covering the fundamental provisions in the balance of Unit 1, this text proceeds to address code requirements by type of occupancy. Comprehensive information is given for one-family dwellings, multifamily dwellings, commercial locations, and special occupancies. To accomplish this task, information has been gathered logically from throughout the *Code* book and concentrated in one section, under the appropriate occupancy. Each occupancy type is broken down into its finite components, and each component is thoroughly discussed and illustrated (see table of contents).

Text Conventions

General text is grouped in small areas surrounding an illustration. **Notes** provide additional information considered relevant to the point being discussed. **Cautions** indicate that particular care is needed during application. **Warnings** indicate potential danger and are intended to prevent misunderstanding of a given rule.

Terms *Luminaire* and *Lighting Fixture*

The word *luminaire* is the international term for *lighting fixture*. As defined in *Article 100*, a luminaire is a complete lighting unit consisting of a light source such as a lamp or lamps, together with the parts designed to position the light

source and to connect it to the power supply. It may also include parts to protect the light source, ballast, or distribute the light. A lampholder itself is not a luminaire. Starting with the 2002 edition, *luminaire* became the main term and *fixture* or *lighting fixture* followed in parentheses. In the 2008 edition, *fixture* and *lighting fixture* were removed and do not follow the term *luminaire.* Throughout this text, *fixture* and *lighting fixture* have also been omitted.

Studying This Text

As the title implies, frequent references are made to the *National Electrical Code*. Keep a copy of the latest edition of the *Code* close at hand. Any confusion about terminology not cleared up by the "Definitions" section of this text may be explained by consulting the *Code's Article 100—Definitions* section. Whenever direct references are made to the *Code,* benefits will be gained by taking the time to read the suggested article or section. The *Illustrated Guide to the NEC* is not intended, in any way, to replace the *Code.* Each unit's "Competency Test" requires a thorough understanding of related *NEC* subject matter. Use of this text alone is insufficient to successfully complete the test. It is, however, intended as an indispensable supplement to the *NEC.*

Note that when comparing calculations made by both the English and metric systems, slight differences will occur due to the conversion method used. These differences are not significant, and calculations for both systems are, therefore, valid.

ADDITIONAL ELECTRICAL REQUIREMENTS

Local Ordinances

The importance of local (state, city, etc.) electrical codes cannot be overemphasized. Local agencies can adopt the *NEC* exactly as written or can amend the *Code* by incorporating more or less stringent regulations. While the *NEC* represents the minimum standards for safety, some jurisdictions have additional restrictions. Obtain a copy of additional requirements (if any) for your area.

Engineers or architects who design electrical systems may also set requirements beyond the provisions of the *NEC.* For example, an engineer might require the installation of 20-ampere circuits in areas where the *NEC* allows 15-ampere circuits. Requirements from engineers or architects are found in additional documents, such as the following.

Plans and Specifications

If plans and specifications are provided for a project by knowledgeable engineers or architects, this information must be considered and, if need be, compared to the requirements set forth by the *NEC.* It is unlikely that the plans or specifications provided by competent professionals will conflict with or contradict the *Code.* Nonetheless, it is best to be diligent in applying the governing principals of the *NEC.*

Manufacturer Instructions

Equipment or material may include instructions from the manufacturer. In accordance with 110.3(B), these instructions must be followed. For example, baseboard heaters generally include installation instructions. The *NEC* does not prohibit the installation of receptacle outlets above baseboard heaters, but the manufacturer's instructions may prohibit the installation of its heater below receptacles.

CONCLUSION

While this unit briefly discusses the history of the *National Electrical Code*, it is not possible to do justice to the importance of the *Code* in a few short pages. With only a glimpse into its history and present-day supporting structure, this text moves on to the task of understanding the contents of the *Code*. The *Illustrated Guide to the NEC* presents visually stimulating information in an occupancy-organized, concise format. To begin the journey through the 2017 edition of the *National Electrical Code*, simply turn the page, read, look, and understand.

Unit 1 Competency Test

NEC® Reference	Answer	
_____	_____	1. The National Fire Protection Association has acted as sponsor of the *National Electrical Code* since _____.
_____	_____	2. Informative Annex _____ provides a list of product safety standards used for product listing where that listing is required by the *NEC*.
_____	_____	3. Which chapters in the *NEC* apply generally to all installations?
_____	_____	4. Every three years, the *National Electrical Code* is revised, but the Code has only been on a three-year cycle since _____.
_____	_____	5. The purpose of the *National Electrical Code* is the practical safeguarding of _____ from hazards arising from the use of electricity.
_____	_____	6. The original Code document was developed in _____ as a result of the united efforts of various insurance, electrical, architectural, and allied interests.
_____	_____	7. Informative annexes are not part of the requirements of the *NEC* but are included for _____ only.
_____	_____	8. What city was home to the first central-station electric generating plant developed by Thomas A. Edison?
_____	_____	9. Chapter _____ consists of tables that are applicable as referenced.
_____	_____	10. In the *NEC*, UL is the abbreviation for _____.
_____	_____	11. Listed or labeled equipment shall be installed and used in accordance with any _____ included in the listing or labeling.

UNIT 2

SECTION ONE: FOUNDATIONAL PROVISIONS

Definitions

OBJECTIVES

After studying this unit, the student should be able to:

- explain the meaning of the term **accessible** (1) when applied to wiring methods and (2) when applied to equipment.
- identify accessible equipment that is not readily accessible.
- evaluate accurately a location as accessible, readily accessible, or not readily accessible.
- identify equipment classified as appliances.
- name the one required item and at least one other item that defines an area as a bathroom.
- list the four categories of branch circuits and their differences.
- distinguish the difference between the terms **enclosed** and **guarded**.
- determine whether a load is continuous or noncontinuous.
- explain the difference between branch-circuit conductors and feeder conductors.
- describe the differences between the terms associated with grounded and grounding.
- recall the maximum distance permitted for **within sight** situations.
- identify examples of damp, dry, and wet locations.
- determine which conductors are neutral conductors.
- explain the electrical vocabulary associated with the word **service**.
- clarify what constitutes a separately derived system.
- recall that the authority having jurisdiction (AHJ) could provide special permission, which is defined as **written consent**.

INTRODUCTION

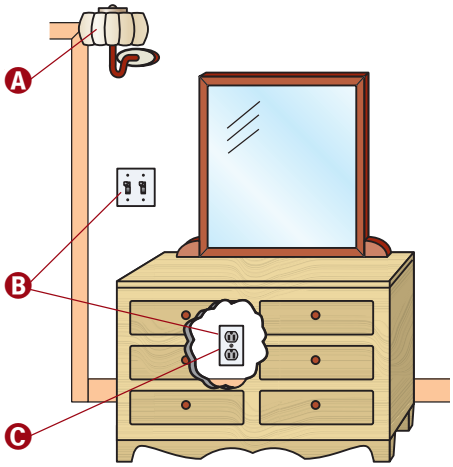
What is the difference between accessible and readily accessible? Which is appropriate in a given application? When sizing a branch circuit or feeder, is the electrical load considered continuous or noncontinuous? What is the difference between a damp location and a wet location? For a motor disconnecting means to be considered within sight of the motor, what is the maximum distance?

These and many other questions can be accurately answered only through a thorough understanding of *National Electrical Code® (NEC)* terminology. Knowing the correct definition of words and phrases as found in Article 100 is crucial to installing a hazard-free electrical system. Article 100 does not include commonly defined general or technical terms from related codes and standards. Normally, only terms used in two or more articles are defined in Article 100. Other terms are defined within the article in which they appear but may be referenced in Article 100. Part I of Article 100 contains definitions to be applied wherever the terms are used throughout the *NEC*. Part II contains definitions applicable only to the parts of articles specifically covering installations and equipment operating at over 1000 volts, nominal. Part III contains definitions applicable to Hazardous (Classified) Locations.

DEFINITIONS

Accessible (As Applied to Wiring Methods)

Wiring components are considered accessible when (1) access can be gained without damaging the structure or finish of the building or (2) they are not permanently closed in by the structure or finish of the building »*Article 100*«.



A Conductors in junction boxes behind luminaires are considered accessible if, by removing the luminaire, access to the conductors is available.

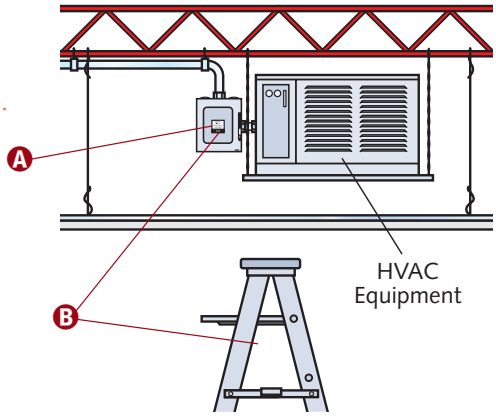
B Boxes, conduit bodies, and handhole enclosures shall be installed so that the wiring contained in them can be rendered accessible »*314.29*«. Conductors connected to switches and receptacles are accessible by removing the cover-plate and device.

C Receptacles behind furniture are accessible because the furniture can be moved.

NOTE

Unlike readily accessible, wiring methods meet the definition of being accessible if access to the wiring method can be gained by using tools to remove covers or by climbing on ladders.

Accessible (As Applied to Equipment)

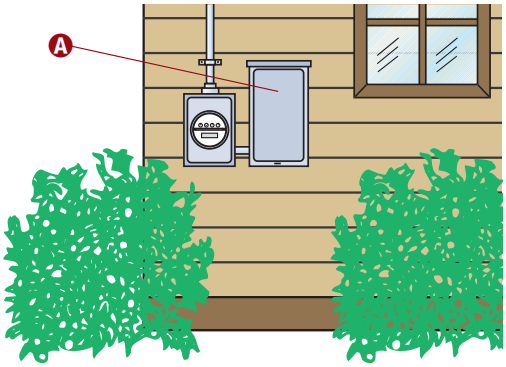


A **Accessible** equipment is equipment capable of being reached for operation, renewal, and inspection »*Article 100*«. Equipment installed in locations requiring the use of portable means, such as a ladder, is considered accessible, but not *readily* accessible.

B Overcurrent devices do not have to be **readily accessible** if located adjacent to the equipment where access is achieved by the use of portable means »*240.24(A)(4)*«.

Accessible, Readily (Readily Accessible)

Readily accessible means capable of being reached quickly (for operation, renewal, or inspections) without having to take actions such as to use tools (other than keys), to climb over or under, to remove obstacles, or resort to portable ladders, etc. »*Article 100*«.

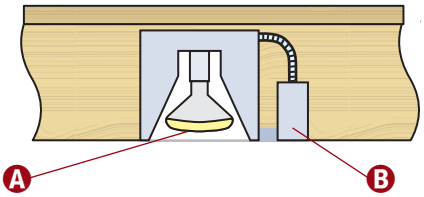


A The service disconnecting means must be readily accessible. It may be located either outside or inside, near the entry point of the service conductors »*230.70(A)(1)*«.

NOTE

Use of keys is a common practice under controlled or supervised conditions and a common alternative to the ready access requirements under such supervised conditions as provided elsewhere in the *NEC*.
»*Informational Note under Readily Accessible*«

Accessible



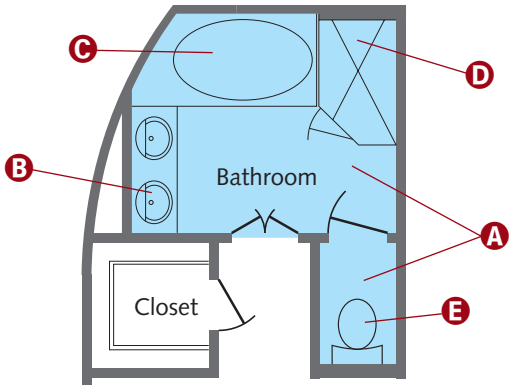
A Ready accessibility to wiring in luminaires is not required. In most cases, access can be gained through the use of a ladder, scaffolding, etc.

B Conductors within junction boxes of recessed luminaires can be accessed by removing part of the luminaire, such as trims, lamps, internal shells, etc.

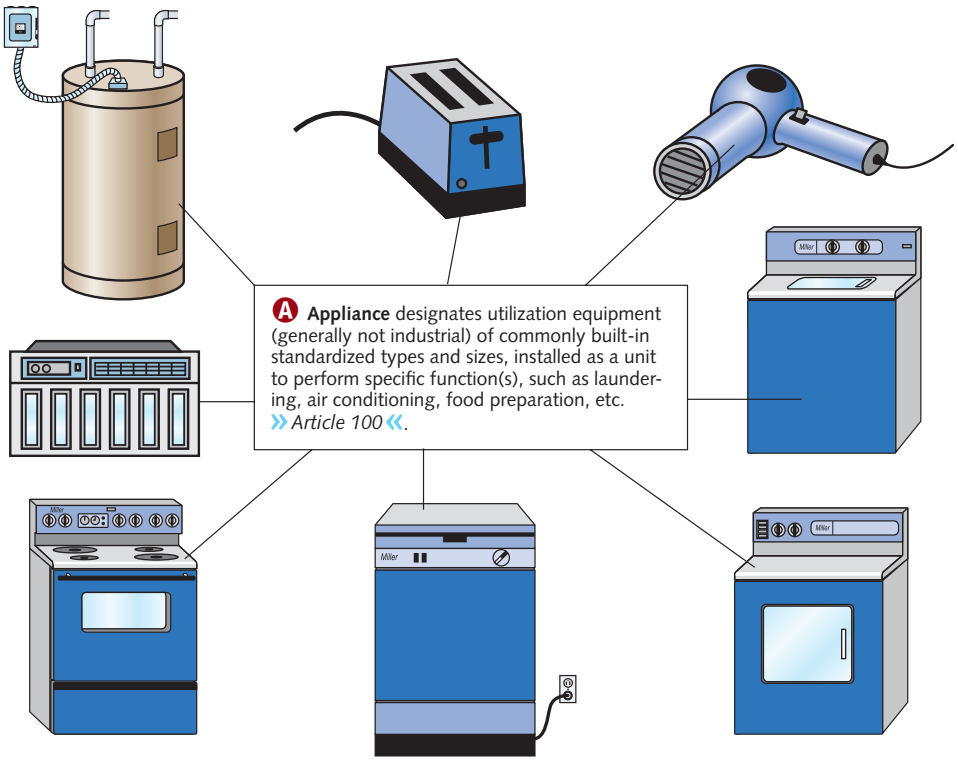
Bathroom

A bathroom is an area that includes a sink (basin) with one or more of the following: a toilet, a urinal, a tub, a shower, a bidet, or similar plumbing fixtures »*Article 100*«.

- **A** A bathroom is an area; it is not limited to a single room.
- **B** A bathroom includes at least one sink (basin).
- **C** An area having a sink and a tub is a bathroom.
- **D** An area having a sink and a shower is a bathroom.
- **E** An area having a sink and a toilet is a bathroom.



Appliance

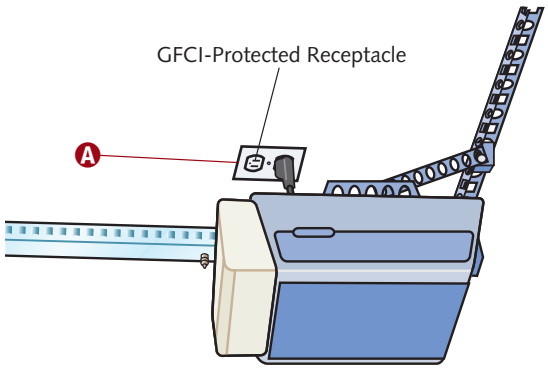


Not Readily Accessible

A While a ceiling receptacle installed for a garage door opener is not readily accessible, it is accessible. Even though this receptacle is not readily accessible, it must have ground-fault circuit-interrupter (GFCI) protection for personnel »*210.8(A)(2)*«.

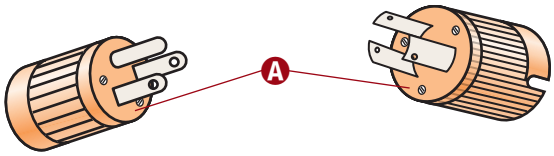
CAUTION

The ground-fault circuit interrupter shall be installed in a readily accessible location »*210.8*«.



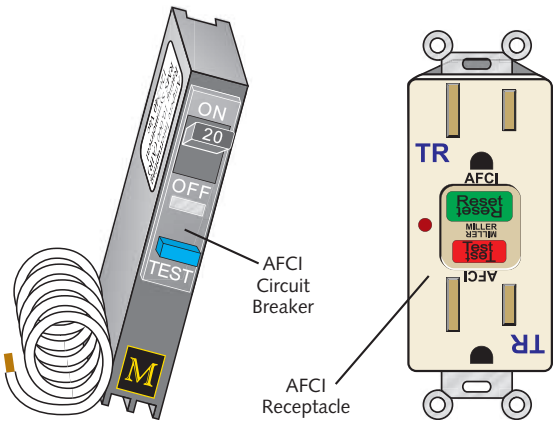
Attachment Plug (Plug Cap) (Plug)

A An attachment plug (plug cap) (plug) is a device that, when inserted into a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors permanently connected to the receptacle »*Article 100*«.



Arc-Fault Circuit Interrupter (AFCI)

A device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected »*Article 100*«.



Bonding Conductor or Jumper, Supply-Side Bonding Jumper, and Main Bonding Jumper

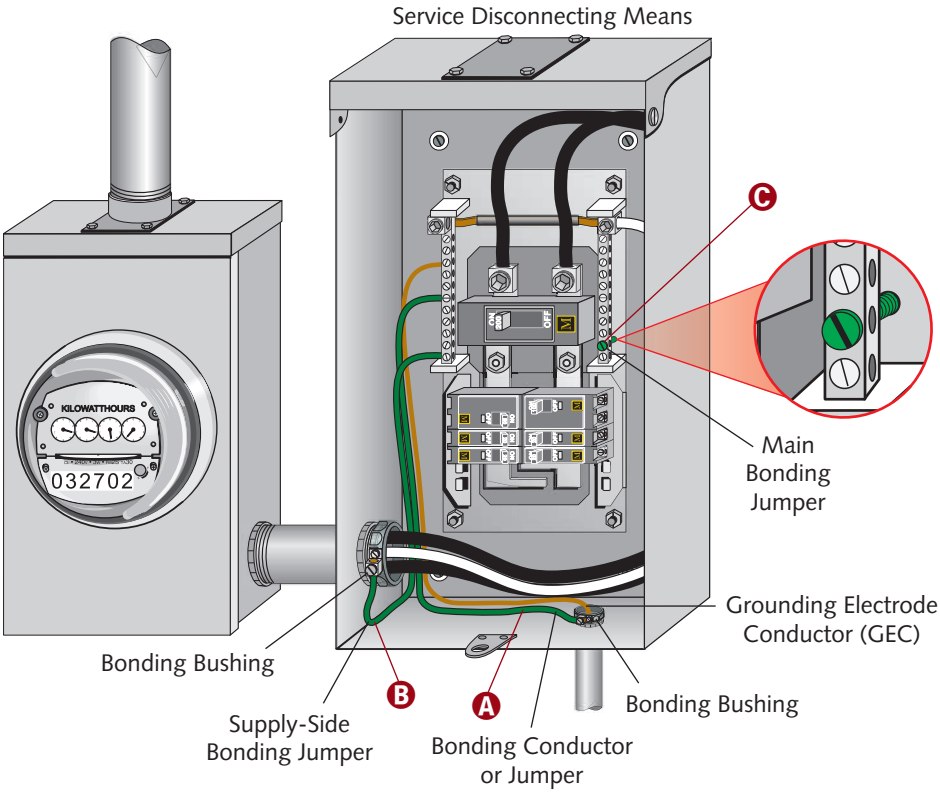
A When metal parts are required to be electrically connected, a reliable conductor (bonding jumper) is installed, thereby guaranteeing the required electrical conductivity »*Article 100*«.

B A supply-side bonding jumper is a conductor installed on the supply side of a service or within a service equipment enclosure(s) that ensures the required electrical conductivity between metal parts required to be electrically connected. A supply-side bonding jumper is also a conductor installed for a separately derived system that ensures the required electrical conductivity between metal parts required to be electrically connected »*Article 100*«.

C The main bonding jumper is the connection at the service between the grounded circuit conductor and the equipment grounding conductor or the supply-side bonding jumper, or both »*Article 100*«.

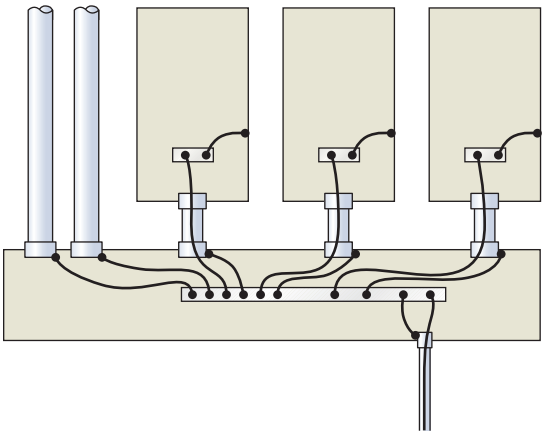
NOTE

Main bonding jumpers must be made of copper or other corrosion-resistant material. A wire, bus, screw, or similar suitable conductor is acceptable as a main bonding jumper »***250.28(A)***«.



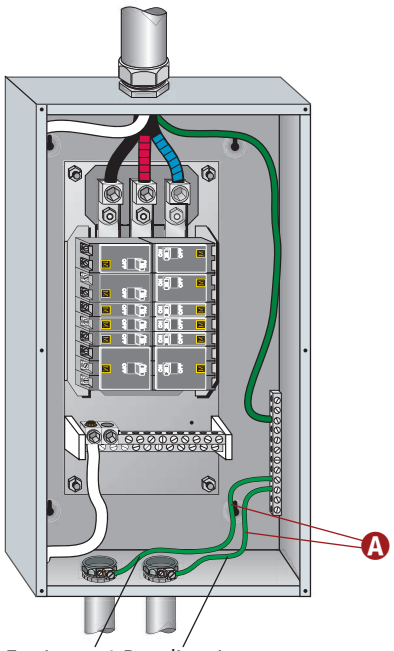
Bonded (Bonding)

Bonded is connected to establish electrical continuity and conductivity »*Article 100*«.



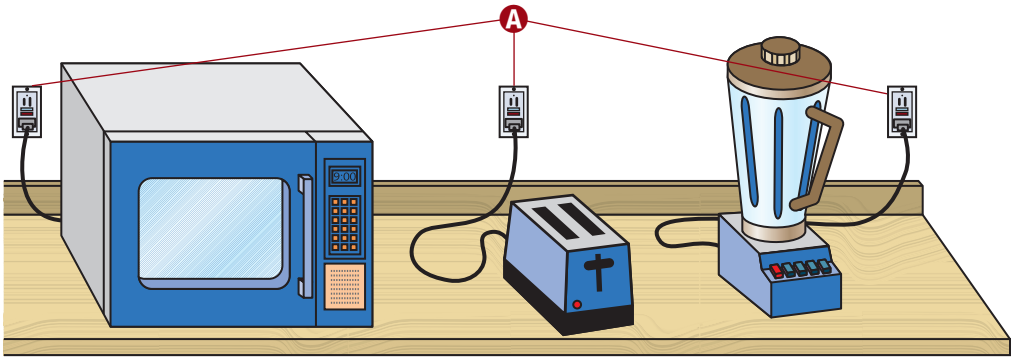
Bonding Jumper, Equipment

(A) An equipment bonding jumper is the connection between two or more portions of the equipment grounding conductor »*Article 100*«.



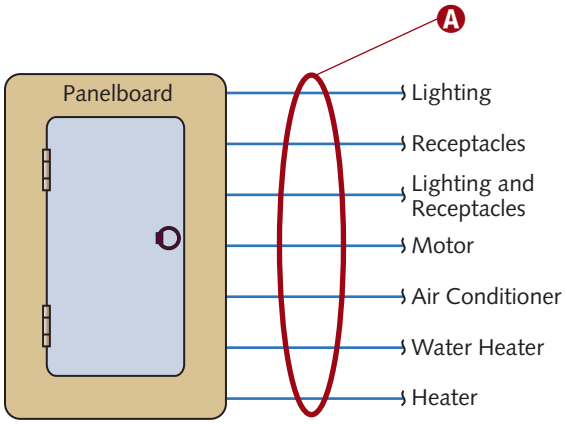
Branch Circuit, Appliance

(A) An appliance branch circuit supplies energy to one or more outlets for the purpose of connecting appliance(s). These circuits exclude the connection of luminaires unless they are part of the appliance being connected »*Article 100*«.



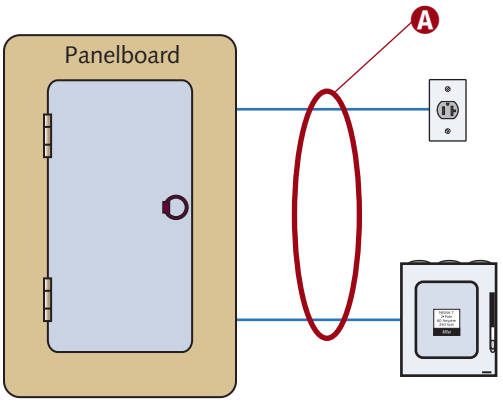
Branch Circuit

(A) The circuit conductors found between a circuit's final overcurrent protective device (such as the last fuse or circuit breaker) and the circuit's outlet(s) is called a branch circuit »*Article 100*«. Branch circuits are divided into four categories: appliance, general purpose, individual, and multiwire.



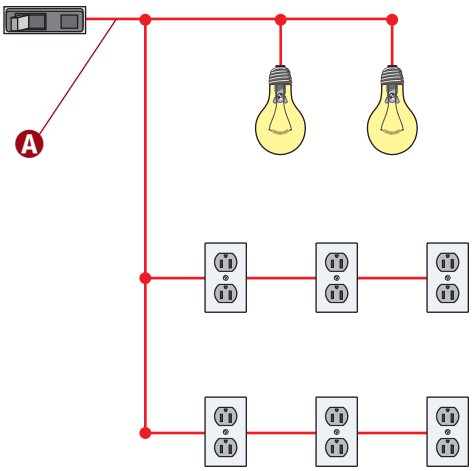
Branch Circuit, Individual

A An individual branch circuit supplies only one piece of utilization equipment »*Article 100*«.



Branch Circuit, General Purpose

A A general purpose branch circuit supplies two or more receptacles or outlets for lighting and appliances »*Article 100*«.



Branch Circuit, Multiwire

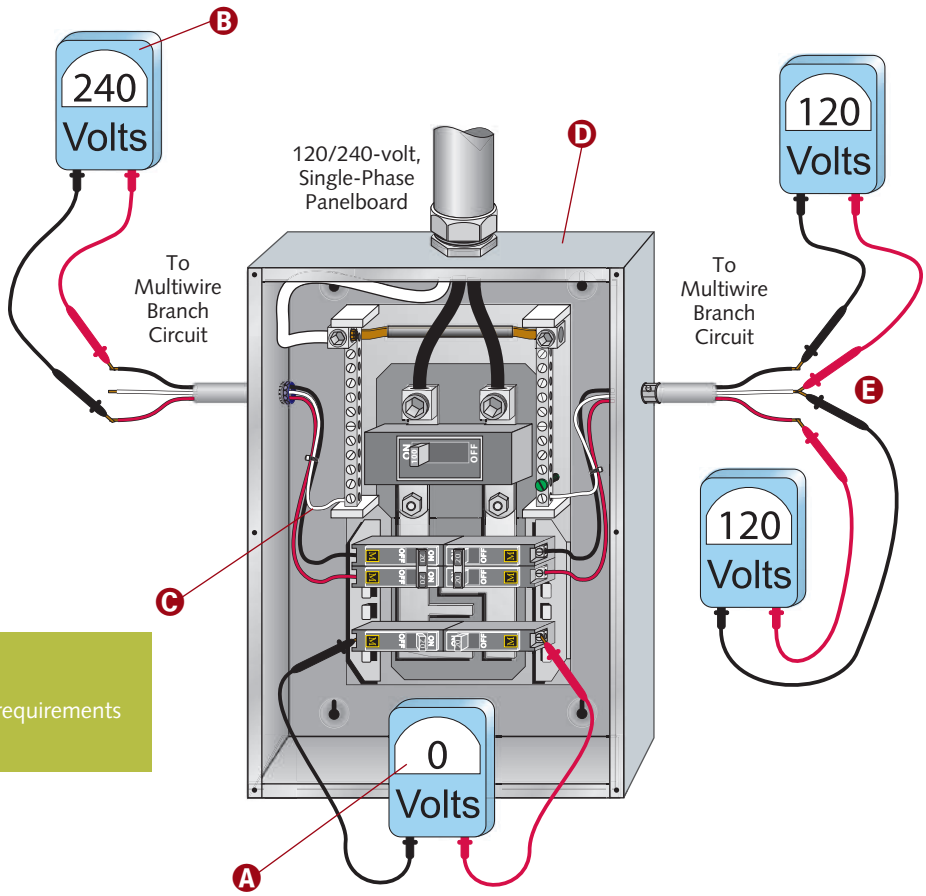
A A voltmeter will not register a voltage (potential difference) when connected to the same ungrounded (hot) phase. Therefore, a multiwire circuit must consist of conductors connected to different phases.

B A multiwire branch circuit consists of two or more ungrounded (hot) conductors that have a voltage between them »*Article 100*«. Additionally, see **C** and **E**.

C The one grounded (neutral) conductor of a multiwire circuit must be connected to the neutral or grounded conductor of the system »*Article 100*«. Additionally, see **B** and **E**.

D All conductors of a multiwire branch circuit must originate from the same panelboard or similar distribution equipment »*210.4(A)*«.

E There must be only one grounded (neutral) conductor, and there must be an equal voltage between it and each ungrounded conductor of the circuit »*Article 100*«. Additionally, see **B** and **C**.



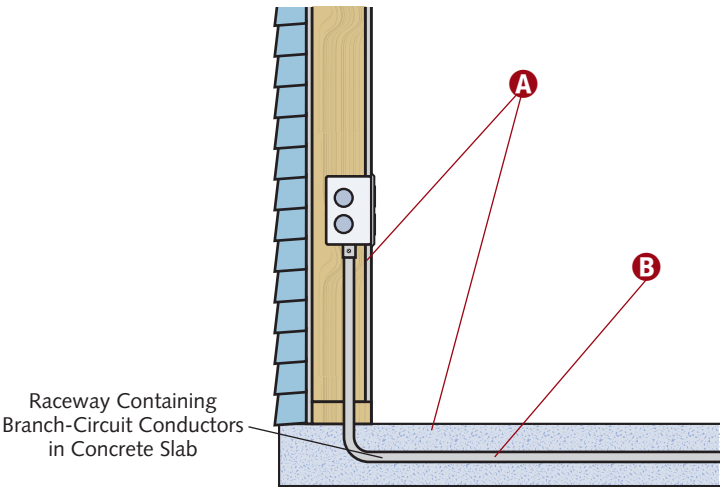
NOTE

See 210.4(A) through (D) for additional requirements for multiwire branch circuits.

Concealed

Ⓐ Concealed means rendered inaccessible by the structure or finish of the building »*Article 100*«.

Ⓑ Conductors in concealed raceways, even though they may become accessible by withdrawing them, are still considered concealed »*Informational Note under Concealed*«.



Receptacles on Multiwire Branch Circuits

A multiwire receptacle circuit consists of one (or more) duplex receptacles, one (or more) multiple receptacles, two (or more) single receptacles, or combinations thereof.

Ⓐ A duplex receptacle can be supplied by two branch circuits by removing the tab. This receptacle is fed from a multiwire branch circuit.

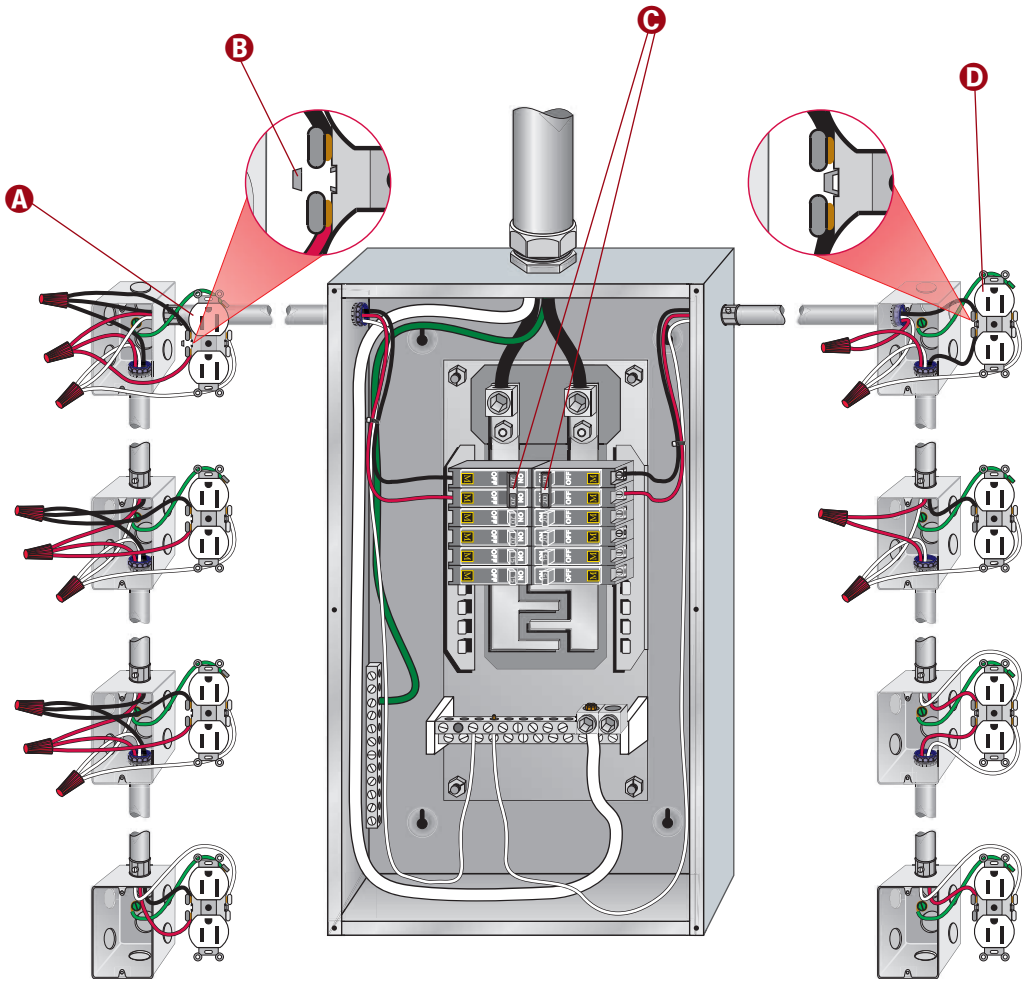
Ⓑ The tab has been removed to allow separate feed of each outlet.

Ⓒ Each multiwire branch circuit must be provided with a means that simultaneously disconnects all ungrounded (hot) conductors at the point where the branch circuit originates »*210.4(B)*«. This is accomplished through the use of either one double-pole breaker or two single-pole breakers with identified handle ties.

Ⓓ Although the box contains a multiwire branch circuit, only one ungrounded (hot) conductor is feeding this duplex receptacle.

WARNING

In multiwire branch circuits, the continuity of a grounded conductor shall not be dependent on the device »*300.13(B)*«. If breaking the grounded conductor at the receptacle breaks the circuit down the line, then the grounded conductors must not be connected to the receptacle. Simply splice the grounded conductors and install a jumper wire to the receptacle.



NOTE

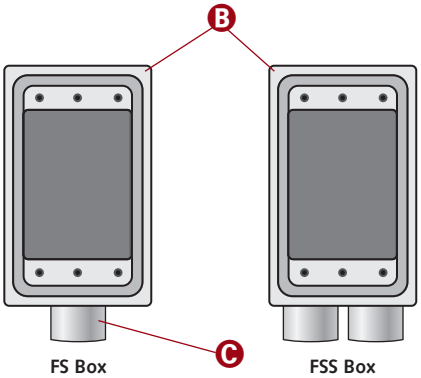
Switch-controlled split-wire duplex receptacle(s) are sometimes installed in lieu of a lighting outlet ***»210.70(A)(1) Exception No. 1«***. One half of the duplex receptacle is controlled by a wall switch, while the other half is a typical receptacle. A split-wire receptacle receiving power from a single source (one breaker or one fuse) is not a multiwire receptacle.

Conduit Body

A A conduit body is a separate portion of a conduit (or tubing) system providing access to the interior of the system through a removable cover(s) at a junction of multiple sections or at a terminal point of the system »*Article 100*«.

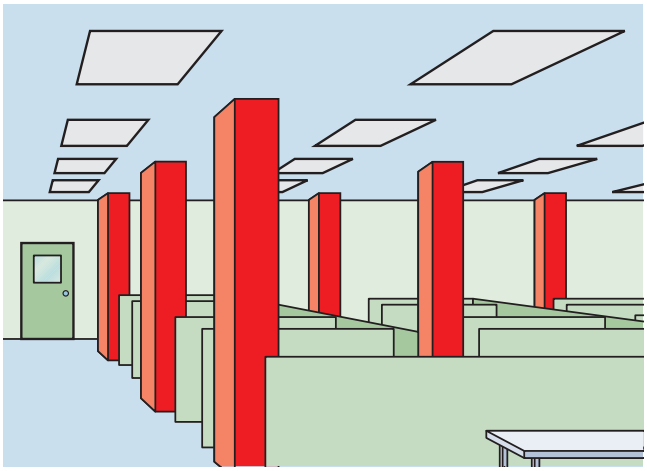
B FS, FD, and larger boxes (cast or sheet metal) are not classified as conduit bodies »*Article 100*«.

C A single conduit is not permitted as sole support for an FS-type or weatherproof junction box »*314.23(E)* and *314.23(F)*«.



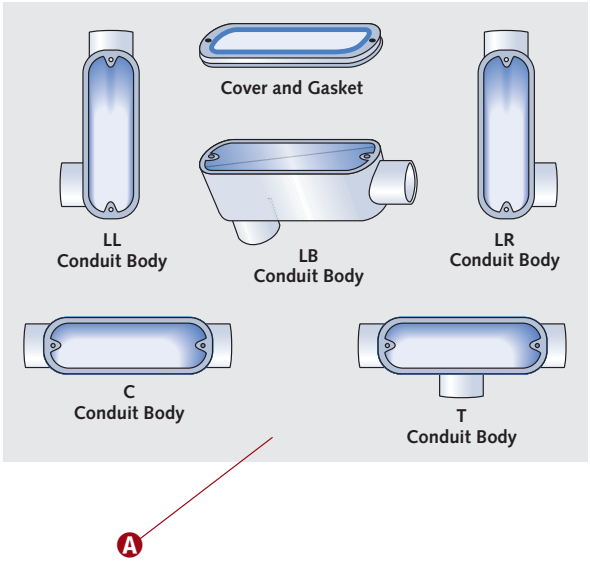
Continuous Load

A load having the maximum level of current sustained for three hours or more is referred to as a continuous load »*Article 100*«. Office lighting is an example of a continuous load.



Device

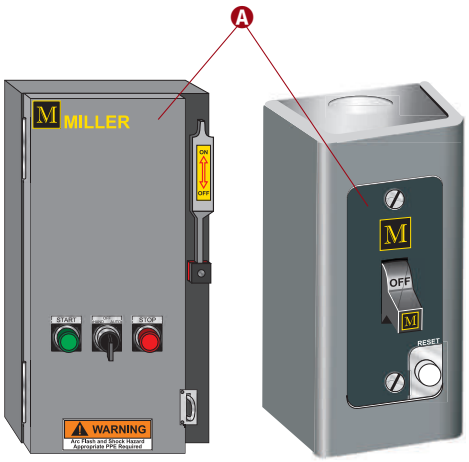
A A unit of an electrical system, other than a conductor, that carries or controls electrical energy as its principal function is known as a device »*Article 100*«.

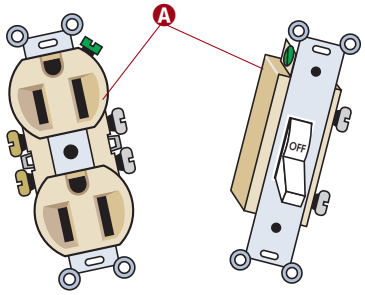


Controller

A controller is a device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected »*Article 100*«.

A The *NEC* refers to these as controllers. Out in the field, these are called motor starters or starters.





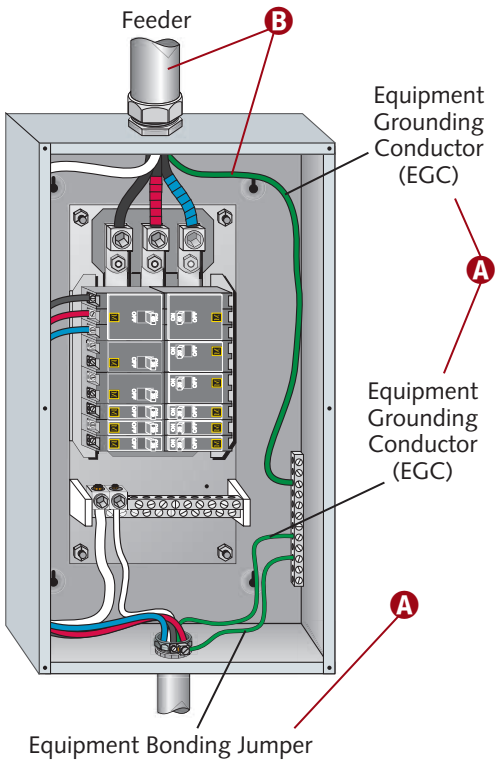
Effective Ground-Fault Current Path

A An effective ground-fault current path is an intentionally constructed, low-impedance electrically conductive path designed and intended to carry current under ground-fault conditions from the point of a ground fault on a wiring system to the electrical supply source. The reason for this intentionally constructed, low-impedance electrically conductive path is to facilitate the operation of the overcurrent protective device or ground-fault detector during a ground-fault condition »*Article 100*«.

B A ground-fault current path is defined as an electrically conductive path from the point of a ground fault on a wiring system through normally non–current-carrying conductors, equipment, or the earth to the electrical supply source. Examples of ground-fault current paths are any combination of equipment grounding conductors, metallic raceways, metallic cable sheaths, electrical equipment, and any other electrically conductive material such as metal, water, and gas piping; steel framing members; stucco mesh; metal ducting; reinforcing steel; shields of communications cables; and the earth itself »*Article 100*«.

NOTE

Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground-fault detector. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault may occur to the electrical supply source. The earth shall not be considered as an effective ground-fault current path »*250.4(A)(5)*«.



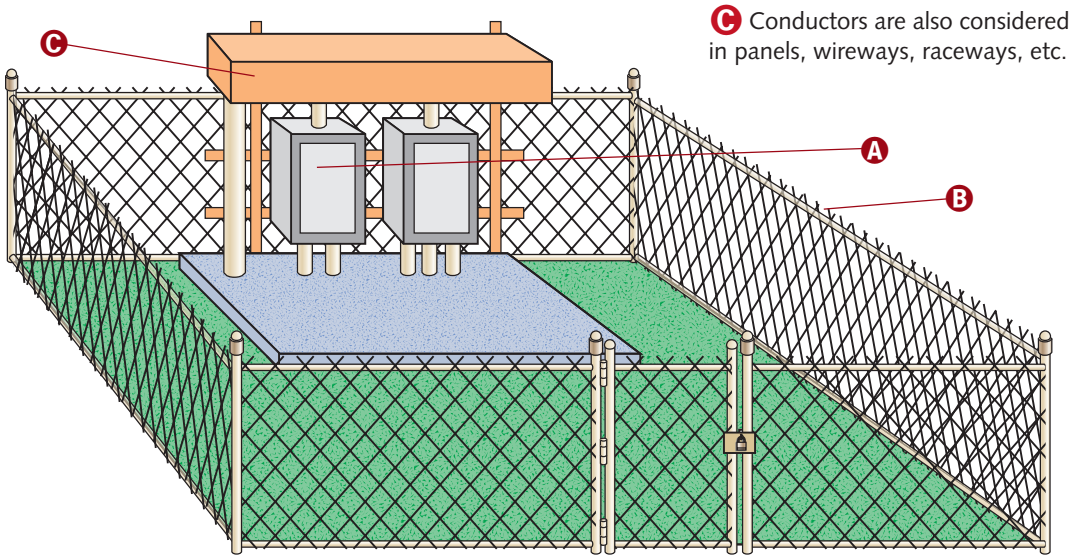
Enclosed

Equipment, conductors, etc., surrounded by a case, housing, fence, or walls that prevent persons from accidentally contacting energized parts are referred to as enclosed »*Article 100*«.

A Panelboards located within cabinets or cutout boxes are considered enclosed.

B Electrical equipment installed within the perimeter of a fence, or similar area, qualifies as enclosed.

C Conductors are also considered enclosed when installed in panels, wireways, raceways, etc.

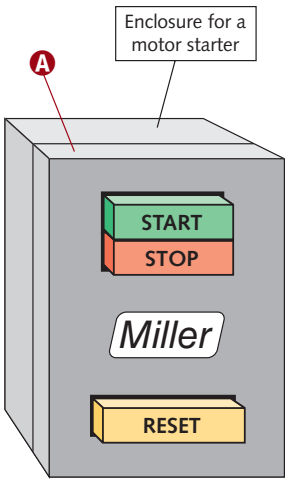


Enclosure

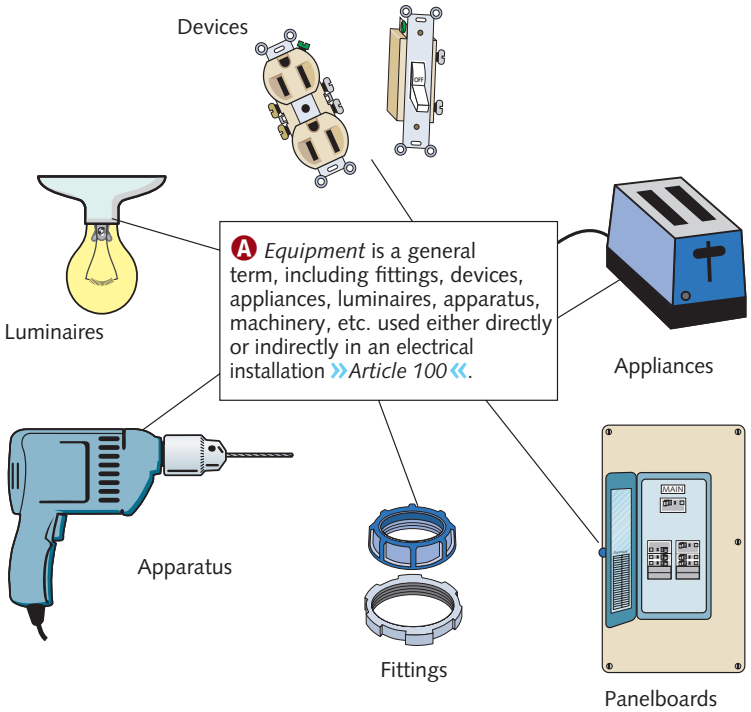
(A) Any case, housing, apparatus, fence, or walls surrounding an installation, designed to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage, serves as an enclosure »*Article 100*«.

NOTE

See Table 110.28 in the *NEC* for examples of enclosure types.



Equipment

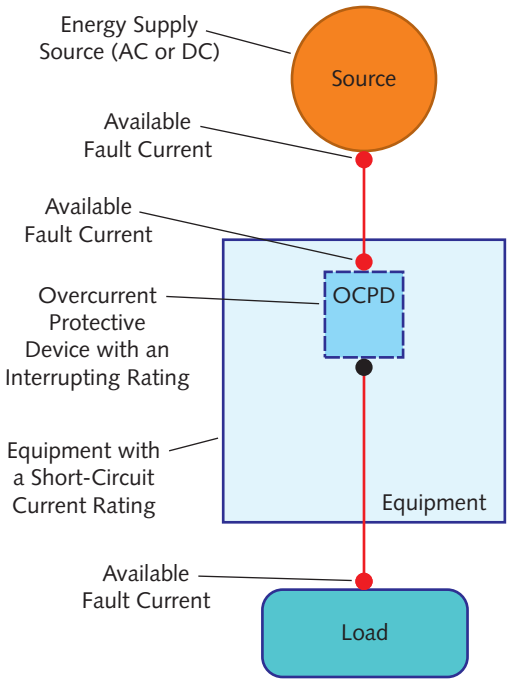


Available Fault Current

Available fault current is the largest amount of current capable of being delivered at a point on the system during a short-circuit condition »*Article 100*«. A short-circuit can occur during abnormal conditions such as a fault between circuit conductors or a ground fault »*Informational Note under Available Fault Current*«.

NOTE

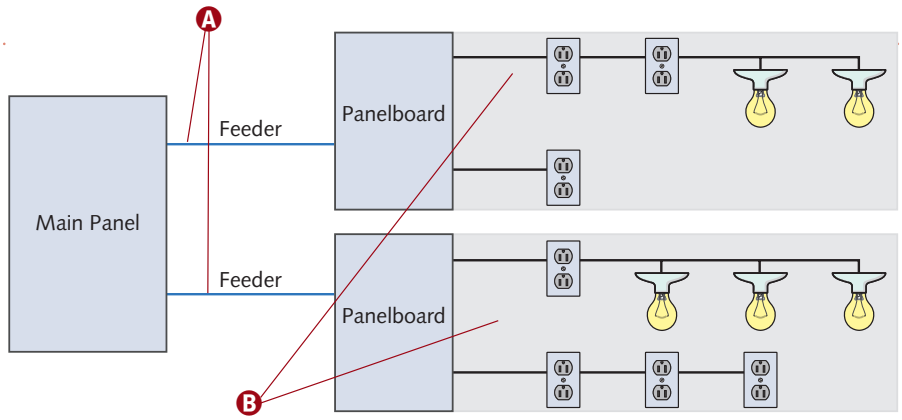
Fault current is the current delivered at a point on the system during a short-circuit condition »*Article 100*«.



Feeder

A A feeder consists of all circuit conductors located between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device »*Article 100*«.

B Branch circuits (see definition).

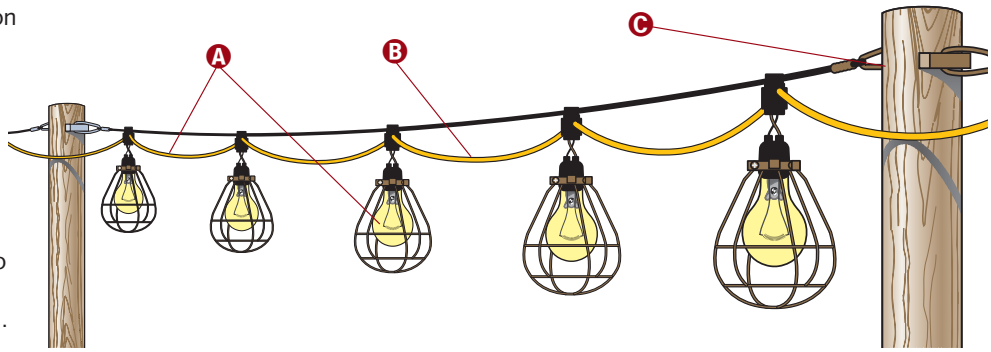


Festoon Lighting

A Festoon lighting is a string of outdoor lights suspended between two points »*Article 100*«.

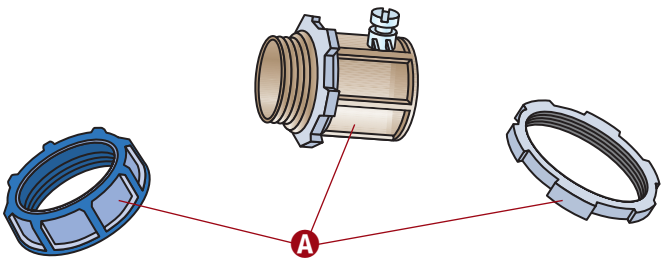
B Overhead conductors for festoon lighting shall not be smaller than 12 AWG unless supported by messenger wires »*225.6(B)*«.

C Messenger wire, together with strain insulators, shall be used to support conductors in all spans exceeding 40 ft (12 m) in length. Conductors shall not be attached to any fire escape, downspout, or plumbing equipment »*225.6(B)*«.



Fitting

A A fitting is an accessory such as a locknut, bushing, or other part of a wiring system whose function is primarily mechanical, rather than electrical, in nature »*Article 100*«.



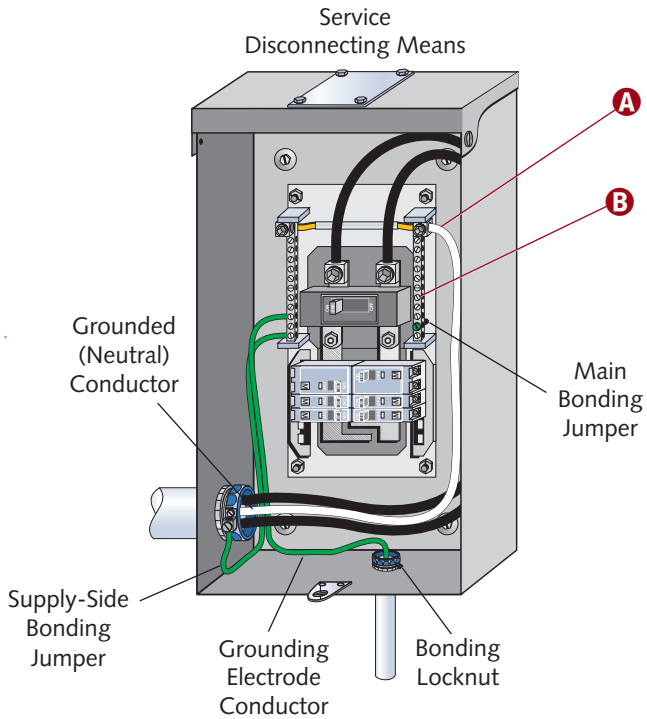
Grounded and Grounded Conductor

A A grounded conductor is a system or circuit conductor that is intentionally grounded »*Article 100*«.

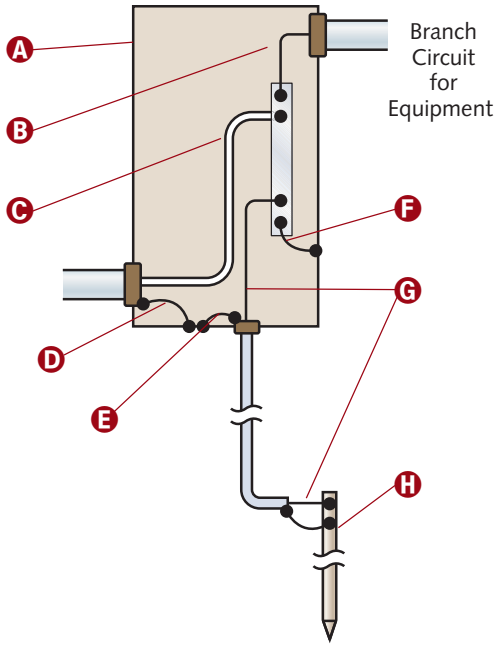
B Grounded (grounding) is defined as being connected to ground or to a conductive body that extends the ground connection »*Article 100*«.

NOTE

Ground is defined as the earth »*Article 100*«.



Grounding Electrode, Grounding Electrode Conductor, and Equipment Grounding Conductor (EGC)



A Main service equipment

B The conductive path(s) that is part of an effective ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor, the grounding electrode conductor, or both is called an equipment grounding conductor »*Article 100*«.

C System grounded (neutral) conductor

D Supply-side bonding jumper

E Bonding jumper or conductor

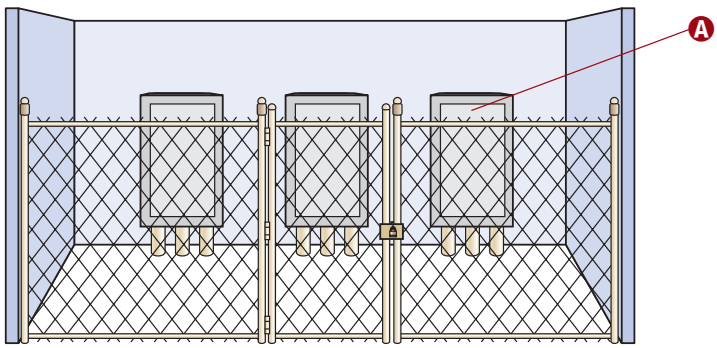
F Main bonding jumper

G The grounding electrode conductor is the conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system »*Article 100*«.

H A grounding electrode is a conducting object that establishes a direct connection to earth »*Article 100*«.

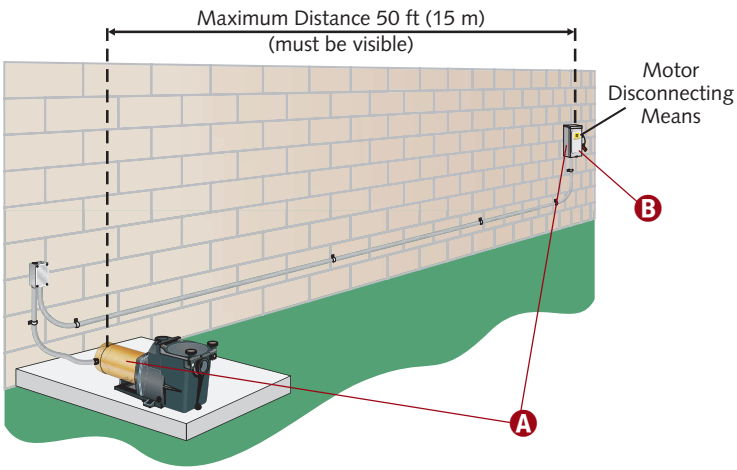
Guarded

Guarded is defined as covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms effectively removing the likelihood of approach or contact by persons or objects »*Article 100*«.



A Panelboards having doors or covers are considered guarded.

In Sight From (Within Sight From, Within Sight)



A The *NEC* terms *in sight from, within sight from,* or *within sight,* etc., applied to equipment indicate that the specified items of equipment are visible and are not more than 50 ft (15 m) apart »*Article 100*«.

B A motor disconnecting means must be located in sight from the motor location as required by 430.102(B).

Industrial Control Panel

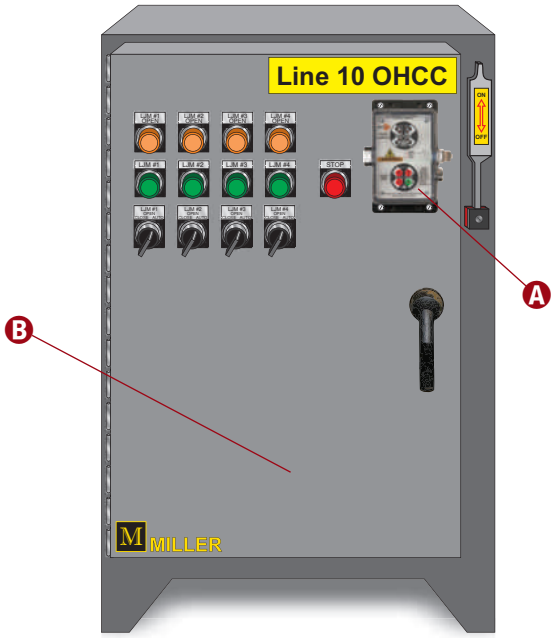
An industrial control panel is an assembly of two or more components consisting of one of the following: (1) power circuit components only, such as motor controllers, overload relays, fused disconnect switches, and circuit breakers; (2) control circuit components only, such as push buttons, pilot lights, selector switches, timers, switches, and control relays; and (3) a combination of power and control circuit components »***Article 100***«**.**

A The power and control circuit components, with associated wiring and terminals, are mounted on, or contained within, an enclosure or mounted on a subpanel »*Article 100*«.

B The industrial control panel does not include the controlled equipment »*Article 100*«.

NOTE

Requirements for industrial control panels are in Article 409. Article 409 covers industrial control panels intended for general use and operating at 1000 volts or less »***409.1***«.



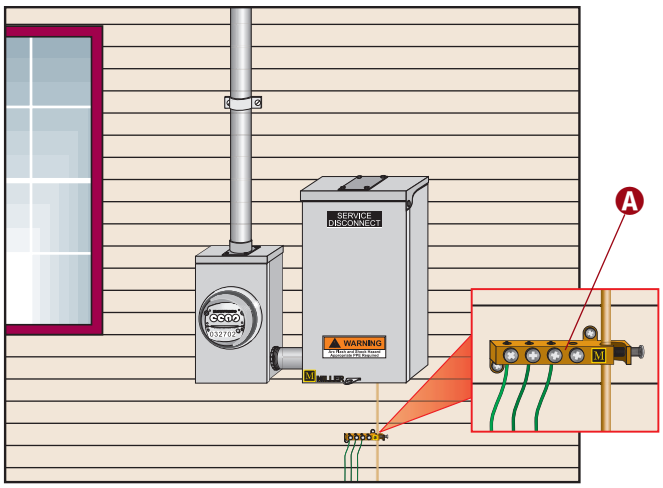
Industrial Control Panel

Intersystem Bonding Termination

A An intersystem bonding termination is a device that provides a means for connecting intersystem bonding conductors for communications systems to the grounding electrode system »*Article 100*«.

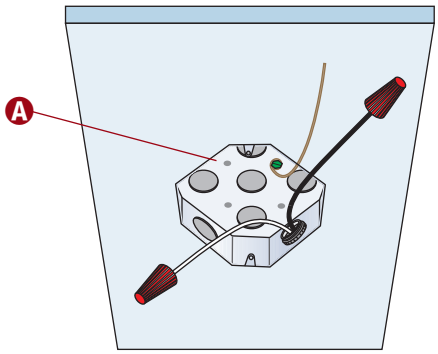
NOTE

For intersystem bonding termination requirements, see Unit 9 Services and Electrical Equipment.



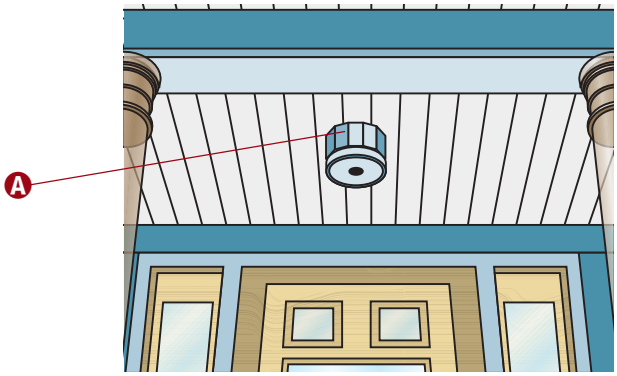
Lighting Outlet

A An outlet intended for the direct connection of a lampholder or luminaire is called a lighting outlet »*Article 100*«.



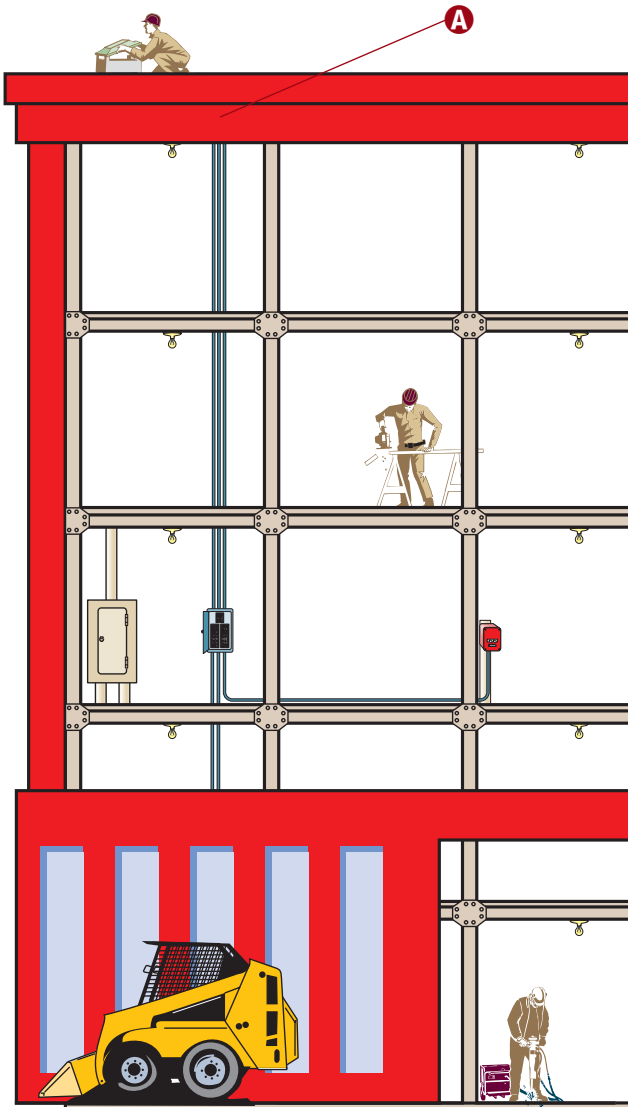
Location, Damp

(A) Damp locations are those subject to moderate degrees of moisture. Damp locations are those protected from weather and not subject to saturation with water or other liquids. Examples of such locations include partially protected locations under canopies, marquees, roofed (open) porches, and similar sites as well as interior locations subject to moderate degrees of moisture such as some basements, some barns, and some cold-storage warehouses »*Article 100* and *Informational Note*«.



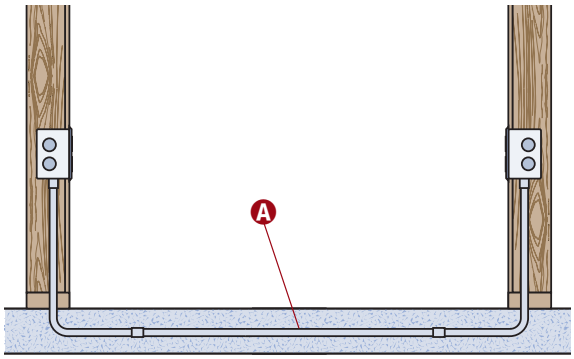
Location, Dry

(A) Dry locations are those not normally subject to moisture, except on a temporary basis such as a building under construction »*Article 100*«.



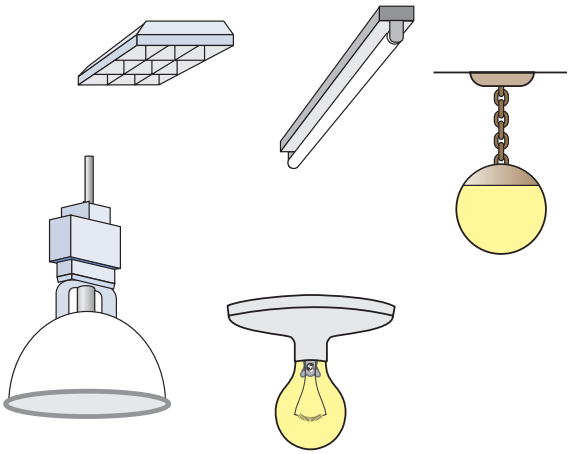
Location, Wet

(A) Installations in any of the following categories are wet locations: underground, within concrete slabs, in masonry (directly contacting the earth), in areas subject to saturation (water or other liquids), and in locations unprotected from weather »*Article 100*«.



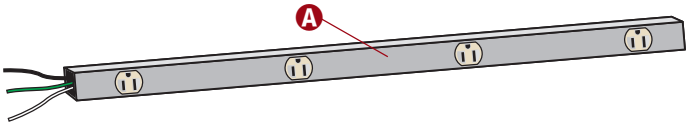
Luminaire

A luminaire is a complete lighting unit consisting of a light source such as a lamp or lamps, together with the parts designed to position the light source and to connect it to the power supply. It may also include parts to protect the light source, ballast, or distribute the light. A lampholder itself is not a luminaire.



Multioutlet Assembly

Ⓐ A surface, flush, or freestanding raceway designed to hold conductors and receptacles (assembled in the field or at the factory) is called a multioutlet assembly »*Article 100*«.



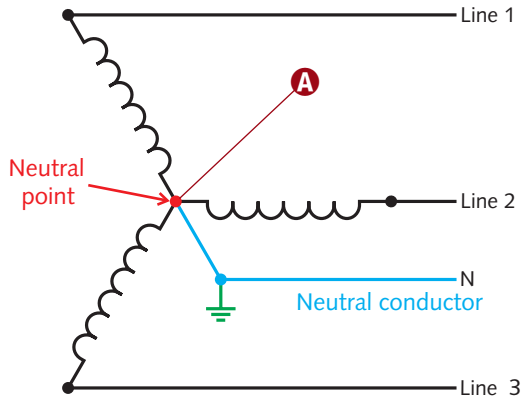
Neutral Conductor and Neutral Point

A neutral conductor is defined as the conductor connected to the neutral point of a system that is intended to carry current under normal conditions »*Article 100*«.

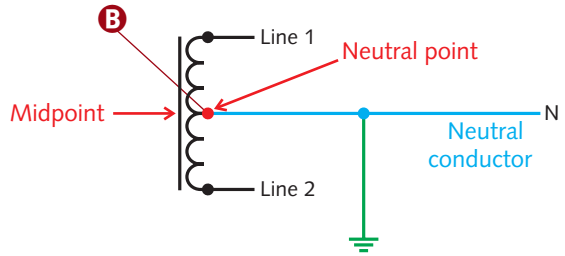
The neutral point is the common point on a wye-connection in a polyphase system or midpoint on a single-phase, 3-wire system, or midpoint of a single-phase portion of a 3-phase delta system, or a midpoint of a 3-wire, direct-current system »*Article 100*«.

Ⓐ The neutral point is the common point on a wye-connection in a polyphase system.
Ⓑ The neutral point is the midpoint on a single-phase, 3-wire system.
Ⓒ The neutral point is the midpoint of a single-phase portion of a 3-phase delta system.
Ⓓ The neutral point is the midpoint of a 3-wire direct-current system.

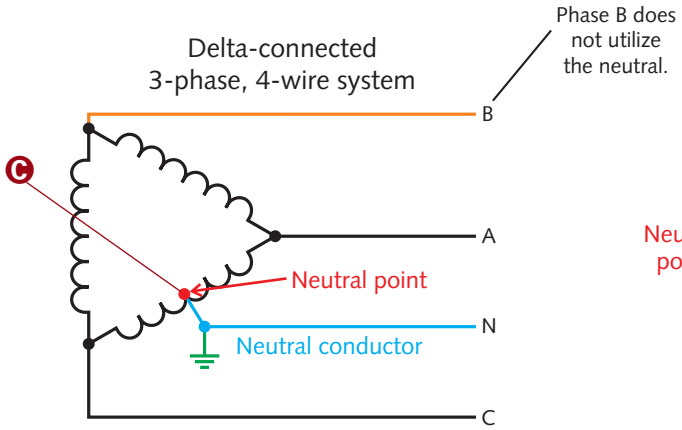
Wye-connected,
3-phase, 4-wire system



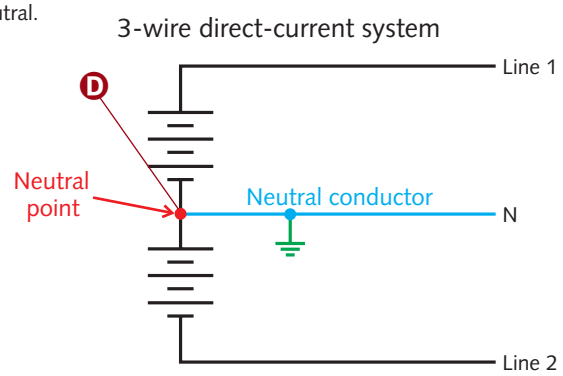
120/240 volt, single-phase, 3-wire system



Delta-connected
3-phase, 4-wire system



3-wire direct-current system



NOTE

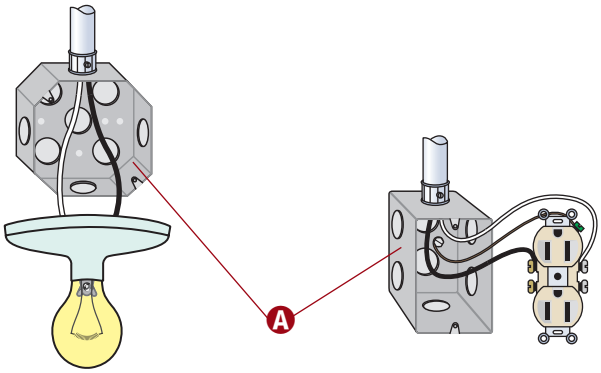
At the neutral point of the system, the vectorial sum of the nominal voltages from all other phases within the system that utilize the neutral, with respect to the neutral point, is zero potential ***»Informational Note to neutral point in Article 100«***.

WARNING

Neutral conductors must be identified in accordance with the requirements in 200.6.

Outlet

A point in a wiring system from which current is taken to supply utilization equipment is known as an outlet »*Article 100*«.



Overcurrent Protective Device, Branch-Circuit

A branch-circuit overcurrent protective device is a device capable of providing protection for service, feeder, and branch circuits and equipment over the full range of overcurrents between its rated current and its interrupting rating. Such devices are provided with interrupting ratings appropriate for the intended use but no less than 5000 amperes »*Article 100*«.

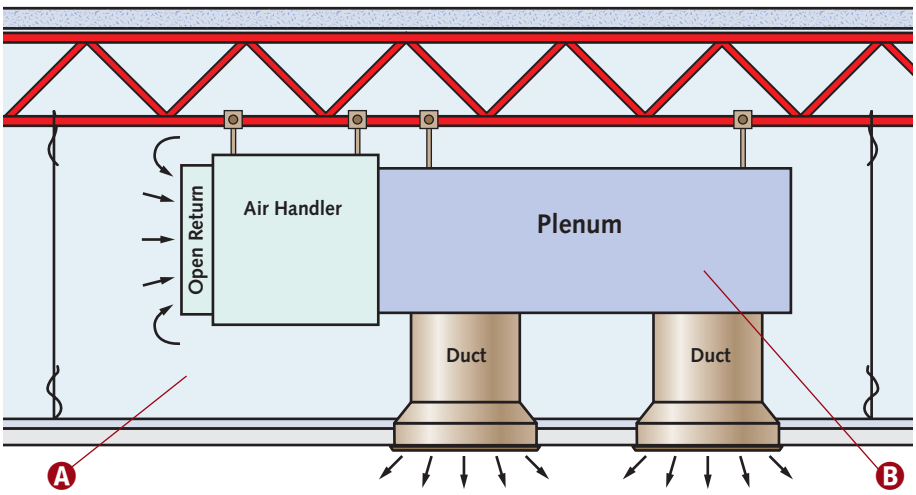
NOTE

A supplementary overcurrent protective device is a device intended to provide limited overcurrent protection for specific applications and utilization equipment such as luminaires and appliances. This limited protection is in addition to the protection provided in the required branch circuit by the branch-circuit overcurrent protective device »*Article 100*«. An in-line fuse is an example of a supplementary overcurrent device.

Plenum

A The space above a suspended ceiling used for environmental air-handling purposes is an example of **other space used for environmental air (plenum)** as described in 300.22(C).

B A compartment or chamber having one or more attached air ducts and forming part of the air distribution system is known as a plenum »*Article 100*«.

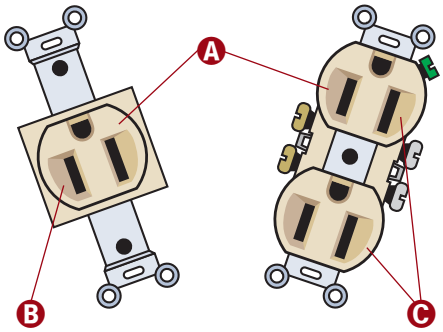


Receptacle

A A contact device installed at an outlet for the connection of an attachment plug or for the direct connection of electrical utilization equipment designed to mate with the corresponding contact device is a receptacle »*Article 100*«.

B A single receptacle is a single contact device with no other contact device on the same yoke or strap »*Article 100*«.

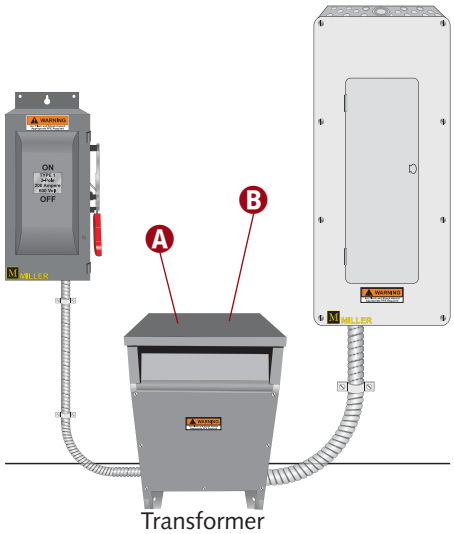
C A multiple receptacle is two or more contact devices on the same yoke or strap »*Article 100*«.



Separately Derived System

(A) Article 450 contains provisions for transformers.

(B) A separately derived system is an electrical source, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections »*Article 100*«.



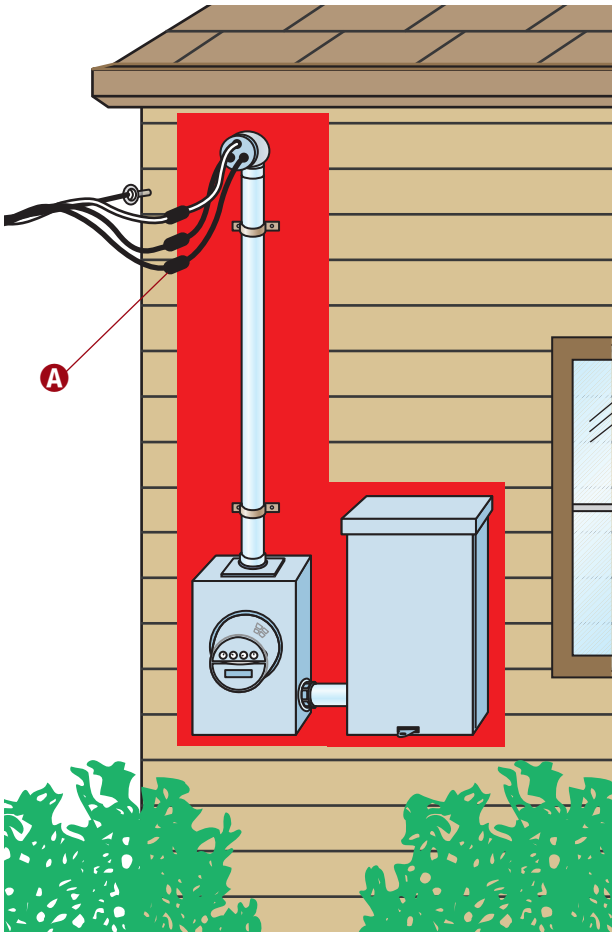
Transformer

NOTE

An alternate ac power source, such as an on-site generator, is not a separately derived system if the grounded conductor is solidly interconnected to a service-supplied system grounded conductor »***250.30 Informational Note No. 1***«.

Service

(A) The conductors and equipment connecting the serving utility to the wiring system of the premises served is called the service »*Article 100*«.

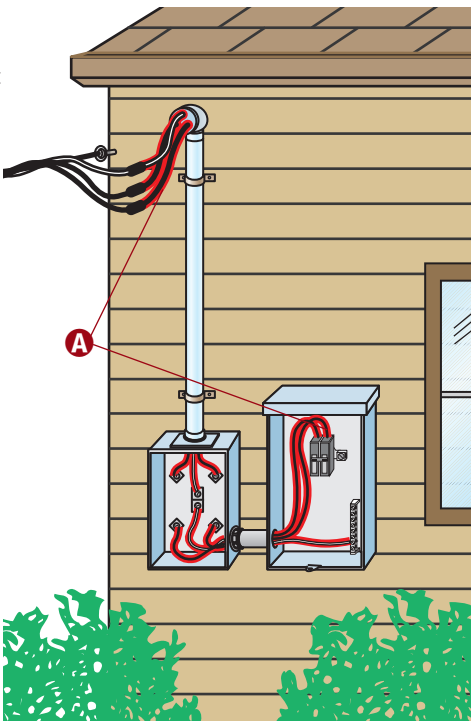


NOTE

Conductors and equipment are also defined as a service where receiving power underground.

Service Conductors

(A) The conductors from the service point to the service disconnecting means are known as service conductors »*Article 100*«.



NOTE

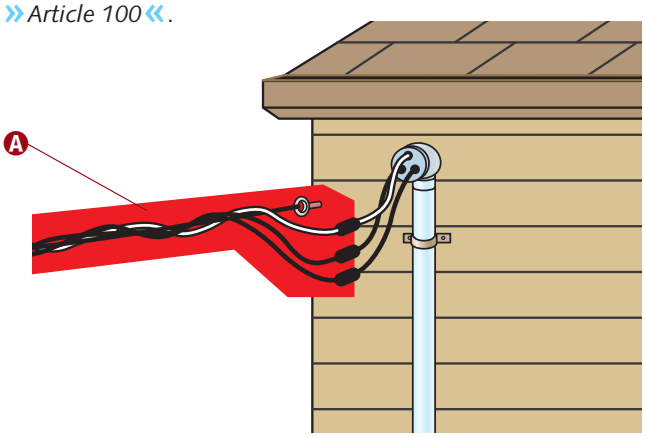
Overhead service conductors are the overhead conductors between the service point and the first point of connection to the service-entrance conductors at the building or other structure »***Article 100***«.

NOTE

Service conductors include: overhead service conductors, underground service conductors, overhead system service-entrance conductors, and underground system service-entrance conductors.

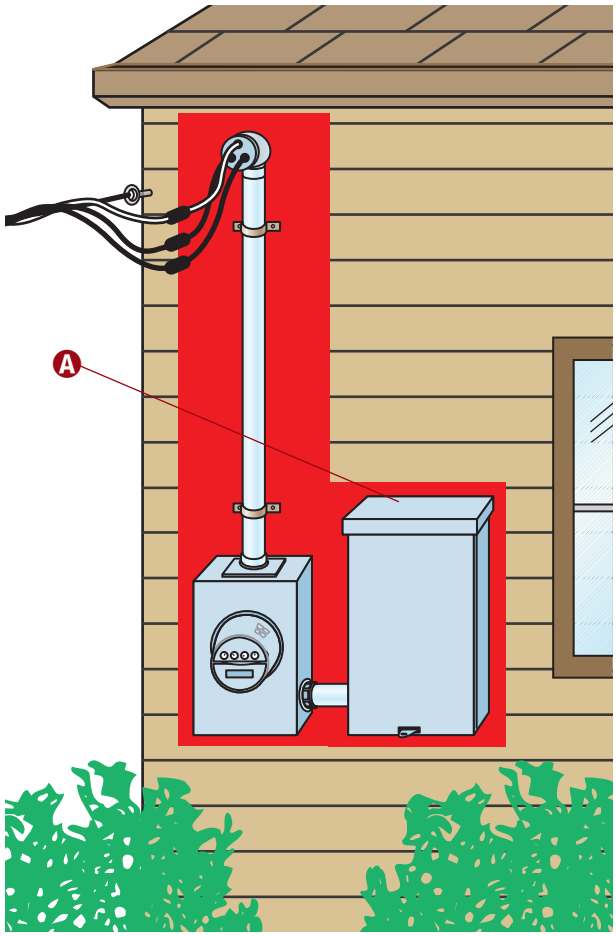
Service Drop

(A) The overhead conductors between the utility electric supply system and the service point »*Article 100*«.



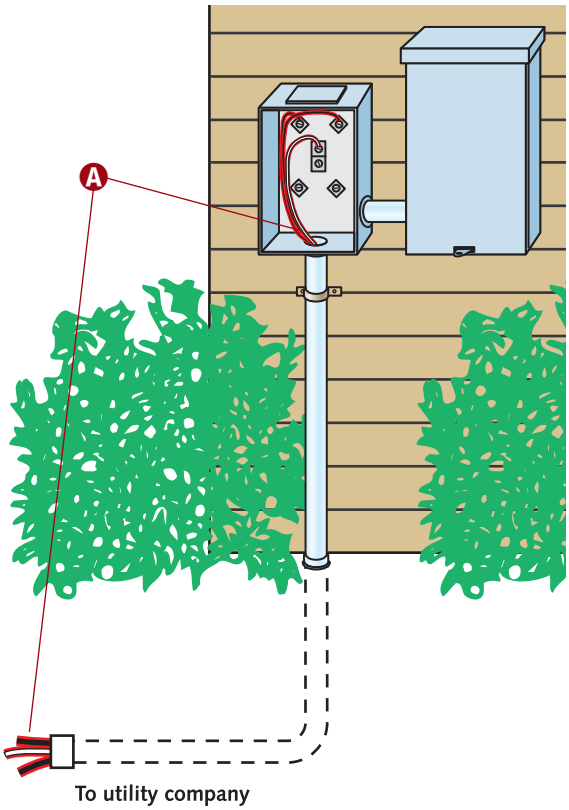
Service Equipment

(A) Service equipment is the necessary equipment, consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the serving utility and intended to constitute the main control and disconnect of the serving utility »*Article 100*«.



Service Lateral

(A) The service lateral is the underground conductors between the utility electric supply system and the service point »*Article 100*«.



NOTE

Underground service conductors are defined as the underground conductors between the service point and the first point of connection to the service-entrance conductors in a terminal box, meter, or other enclosure, inside or outside the building wall.

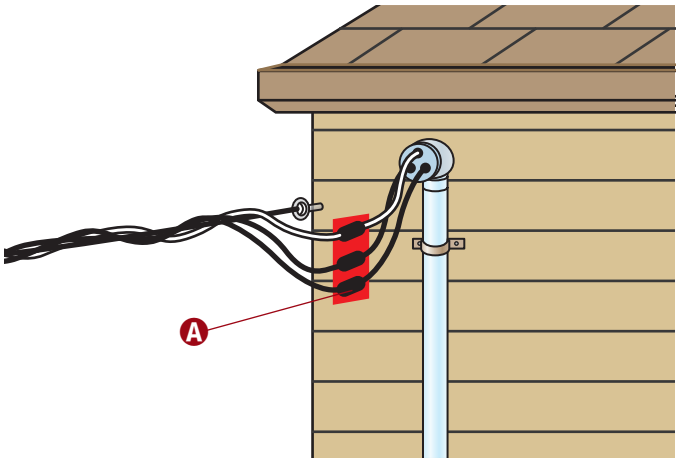
In accordance with the informational note under the definition of underground service conductors, where there is no terminal box, meter, or other enclosure, the point of connection is considered to be the point of entrance of the service conductors into the building »***Article 100***«.

NOTE

Underground system service-entrance conductors are the service conductors between the terminals of the service equipment and the point of connection to the service lateral or underground service conductors. As stated in the informational note, where service equipment is located outside the building walls, there may be no service-entrance conductors or they may be entirely outside the building »***Article 100***«.

Service Point

A The service point is the point of the connection between the facilities of the serving utility and the premises wiring »*Article 100*«.



NOTE

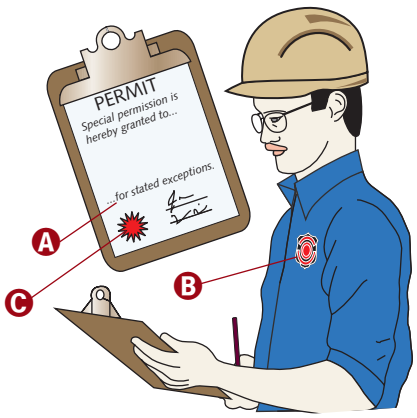
The service point can be described as the point of demarcation between where the serving utility ends and the premises wiring begins. The serving utility generally specifies the location of the service point based on the conditions of service »***Article 100 Informational Note***«.

Special Permission and Authority Having Jurisdiction

A Special permission is the written consent of the authority having jurisdiction (AHJ) »*Article 100*«.

B The AHJ for enforcing the *NEC* may grant exception for the installation of conductors and equipment (not under the exclusive control of the electric utilities) used to connect the electric utility supply system to the service conductors of the premises served (provided such installations are outside a building or structure, or terminate inside at a readily accessible location nearest the point of entrance of the service conductors) »*90.2(C)*«.

C AHJ is the organization, office, or individual responsible for enforcing the requirements of a code (or standard), or for approving equipment, materials, an installation, or a procedure »*Article 100*«.



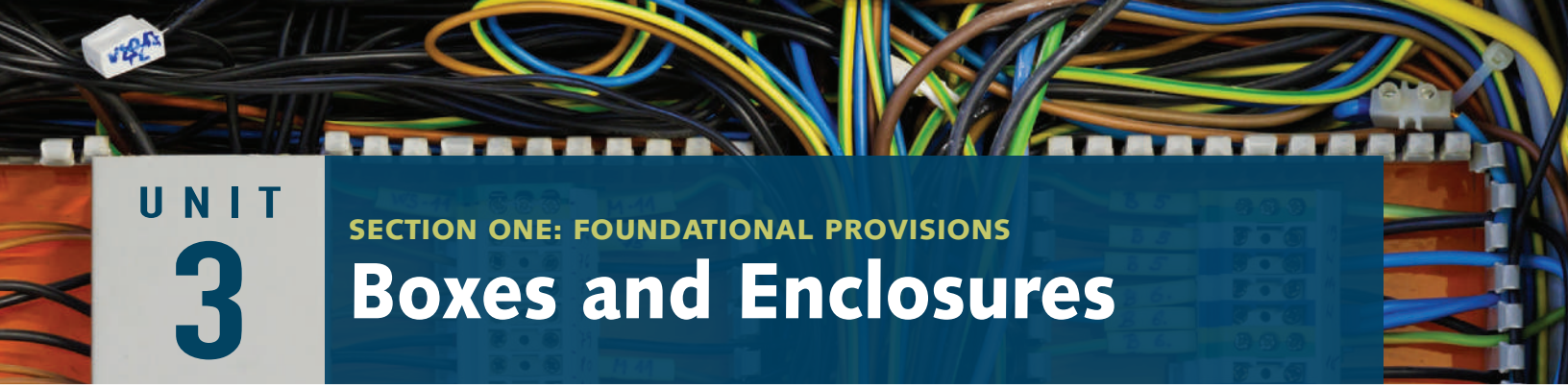
Summary

- Conductors within junction boxes must be accessible without damaging the construction or finish of the building or structure.
- Certain equipment, such as the service disconnecting means, must be readily accessible.
- The term *appliance* denotes more than just kitchen equipment.
- Branch circuits are divided into four categories: appliance, general purpose, individual, and multiwire.
- General-purpose branch circuits may feed lights and receptacles or any combination thereof.
- An individual branch circuit feeds only one piece of equipment.
- The terms *bonded* and *grounded* are not interchangeable.
- A multiwire branch circuit must have a means to simultaneously disconnect all ungrounded (hot) conductors.
- A load having the maximum level of current sustained for three hours or more is a continuous load.
- *Equipment* is a general term encompassing a wide variety of items.
- A grounded conductor and a grounding conductor have different functions.
- A grounded conductor is not necessarily a neutral conductor.
- One duplex receptacle is not defined as a single receptacle.
- Special permission is the written consent of the AHJ.

Unit 2 Competency Test

NEC® Reference	Answer	
_____	_____	1. A(n) _____ branch circuit supplies two or more receptacles or outlets for lighting and appliances.
_____	_____	2. _____ is the largest amount of current capable of being delivered at a point on the electrical system during a short-circuit condition.
_____	_____	3. A(n) _____ branch circuit consists of two or more ungrounded conductors having a potential difference between them, and a grounded conductor having equal potential difference between it and each ungrounded conductor of the circuit and that is connected to the neutral or grounded conductor of the system.
_____	_____	4. An intermittent operation in which load conditions are regularly recurrent is the definition of _____.
_____	_____	5. The _____ is the connection between the grounded-circuit conductor and the equipment grounding conductor at the service.
_____	_____	6. A(n) _____ is used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.
_____	_____	7. Rainproof, raintight, or watertight equipment can fulfill the requirements for _____ where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.
_____	_____	8. A(n) _____ is an intentionally constructed, low-impedance electrically conductive path designed and intended to carry current under ground-fault conditions from the point of a ground fault on a wiring system to the electrical supply source and that facilitates the operation of the overcurrent protective device or ground-fault detectors.
_____	_____	9. A(n) _____ is a manually operated device used in conjunction with a transfer switch to provide a means of directly connecting load conductors to a power source and of disconnecting the transfer switch.
_____	_____	10. A type of surface, flush, or freestanding raceway, designed to hold conductors and receptacles, assembled in the field or at the factory is called a(n) _____.
_____	_____	11. A raceway encased in 4 in. (102 mm) of concrete on the ground floor (in direct contact with the earth) shall be considered a(n) _____ location.
_____	_____	12. A(n) _____ may consist of one or more sensing elements integral with the motor-compressor and an external control device.
_____	_____	13. An enclosure designed for either surface or flush mounting and provided with a frame, mat, or trim in which a swinging door or doors are or can be hung is called a(n) _____.
_____	_____	14. A(n) _____ is a shaftway, hatchway, well hole, or other vertical opening of space in which an elevator or dumbwaiter is designed to operate.
_____	_____	15. A multiwire branch circuit can supply: I. 120/240 volts to only one piece of utilization equipment II. 120/240 volts where all ungrounded conductors are opened simultaneously a) I only b) II only c) either I or II d) neither I nor II
_____	_____	16. An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it is the definition of a(n) _____.
_____	_____	17. _____ is a string of outdoor lights suspended between two points.

NEC® Reference	Answer	
_____	_____	18. Name two items that must be present when defining an area as a bathroom.
_____	_____	19. A continuous load is where the _____ current is expected to continue for three hours or more. a) 80% b) average c) maximum d) 125%
_____	_____	20. Solidly grounded is defined as connected to ground without inserting any _____ or impedance device.
_____	_____	21. A(n) _____ is a point on the wiring system at which current is taken to supply utilization equipment.
_____	_____	22. A(n) _____ is defined as the circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).
_____	_____	23. _____ enclosures are constructed or protected so that exposure to a beating rain will not result in the entrance of water under specified test conditions.
_____	_____	24. Continuous duty is an operation at a substantially constant load for _____. a) 1 hour or more b) 1½ hours or more c) 3 hours or more d) an indefinitely long time
_____	_____	25. Ampacity is defined as the maximum current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding _____.
_____	_____	26. When a disconnecting means must be located within sight from a motor, the disconnect must be visible and not more than _____ ft from the motor.
_____	_____	27. A building containing three dwelling units is called a(n) _____.
_____	_____	28. Ground is defined as _____.
_____	_____	29. At the neutral point of the system, the _____ of the nominal voltages from all other phases within the system that utilize the neutral, with respect to the neutral point, is zero potential.
_____	_____	30. Four panelboards are in an electrical room behind locked doors. Only authorized personnel have keys to this electrical room. In accordance with 240.24, overcurrent devices shall be readily accessible. Since a key must be used to gain entry into the electrical room, are the overcurrent devices in these panelboards considered readily accessible?
_____	_____	31. A(n) _____ is defined as an electrical source, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections.
_____	_____	32. A feeder is defined as all circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final _____ overcurrent device.
_____	_____	33. A(n) _____ is defined as utilization equipment, generally other than industrial, that is normally built in standardized sizes or types and is installed or connected as a unit to perform one or more functions such as clothes washing, air-conditioning, food mixing, deep frying, and so forth.



UNIT 3

SECTION ONE: FOUNDATIONAL PROVISIONS

Boxes and Enclosures

OBJECTIVES

After studying this unit, the student should be able to:

- determine the cubic-inch capacity of boxes (metal and nonmetallic) when installing 6 American Wire Gauge (AWG) and smaller conductors.
- identify which items are counted and which are not when calculating box fill.
- explain why two switches mounted side by side in a two-gang device box could each have different cubic-inch volume allowances.
- determine the minimum box size (including plaster ring, extension ring, etc.) that is needed if the number of conductors (6 AWG and smaller) is known.
- explain box requirements when using nonmetallic-sheathed cable.
- explain the minimum length of free conductor required to be left inside boxes.
- recall that boxes and conduit bodies must remain accessible after installation.
- clarify mounting and supporting provisions for boxes and conduit bodies.
- determine the type of box needed for various applications.
- explain calculation procedures for junction boxes containing 4 AWG and larger conductors.

INTRODUCTION

Choosing the right type and size of box (or enclosure) is very important to installing a system essentially free from hazard. Article 314 covers a variety of provisions concerning boxes (outlet, device, pull, and junction), conduit bodies, and fittings. Box selection must be based on requirements for a given location (such as dry, damp, wet, or hazardous). Boxes have particular requirements concerning the maximum number of conductors. Boxes containing 6 AWG and smaller conductors are required to have a minimum cubic-inch capacity, which is determined by the size and number of conductors. Boxes containing 4 AWG and larger conductors are required to have a minimum height, width, and depth that is determined by the size and number of raceway entries. Article 314 contains provisions for installing, as well as supporting, boxes and conduit bodies. Boxes must be rigidly and securely fastened in place whether mounted *on* the surface, mounted to a framing member, or mounted *in* a finished surface. Under certain conditions, the only means of support a box needs is two threaded conduits. Access to conductors and devices located within boxes and conduit bodies must be available. Article 314 covers more information than the length of this book allows, such as manholes and boxes (pull and junction) for systems over 1000 volts, nominal.

GENERAL REQUIREMENTS

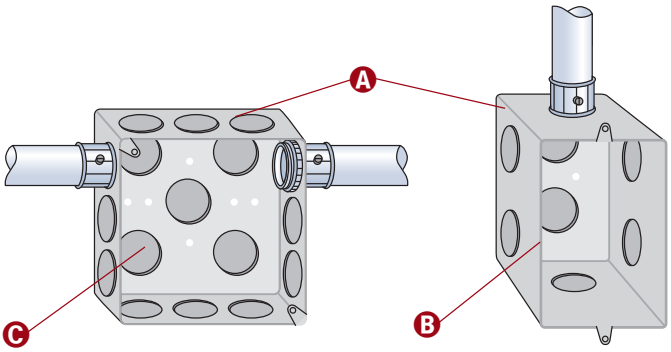
Metal Boxes

The maximum number of conductors (for sizes 18 AWG through 6 AWG) permitted in various standard size metal boxes is listed in Table 314.16(A). Minimum cubic-inch capacities are also shown.

A Volume does not have to be marked on metal boxes listed in Table 314.16(A) »*314.16(A)(2)*«.

B A 3- × 2-in. (75- × 50-mm) device box, 2½ in. (65 mm) deep, has a volume of 12.5 in.³ (205 cm³) »*Table 314.16(A)*«.

C A 4-in. (100-mm) square box with a depth of 1½ in. (38 mm) has a volume of 21 in.³ (344 cm³) »*Table 314.16(A)*«.



NOTE

Where a box is provided with one or more securely installed barriers, the volume shall be apportioned to each of the resulting spaces. Each barrier, if not marked with its volume, shall be considered to take up ½ in.³ (8.2 cm³) if metal, and 1.0 in.³ (16.4 cm³) if nonmetallic ***»314.16(A)«***.

NOTE

A means shall be provided in each metal box for the connection of an equipment grounding conductor. The means shall be permitted to be a tapped hole or equivalent ***»314.40(D)«***.

Volume Markings on Metal Boxes

It is permissible to use the volume marked on a metal box even if it is more than is shown in Table 314.16(A) for the same size box »*314.16(A)(2)*«.

A The minimum volume for this size box in Table 314.16(A) is 21.5 in.³.

B The volume marked on this box is 22.5 in.³.

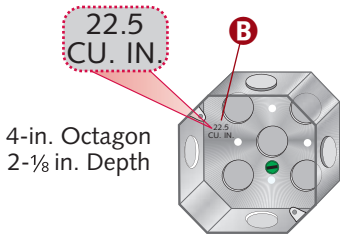


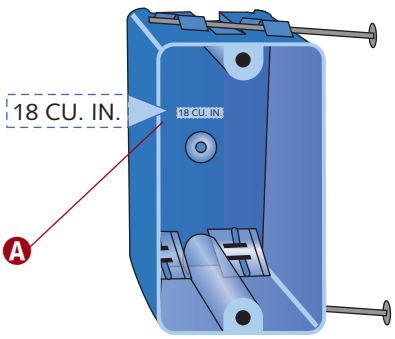
Table 314.16(A) Metal Boxes

Box Trade Size			Minimum Volume	
mm	in.		cm³	in.³
100 x 54	4 x 2-1/8	Round/Octagonal	353	21.5

A

Nonmetallic Boxes

A Volume shall be marked on all nonmetallic boxes and boxes with a volume of 100 in.³ (1650 cm³) or less, except for boxes listed in Table 314.16(A) »*314.16(A)(2)*«.



Additional Capacity

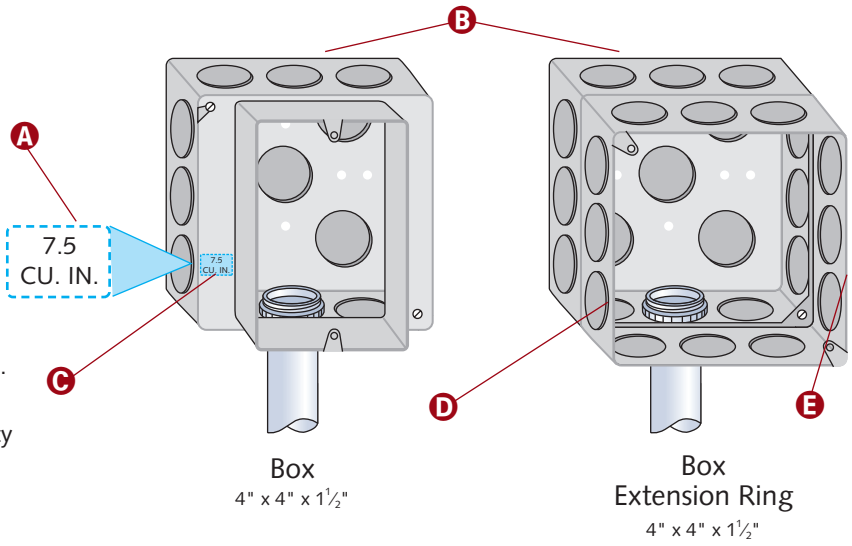
A Additional capacity can only be calculated when the plaster ring, extension ring, etc. is clearly marked with a volume or when it corresponds in size to a box listed in Table 314.16(A).

B Volume can be increased by using plaster (mud) rings, domed covers, extension rings, or similar items »*314.16(A)*«.

C The combined volume of this box and plaster (mud) ring is 28.5 in.³ (467 cm³) »*Table 314.16(A)*«.

D The combined volume of the box and extension ring is 42 in.³ (688 cm³) »*Table 314.16(A)*«.

E A 4-in. (100-mm) square extension ring, having a depth of 1½ in. (38 mm), has a capacity of 21 in.³ (344 cm³) because it has the same dimensions as a box listed in Table 314.16(A).



Additional Markings

A All nonmetallic boxes must be durably and legibly marked by the manufacturer with the volume of the box.

B Some nonmetallic boxes are marked with the maximum number of certain sizes of conductors. This marking is not required.

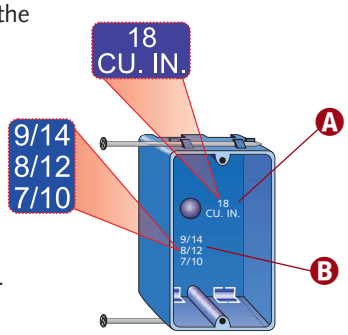
C The maximum number of conductors applies only if the box does not contain any fittings or devices.

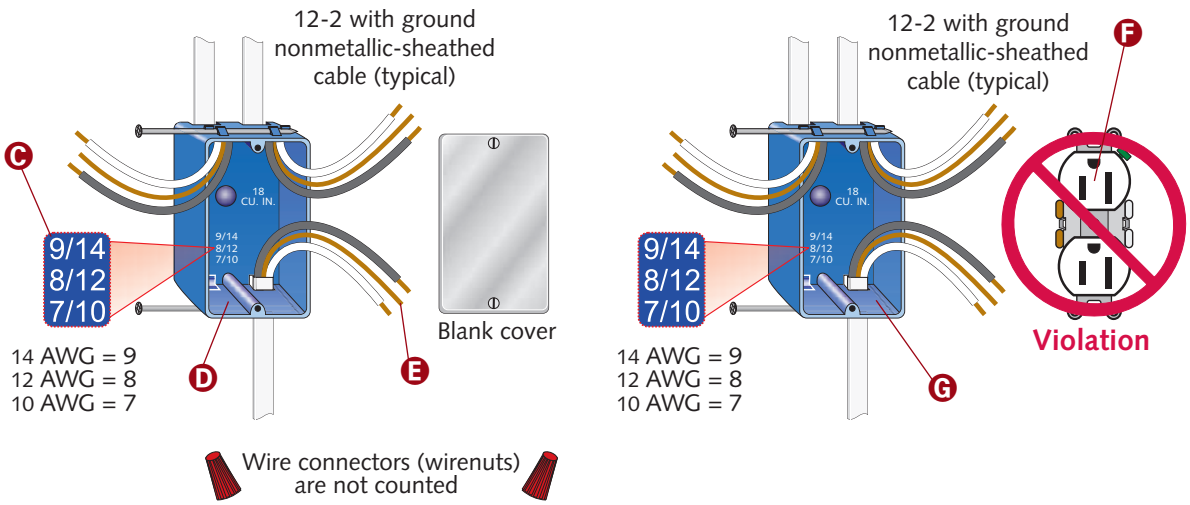
D The box fill calculation for this box is seven 12 AWG conductors. Because eight 12 AWG conductors are permitted, this installation is *Code* compliant.

E The three equipment grounding conductors in this box count as one conductor.

F Installing a device in this box is a violation of *314.16*.

G Because the calculated number of 12 AWG conductors in this box is seven and a device counts as two 12 AWG conductors, the total number of 12 AWG conductors would be nine. In accordance with the marking on this box, only eight 12 AWG conductors are permitted.





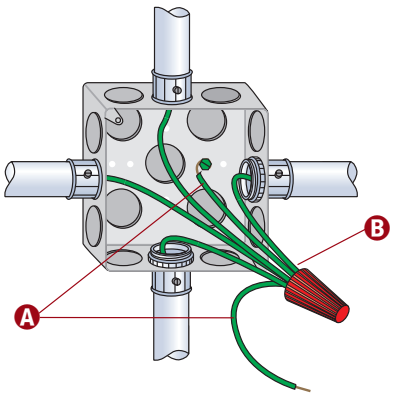
BOX FILL CALCULATIONS

Equipment Grounding Conductor Fill

Where up to four equipment grounding conductors or equipment bonding jumpers enter a box, a single volume allowance in accordance with Table 314.16(B) shall be made based on the largest equipment grounding conductor or equipment bonding jumper entering the box. A ¼ volume allowance shall be made for each additional equipment grounding conductor or equipment bonding jumper that enters the box, based on the largest equipment grounding conductor or equipment bonding conductor »*314.16(B)(5)*«.

A Conductors that do not enter the box, such as equipment bonding jumpers and pigtails, are not counted.

B Equipment grounding conductor(s) or equipment bonding jumpers entering a box count as one conductor unless there are more than four equipment grounding conductors »*314.16(B)(5)*«. Only the largest equipment grounding conductor shall be counted if multiple grounding conductors (of different sizes) enter the box.



NOTE

Isolated equipment grounding conductors are no longer a consideration when determining equipment grounding conductor fill.

Equipment Grounding Conductor Fill — More than Four Conductors

Where up to four equipment grounding conductors or equipment bonding jumpers enter a box, a single volume allowance in accordance with Table 314.16(B) shall be made based on the largest equipment grounding conductor or equipment bonding jumper entering the box. A ¼ volume allowance shall be made for each additional equipment grounding conductor or equipment bonding jumper that enters the box, based on the largest equipment grounding conductor or equipment bonding conductor »*314.16(B)(5)*«.

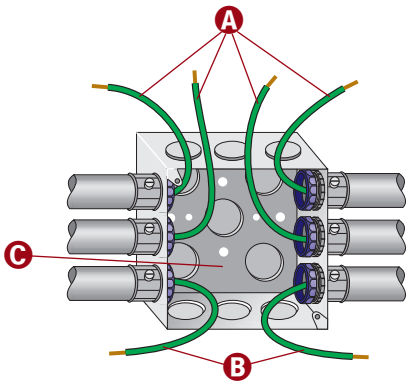
A These first four equipment grounding conductors count as one 14 AWG conductor. As shown in Table 314.16(B), the volume allowance required for a 14 AWG conductor is 2 in.^{3}. The volume allowance required for these four 14 AWG equipment grounding conductors is 2 in.^{3}.

B Because there are two additional equipment grounding conductors (more than four), each of these equipment grounding conductors require a ¼ volume allowance. As shown in Table 314.16(B), the volume allowance required for a 14 AWG conductor is 2 in.^{3}. The volume allowance required for each of these additional 14 AWG equipment grounding conductors is 0.5 in.^{3} ($2 \times 0.25 = 0.5$). The volume allowance required for two additional 14 AWG equipment grounding conductors is 1 in.^{3} ($2 \times 0.5 = 1$).

C The volume allowance required for all six of these 14 AWG equipment grounding conductors is 3 in.^{3} ($2 + 1 = 3$).

NOTE

Isolated equipment grounding conductors are no longer a consideration when determining equipment grounding conductor fill.



Six 14 AWG equipment grounding conductors

Determining the Number of Conductors

A Raceway fittings (connectors, hubs, etc.) are not counted.

B Each conductor originating outside the box that is terminated or spliced inside the box counts as one conductor »*314.16(B)(1)*«. These red conductors are counted as two conductors.

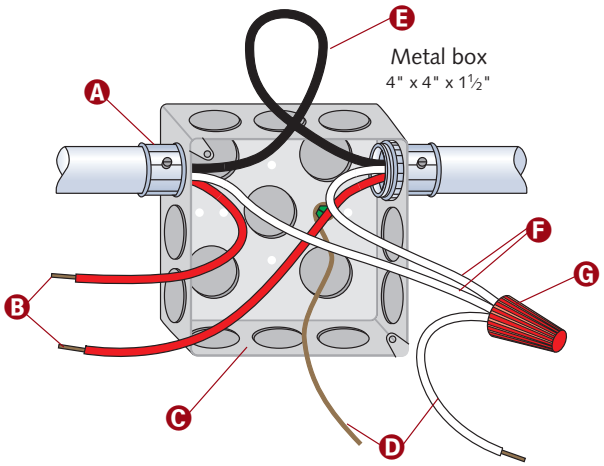
C This box, as pictured, contains five conductors. If all of the conductors are 12 AWG, the box could hold a maximum of nine conductors »*Table 314.16(A)*«.

D A conductor that does not leave the box, such as equipment bonding jumpers and pigtails, is not counted »*314.16(B)(1)*«.

E A conductor that passes through the box without splice or termination (unbroken) counts as one conductor. Each loop or coil of unbroken conductor not less than twice the minimum length required for free conductors in 300.14 must be counted twice »*314.16(B)(1)*«. This black unbroken conductor is counted as one conductor.

F Each conductor originating outside the box that is terminated or spliced inside the box counts as one conductor »*314.16(B)(1)*«. These white conductors count as two conductors.

G Wire connectors are not counted.



NOTE

Each space within a box installed with a barrier shall be calculated separately »*314.16(A)*«.

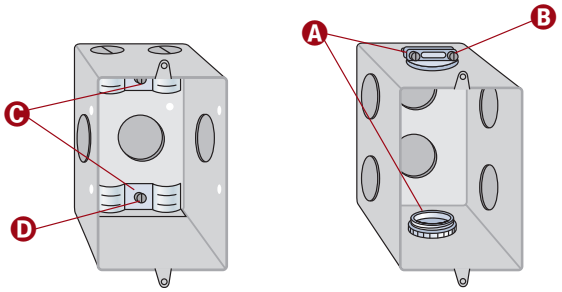
Cable Clamps and Connectors

A External cable connectors are not counted.

B Cable connector(s) with the clamping mechanism outside the box are not counted »*314.16(B)(2)*«.

C Two internal cable clamps count as one conductor.

D Internal cable clamp(s), whether factory or field supplied, shall be counted as one conductor »*314.16(B)(2)*«. Where more than one size conductor is present in the box, the clamp shall be counted as the largest conductor.

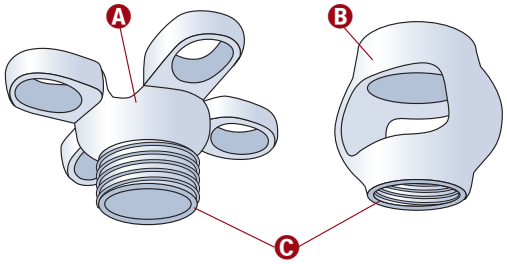


Luminaire Studs and Hickeys

A Luminaire stud(s) shall be counted as one conductor »*314.16(B)(3)*«.

B One or more hickeys shall be counted as one conductor »*314.16(B)(3)*«.

C If conductors of different sizes are present in the box, each one shall be counted as the largest conductor »*314.16(B)(3)*«.

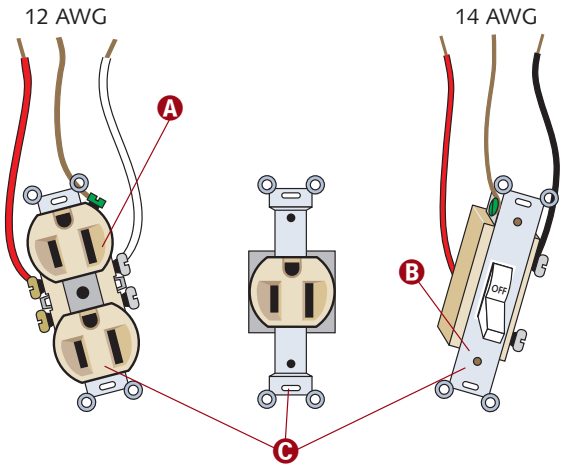


Devices or Equipment

Ⓐ This duplex receptacle counts as two 12 AWG conductors.

Ⓑ This single-pole switch counts as two 14 AWG conductors.

Ⓒ Each mounting yoke or strap counts as two conductors. A mounting yoke or strap can contain one or more devices, such as a single receptacle, a duplex receptacle, a single switch, a double switch, a triple switch, or any combination. The size of the two conductors (when calculating box fill) shall be equal in size to the largest conductor connected to the device »*314.16(B)(4)*«.



NOTE

A device or utilization equipment wider than a single 2-in. (50-mm) device box as described in Table 314.16(A) shall have double-volume allowances provided for each gang required for mounting »*314.16(B)(4)*«.

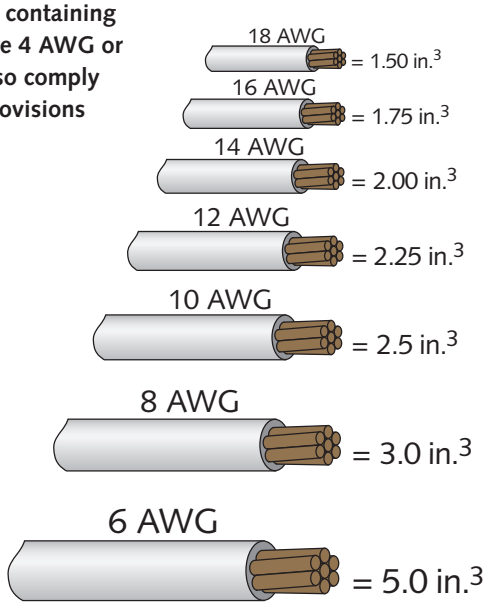
Volume per Conductor

Table 314.16(B) lists the cubic-inch volume for conductors, sizes 18 AWG through 6 AWG.

Boxes, enclosures, and conduit bodies containing conductors, size 4 AWG or larger, must also comply with 314.28 provisions »*314.16*«.

NOTE

Conductor insulation is not a factor when determining box fill calculations.



Box Fill Calculation

Wire connectors, pigtails, locknuts, bushings, raceway connectors, grounding screws, and equipment bonding jumpers are not factors when calculating box fill.

Ⓐ These three conductors, although spliced, count as *three* conductors.

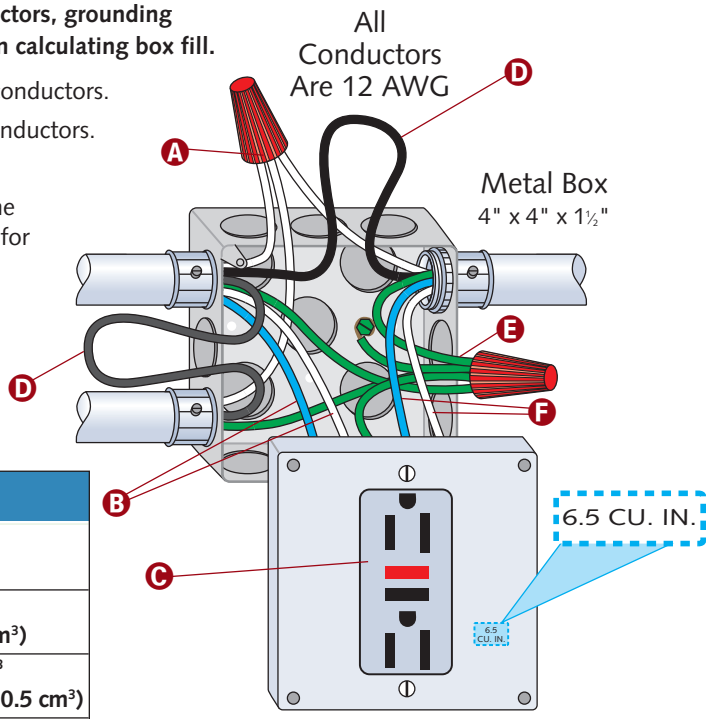
Ⓑ Two conductors that terminate in the box count as *two* conductors.

Ⓒ One receptacle counts as *two* 12 AWG conductors.

Ⓓ An unbroken conductor counts as *one* conductor unless the conductor is not less than twice the minimum length required for free conductors in 300.14.

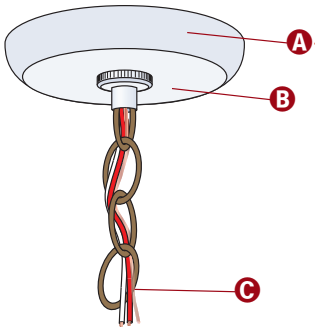
Ⓔ These three equipment grounding conductors that enter the box from the three raceways count as *one* conductor.

Ⓕ These two conductors terminating in the box are counted as *two* conductors.



Total 12 AWG conductors:	Twelve
Volume per 12 AWG	2.25 in.³ (each) (36.9 cm³ [each])
Minimum volume for conductors	12 × 2.25 in.³ = 27 in.³ (12 × 36.9 cm³ = 442.8 cm³)
Volume for box (including raised cover)	21 in.³ + 6.5 in.³ = 27.5 in.³ (344 cm³ + 106.5 cm³ = 450.5 cm³)
This installation complies with 314.16 provisions.	

Domed Covers and Canopies

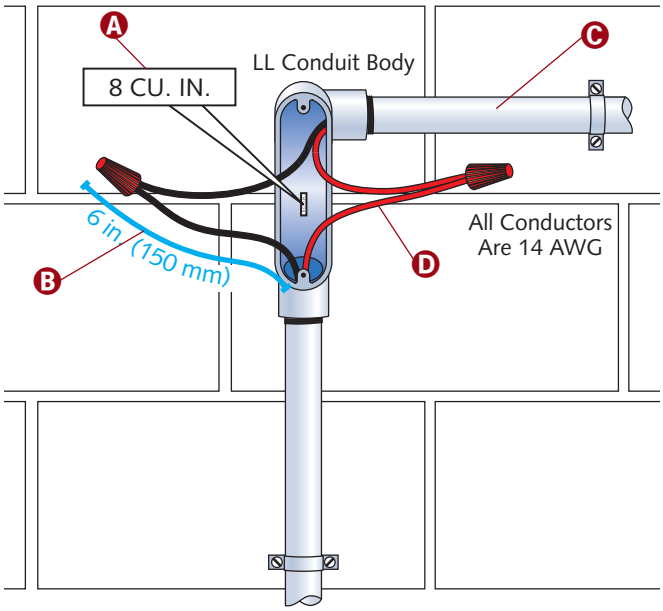


A Four or fewer luminaire wires (smaller than 14 AWG) and an equipment grounding conductor can be omitted from box fill calculations where they enter a box from a domed luminaire (or similar canopy) and terminate within that box »*314.16(B)(1) Exception*«.

B The size of the domed cover or canopy is not a factor.

C Two luminaire wires and one equipment ground are not counted.

Splices Inside Conduit Bodies



A Splices, taps, or devices are permitted inside conduit bodies, if the manufacturer durably and legibly marked the cubic-inch capacity on the conduit body »*314.16(C)(2)*«.

B At least 6 in. (150 mm) of free conductor (measured from the point in the conduit body where it emerges from its raceway or cable sheath) shall be left at each outlet, junction, and switch point »*300.14*«.

C A conduit body can be supported by rigid metal conduit, intermediate metal conduit, rigid nonmetallic conduit, or electrical metallic tubing »*314.23(E) Exception*«.

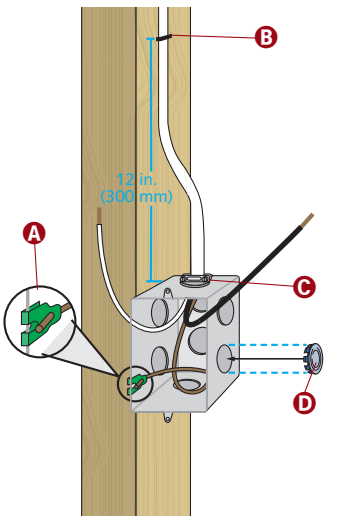
D The maximum number of conductors shall be calculated in accordance with 314.16(B). Four 14 AWG conductors with a volume of 2.0 in.^{3} (32.8 cm^3) each require a total volume of 8 in.^{3} (131.2 cm^3).

NOTE

The maximum number of conductors permitted shall be the maximum number permitted by Table 1 of Chapter 9 for the conduit to which it is attached »***314.16(C)(1)***«.

GENERAL INSTALLATION

Securing Cables to Metal Boxes



Conductors must be protected from abrasion where entering boxes, conduit bodies, or fittings »*314.17*«.

A A connection used for no other purpose shall be made between the equipment grounding conductor(s) and a metal box in accordance with 250.8 »*250.148(C)*«. Grounding conductors must not be connected to enclosures with screws that engage less than two threads in the enclosure (or nut) such as sheet metal, drywall, or wood screws (see 250.8).

B Nonmetallic-sheathed cable shall be secured within 12 in. (300 mm) of every cabinet, box, or fitting. The cable can be secured by using staples; cable ties listed, labeled, and identified for securement and support; or straps, hangers, or similar fittings designed and installed so that the cable remains undamaged »*334.30*«.

C Cables must be securely fastened to any metal box or conduit body that they enter »*314.17(B)(2)*«. The clamping mechanism can be internal or external to the box or conduit body.

D Unused cable or raceway openings in boxes and conduit bodies must be closed so that the protection provided is at least equal to that provided by the wall of the box or conduit body »*110.12(A)*«.

CAUTION

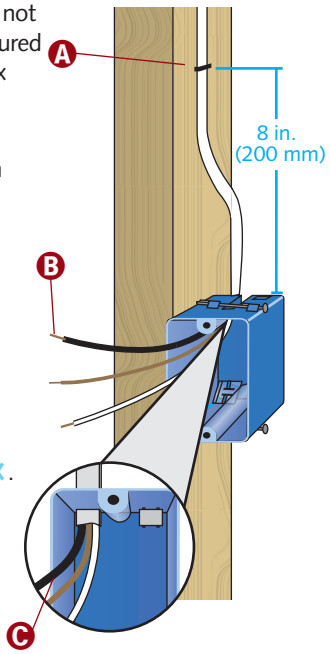
Where nonmetallic-sheathed cable or multiconductor Type UF cable is used, the sheath shall extend not less than ¼ in. (6 mm) inside the box and beyond any cable clamp »*314.17(B)(2)*«.

Single-Gang Nonmetallic Boxes

A Nonmetallic-sheathed cable not fastened to the box must be secured within 8 in. (200 mm) of the box »*314.17(B)(2) Exception*«.

B At least 6 in. (150 mm) of free conductor (measured from the point in the box where it emerges from its raceway or cable sheath) shall be left at each outlet, junction, and switch point »*300.14*«.

C The cable sheath shall extend into the box at least ¼ in. (6 mm) through the cable knockout or opening »*314.17(C)(B)(2) Exception*«.



CAUTION

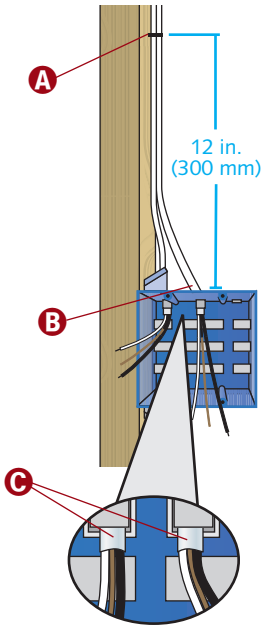
All permitted wiring methods must be secured to the box, unless the exception in 314.17(B)(2) has been met.

Securing Cables to Nonmetallic Boxes

A Nonmetallic-sheathed cable shall be secured within 12 in. (300 mm) of every cable entry into enclosures such as outlet boxes, junction boxes, cabinets, or fittings »*334.30*«.

B Cables entering a nonmetallic box must be secured to the box, unless it is a single-gang nonmetallic box »*314.17(B)(2)*«.

C The cable sheath shall extend into the box at least ¼ in. (6 mm) through the cable knockout or opening »*314.17(B)(2)*«.



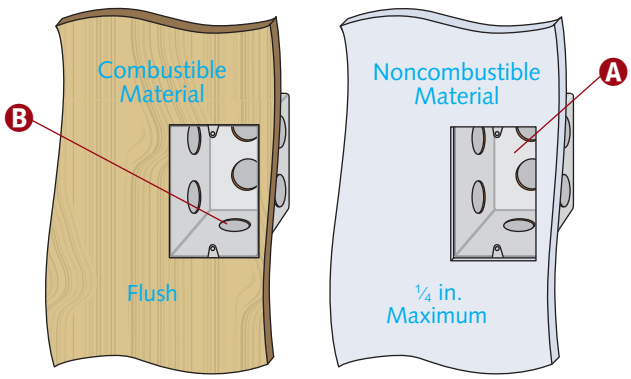
NOTE

The exception pertaining to nonmetallic-sheathed cable entering a box which has no means of securing the cable to the box applies only to *single-gang* nonmetallic boxes **»*314.17(B)(2) Exception*«**.

Boxes in Combustible and Noncombustible Materials

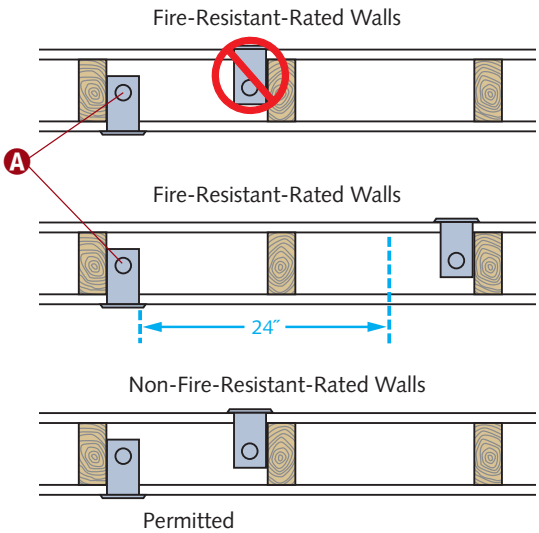
A Flush-mounted installations within or behind a surface of noncombustible material such as concrete, tile, gypsum, and plaster, including boxes employing a flush-type cover or faceplate, shall be made so that the front edge of the box, plaster ring, extension ring, or listed extender will not be set back more than ¼ in. (6 mm) of the finished surface »*314.20*«.

B For installations within a surface of wood or other combustible surface material, boxes, plaster rings, extension rings, or listed extenders shall extend to the finished surface or project therefrom »*314.20*«.

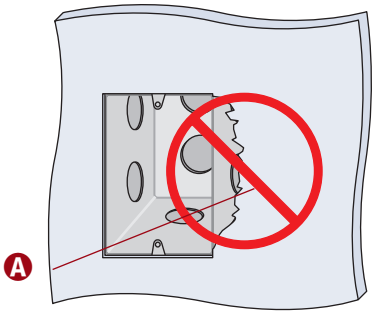


Back-to-Back Boxes in Fire-Resistant-Rated Wall

A Qualified testing laboratories publish electrical construction material directories listing installation restrictions that apply to maintaining fire-resistive ratings of assemblies involving penetrations, or openings. (An example is the minimum 24-in. [600-mm] horizontal separation usually required between boxes on opposite sides of the wall.) These fire-resistance directories, product listings, and building codes offer assistance in 300.21 compliance »*300.21 (Informational Note)*«.

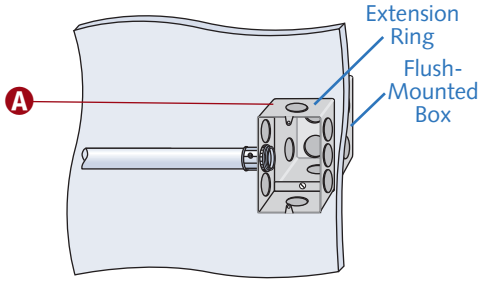


Gaps or Open Spaces



(A) Damaged or incomplete plaster, drywall, or plasterboard surfaces around boxes employing a flush-type cover or faceplate must be repaired so that no gap or open space greater than ⅛ in. (3 mm) surrounds the box or fitting »*314.21*«.

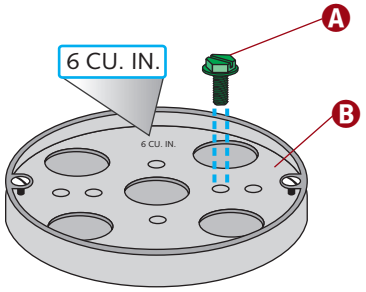
Surface Extensions



Equipment grounding, where required, must be in accordance with Part VI of Article 250.

(A) Surface extensions must have an extension ring mounted and mechanically secured to the box »*314.22*«.

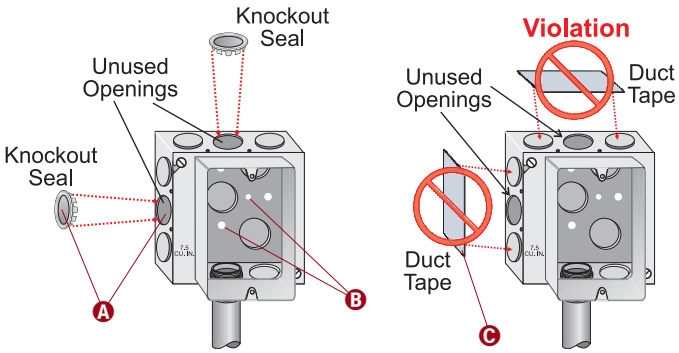
Minimum Internal Depth



(A) Except as permitted in 250.112(I), all metal boxes shall be grounded and bonded in accordance with Parts I, IV, V, VI, VII, and X of Article 250, as applicable »*314.4*«.

(B) Outlet boxes that do not enclose devices or utilization equipment must have an internal depth of at least ½ in. (12.7 mm) »*314.24(A)*«.

Unused Openings

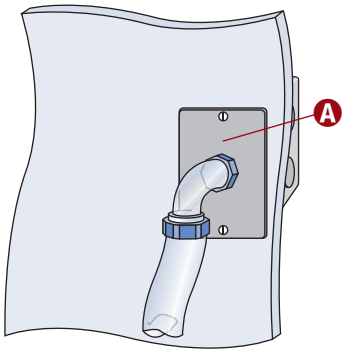


(A) Unused openings shall be closed to afford protection substantially equivalent to the wall of the equipment »*110.12(A)*«.

(B) It is not required to close openings intended for the operation of equipment, openings intended for mounting purposes, or openings permitted as part of the design for listed equipment »*110.12(A)*«.

(C) Duct tape does not provide protection equivalent to the wall of the box.

Surface Extensions Made from Covers



(A) The cover of a flush-mounted box can provide a surface extension where the cover is designed so that it is unlikely to fall off or be removed if its securing means becomes loose. The wiring method shall be flexible for an approved length that permits removal of the cover and provides access to the box interior and shall be arranged so that any grounding continuity is independent of the connection between the box and the cover »*314.22 Exception*«.

Metal Faceplates Covering Nonmetallic Boxes

A Snap switches (including dimmer switches) must be connected to an equipment grounding conductor and must also provide a means to connect metal faceplates to the equipment grounding conductor, even if a metal faceplate is not installed »*404.9(B)*«.

B Both metal and nonmetallic covers and plates shall be permitted. Metal covers or plates, when used, must comply with 250.110 grounding requirements »*314.25(A)*«.

C Should the snap switch enclosure, or the wiring method used, not have an equipment ground, a snap switch without a grounding connection can be used for replacement purposes only. A snap switch wired under the provisions of this exception and located within 8 ft (2.5 m) vertically, or 5 ft (1.5 m) horizontally, of ground or exposed grounded metal objects shall be provided with a faceplate of nonconducting noncombustible material with nonmetallic attachment screws, unless the switch mounting strap or yoke is nonmetallic or the circuit is protected by a ground-fault circuit interrupter »*404.9(B) Exception No. 1 to (B)*«.

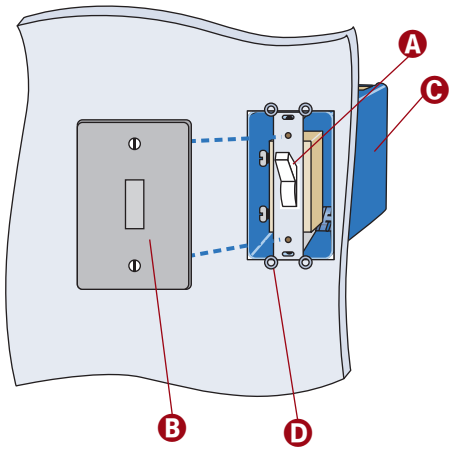
D There are two acceptable methods for grounding snap switches effectively: (1) The switch is mounted with metal screws to a metal box or metal cover that is connected to an equipment grounding conductor or to a nonmetallic box equipped with integral means for connecting to an equipment grounding conductor. (2) An equipment grounding conductor, or equipment bonding jumper, is connected to the equipment grounding termination on the snap switch »*404.9(B)*«.

CAUTION

Isolated ground receptacles, in nonmetallic boxes, must be covered with either a nonmetallic faceplate or with an effectively grounded metal faceplate »*406.3(D)(2)*«.

NOTE

Metal receptacle faceplates (cover plates) shall be grounded »***404.9(B)* and *406.6(B)***«.



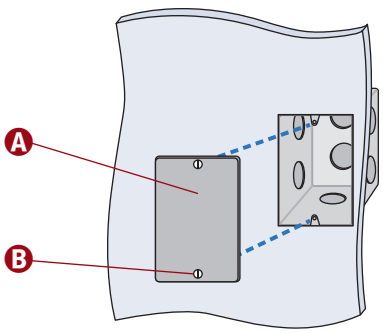
NOTE

Listed kits or listed assemblies shall not be required to be connected to an equipment grounding conductor if all of the following conditions are met:
(1) The device is provided with a nonmetallic faceplate that cannot be installed on any other type of device,
(2) The device does not have mounting means to accept other configurations of faceplates,
(3) The device is equipped with a nonmetallic yoke, and
(4) All parts of the device that are accessible after installation of the faceplate are manufactured of nonmetallic materials »***404.9(B) Exception No. 2 to (B)***«.

Covers and Canopies

A To complete the installation, each box must have a cover, faceplate, lampholder, or luminaire canopy, except where the installation complies with 410.24(B) »*314.25*«.

B Screws used for the purpose of attaching covers, or other equipment, to the box shall be either machine screws matching the thread gauge or size that is integral to the box or shall be in accordance with the manufacturer's instructions »*314.25*«.



Receptacles Mounted on Covers

A Where receptacles are mounted and supported by a cover, they must be secured by more than one screw, unless the box cover or device assembly is listed and identified as single-screw mounting »*406.5(C)*«.