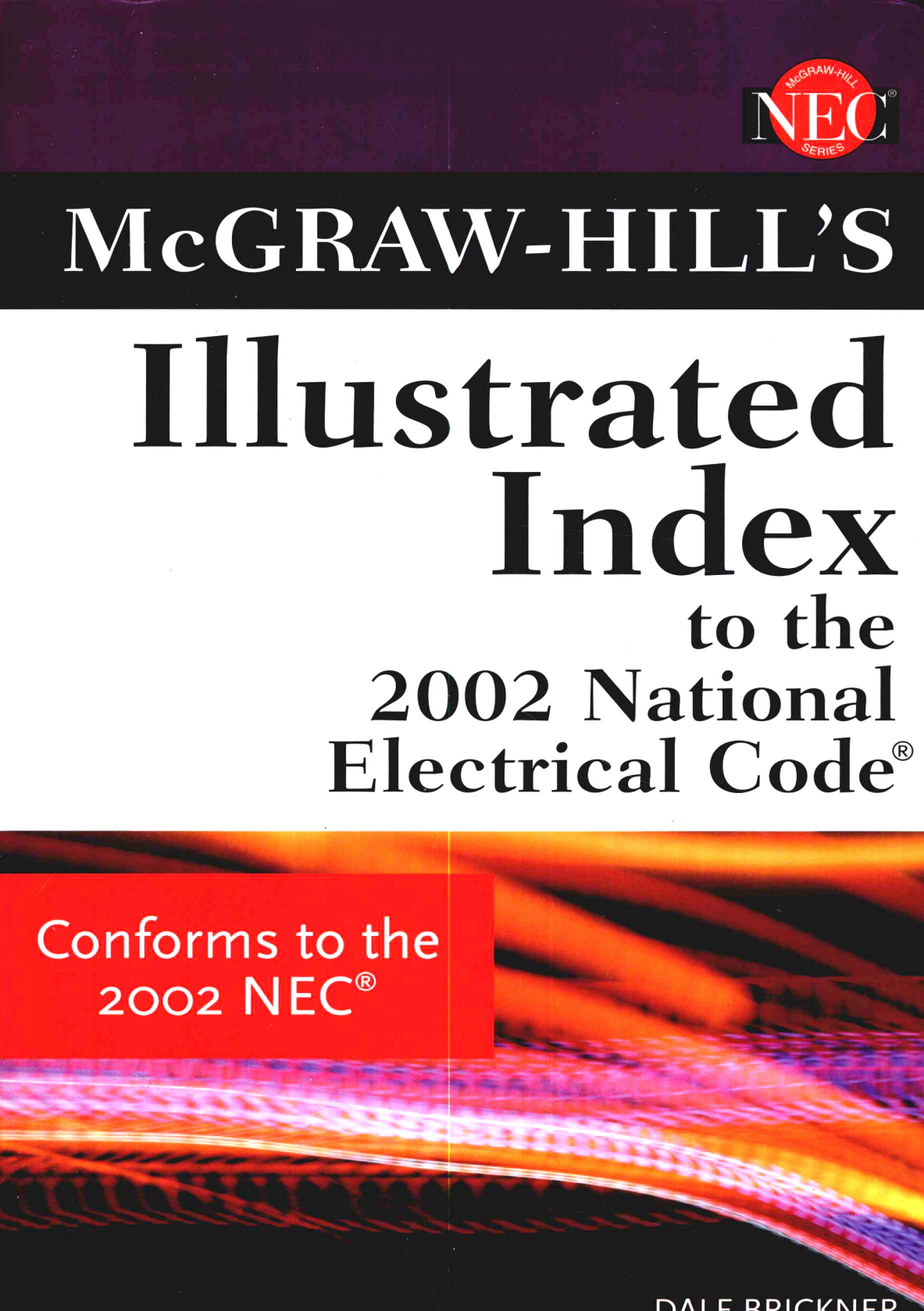
McGRAW-HILL'S
Illustrated Index
to the 2002 National Electrical Code®
Conforms to the 2002 NEC®
DALE BRICKNER

McGraw-Hill's Illustrated Index to the 2002 National Electrical Code®

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McGraw-Hill

New York Chicago San Francisco Lisbon London Madrid
Mexico City Milan New Delhi San Juan Seoul
Singapore Sydney Toronto

Cataloging-in-Publication Data is on file with the Library of Congress

McGraw-Hill

A Division of The McGraw-Hill Companies

1 2 3 4 5 6 7 8 9 0 DOC/DOC 0 8 7 6 5 4 3 2

ISBN 0-07-137524-4

The sponsoring editor for this book was Scott Grillo, the editing supervisor was Caroline Levine, and the production supervisor was Sherri Souffrance. It was set in Century Schoolbook following the MHT 6x9 design by Wayne A. Palmer of McGraw-Hill Professional's Hightstown, N.J., composition unit.

Printed and bound by R. R. Donnelley & Sons Company.

Contents

Introduction

The design and installation of electrical systems employ a wide variety of techniques, often involving special types of equipment and materials designed for specific applications. All installations specified in the National Electrical Code (NEC) Section 90.2(A)(1) through (5) must conform to applicable NEC requirements, local ordinances, and instructions provided by equipment and component manufacturers. This chapter explains the key terms and basic layout of the NEC.

Genesis

Since the first central-station electric generating plant was developed in New York City in 1882 by Thomas A. Edison, the electrical construction industry has grown at an astonishing rate to become one of the largest industries in the United States. The first generating plant created public demand for the use of electric lighting and power in existing buildings, as well as for new construction.

These first electrical wiring installations were usually laid out by workers employed and trained by the power companies, and the majority of these installations were "designed" by mechanics on the job, often as the work progressed. Building contractors then began hiring workers of their own to install electrical wiring systems, but because of the special skills and knowledge required, these same builders soon began leaving the wiring installations to workers who began to specialize in this work as electrical contractors.

As electrical construction continued to become a more important part of general building construction, architects began to prepare layouts of the desired electrical systems on their architectural drawings. This layout usually indicated the lighting outlets, base "plugs," and light switches by means of certain symbols. A line was sometimes drawn from a lighting outlet to a wall switch to indicate how the various lamps were to be controlled, but this was usually the extent of the electrical

design. The details of wiring, number of circuits, and the like were still left to the mechanics (electricians) installing the system. As electrical systems became more extensive and complex, electrical contractors began hiring drafters to prepare working drawings to supplement the sketchy outlet layout on the architectural drawings, to provide a basis for preparing estimates, and to give instructions to electricians in the field.

From that point on, electrical construction continued to become a more important part of general building construction, and soon the architects began to prepare more extensive layouts of the electrical systems, until finally separate drawings were included along with the architectural drawings. As the volume of such layout work increased and electrical systems became still more extensive and complex, a greater engineering knowledge of power and illumination requirements became necessary. Persons with the proper knowledge and training began to devote their time exclusively to designing and laying out electrical installations as consulting engineers. These consulting engineers conveyed their designs by means of working drawings that used symbols, lines, notations, and written specifications. Thus, the electrical designer became a very important cog in the wheel of electrical construction. Yet, the best electrical designs, specifying the best materials and equipment, are useless without trained workers to properly install the systems. Consequently, the trained electrical technician is indispensable in the building construction industry, and a thorough knowledge of the NEC is one of the first requirements in becoming a trained electrical technician. In fact, the NEC is probably the most widely used and generally accepted code in the world. It is used as an electrical installation, safety, and reference guide in the United States, and in many other parts of the world as well.

Purpose and History of the NEC

Owing to the potential fire and explosion hazards caused by the improper handling and installation of electrical wiring, certain rules in the selection of materials, quality of workmanship, and precautions for safety must be followed. To standardize and simplify these rules and provide a reliable guide for electrical construction, the National Electrical Code (NEC) was developed. The NEC, originally prepared in 1897, is frequently revised to meet changing conditions, improved equipment and materials, and new fire hazards. It is a result of the best efforts of electrical engineers, manufacturers of electrical equipment, insurance underwriters, firefighters, and other concerned experts throughout the country.

The NEC is now published by the National Fire Protection Association (NFPA), Batterymarch Park, Quincy, MA 02269. It contains specific rules and regulations intended to help in the practical safeguarding of persons and property from hazards arising from the use of electricity.

Although the NEC itself states, "This Code is not intended as a design specification nor an instruction manual for untrained persons," it does provide a sound basis for the study of electrical installation procedures—under the proper guidance. The probable reason for the NEC's self-analysis is that the code also states, "This Code contains provisions considered necessary for safety. Compliance therewith and proper maintenance will result in an installation essentially free from hazard, but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical use."

The NEC, however, has become the bible of the electrical construction industry, and anyone involved in electrical work, in any capacity, should obtain an up-to-date copy, keep it handy at all times, and refer to it frequently.

This book is not a substitute for the NEC. You need a copy of the most recent edition of the NEC book, and it should be kept handy at all times. The more you know about the code, the more you are likely to refer to it.

NEC Terminology

There are two basic types of rules in the NEC: mandatory rules and permissive rules. Here is how to recognize the two types of rules and how they relate to all types of electrical systems:

- *Mandatory rules.* All mandatory rules have the word shall in them. The word "shall" means must. If a rule is mandatory, you must comply with it.
- *Permissive rules.* Permissive rules identify those actions that are allowed but not required. A permissive rule is characterized by the use of the terms "shall be permitted" or "shall not be required."

Be alert to local amendments to the NEC. Local ordinances may amend the language of the NEC, changing it from "should" to "shall." This means that you must do in that county or city what may only be recommended in some other area. The office that issues building permits or the local electrical inspection office will either sell you a copy of the code that's enforced in that area or tell you where the code is available. In rare instances, the electrical inspector having jurisdiction over the area may issue these regulations verbally.

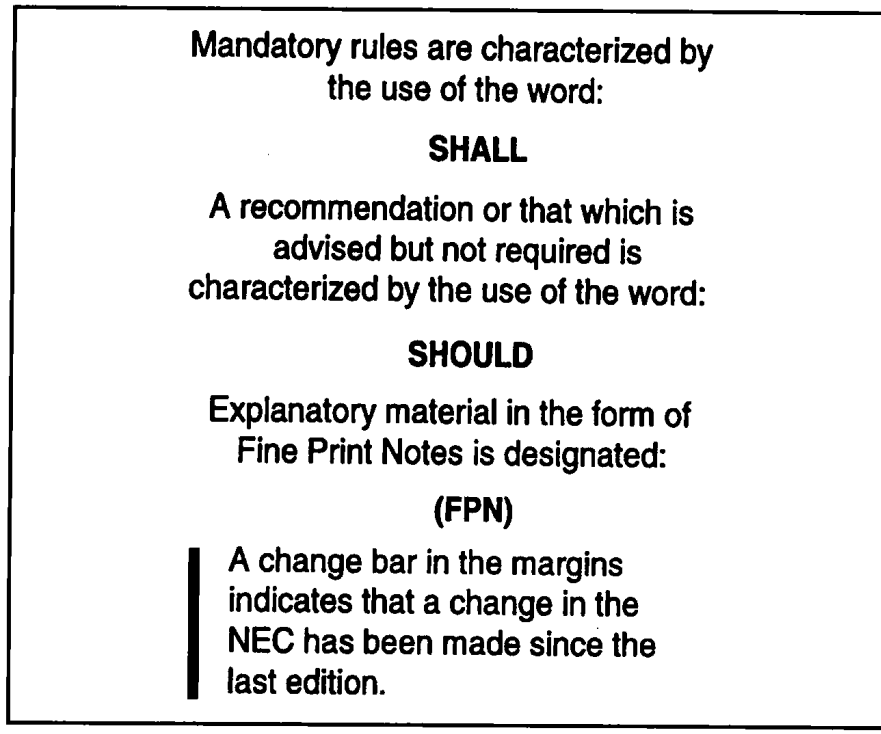


Figure I.1 Summary of NEC terminology.

There are a few other "landmarks" that you will encounter while looking through the NEC. These are summarized in Fig. I.1, and a brief explanation of each follows:

Explanatory material. Explanatory material in the form of Fine Print Notes is designated (FPN). Where these appear, the FPNs normally apply to the NEC Section or paragraph immediately preceding the FPN.

Change bar. A change bar in the margins indicates that a change in the NEC has been made since the last edition. When becoming familiar with each new edition of the NEC, always review these changes. There are also several illustrated publications on the market that point out changes in the NEC with detailed explanations of each. Such publications make excellent reference material.

Extracted text. Material identified by the superscript letter "x" includes text extracted from other NFPA documents as identified in Appendix A of the NEC.

As you open the NEC book, you will notice several different types of text used. Here is an explanation of each:

1. *Black letters.* Basic definitions and explanations of the NEC.
2. *Bold black letters.* Headings for each NEC application.

3. *Exceptions.* These explain the situations when a specific rule does not apply. Exceptions are written in italics under the Section or paragraph to which they apply.
4. *Tables.* Tables are often included when there is more than one possible application of a requirement. See Fig. I.2.
5. *Diagrams.* A few diagrams are scattered throughout the NEC to illustrate certain applications. See Fig. I.3.

Learning the NEC Layout

The NEC is divided into the Introduction (Article 90) and nine chapters. Chapters 1, 2, 3, and 4 apply generally; Chapters 5, 6, and 7 apply to special occupancies, special equipment, or other special conditions. These latter chapters supplement or modify the general rules. Chapters 1 through 4 apply except as amended by Chapters 5, 6, and 7 for the particular conditions.

While looking through these NEC chapters, if you should encounter a word or term that is unfamiliar, look in Chapter 1, Article 100—Definitions. Chances are, the term will be found here. If not, look in the index for the word and the NEC page number. The 1999 code eliminated cross-referencing in Article 100. Such cross-referencing was deemed most appropriate in the Index of the NEC.

This book contains most of the definitions of terms not found in the NEC.

Chapter 8 of the NEC covers communications systems and is independent of the other chapters except where they are specifically referenced therein.

Chapter 9 consists of tables and examples.

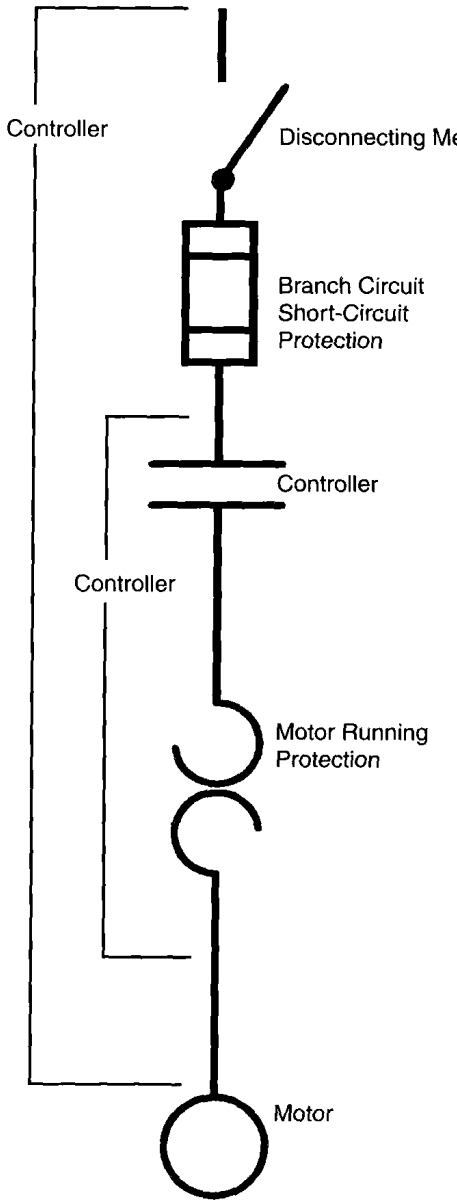
There is also the NEC Contents at the beginning of the book and a comprehensive Index at the back of the book. You will find frequent use for both of these helpful "tools" when searching for various installation requirements.

Each chapter is divided into one or more Articles. For example, Chapter 1 contains Articles 100 and 110. These Articles are subdivided

TABLE 402.5. Allowable Ampacity for Fixture Wires

Size (AWG)	Allowable Ampacity
18	6
16	8
14	17
12	23
10	28

Figure I.2 Typical NEC table.



Art. 430 Part H
Sec. 430.101
thru 430.113

Disconnects motor and controllers from circuit.

1. Continuous rating of 115% or *more of motor FLC.* Also see Art. 430, Part B, Par. 1 below.
2. *Disconnecting means shall be a* motor circuit switch rated in horsepower or a *circuit breaker,* with exceptions. (See 430.109)
3. Must be is sight from controller, and not more than 50 feet distant.

Art. 430 Part D
Sec. 430.51
thru 430.58

Protects branch circuit from short circuits or grounds.

1. Must carry starting current of motor.
2. Rating must not exceed values in Table 430.152 unless not sufficient to carry starting current of motor.
3. Values for branch circuit protective devices shall in no case exceed exceptions listed in 430.52.

Art. 430 Part G
Sec. 430.81
thru 430.90

Used to start and stop motors.

1. Must have current rating of 100% or more of motor FLC.
2. Must be able to interrupt LRC.
3. Must be horsepower rated, not less *than motor, with exceptions.* (See 430.83)

Art. 430 Part C
Sec. 430.31
thru 430.44

Protects motor and controller against *excessive heat due to motor overload.*

1. *Must trip following percent or less of* motor FLC, for continuous motors rated more than one horsepower.
   a) 125% FLC for motors with a marked service factor not less than 1.15 or a marked temperature rise not over 40 C.
   b) 115% FLC for all others. (See part C of NEC for other types of protection)
2. Three thermal units required for any *three phase ac motor.*
3. Must allow motor to start.
4. *Select size from FLC on motor* namplate.

Art. 430 Part B
Sec. 430.21
thru 430.28

Specifies the sizes of conductors capable of carrying the motor current without overheating.

1. *To determine the ampacity of* conductors, switches, branch circuit *overcurrent devices, etc., the full-load* current values given in Tables 430.147 thru 430.150 shall be used instead of actual current rating marked on motor nameplate. (See 430.6)
2. Branch circuit conductors supplying a single motor shall have ampacity not less than 125% of motor FLC, with exceptions. (See 430.22)

Figure I.3 Diagram similar to those found throughout the NEC.

into Sections. For example, Article 110 of Chapter 1 begins with Section 110.2—Approval. Some sections may contain only one sentence or a paragraph, while others may be further subdivided into lettered or numbered paragraphs such as (A), (1), (2), and so on.

Begin your study of the NEC with Articles 80, 90, 100, and 110. These four articles have the basic information that will make the rest of the NEC easier to understand. NEC Article 100 defines terms you will need to understand the code. NEC Article 110 gives the general requirements for electrical installations. Read these four articles over several times until you are thoroughly familiar with all the information they contain. It's time well spent. For example, Article 90 contains the following sections:

- Administration and Enforcement (80.1)
- Purpose (90.1)
- Scope (90.2)
- Code Arrangement (90.3)
- Enforcement (90.4)
- Mandatory Rules, Permissive Rules, and Explanatory Material (90.5)
- Formal Interpretations (90.6)
- Examination of Equipment for Safety (90.7)
- Wiring Planning (90.8)
- Metric Units of Measurement (90.9)

Once you are familiar with Articles 80, 90, 100, and 110, you can move on to the rest of the NEC. There are several key sections you will use often in working with electrical systems.

Wiring Design and Protection. Chapter 2 of the NEC discusses wiring design and protection, the information electrical technicians need most often. It covers the use and identification of grounded conductors, branch circuits, feeders, calculations, services, overcurrent protection, and grounding. This is essential information for any type of electrical system.

Chapter 2 is also a "how-to" chapter. It explains how to provide proper spacing for conductor supports, how to provide temporary wiring, and how to size the proper grounding conductor or electrode. If you run into a problem related to the design/installation of a conventional electrical system, you can probably find a solution for it in this chapter.

Wiring Methods and Materials. Chapter 3 has the rules on wiring methods and materials. The materials and procedures to use on a particular system depend on the type of building construction, the type of occupancy, the location of the wiring in the building, the type of atmosphere in the building or in the area surrounding the building, mechanical factors, and the relative costs of different wiring methods. In most cases, installers will have more than one approved method that may be used.

The provisions of this chapter apply to all wiring installations except remote control switching (Article 725), low-energy power circuits (Article 725), signal systems (Article 725), and communication systems and conductors (Article 800) when these items form an integral part of equipment such as motors and motor controllers.

There are four basic wiring methods used in most modern electrical systems. Nearly all wiring methods are a variation of one or more of these four basic methods:

- Sheathed cables of two or more conductors, such as NM cable and ac armored cable (Articles 320 through 334)
- Raceway wiring systems, such as rigid and EMT conduit (Articles 342 to 358)
- Busways (Article 368)
- Cable tray (Article 392)

Article 310 gives a complete description of all types of electrical conductors. Electrical conductors come in a wide range of sizes and forms. Be sure to check the working drawings and specifications to see what sizes and types of conductors are required for a specific job. If conductor type and size are not specified, choose the most appropriate type and size meeting standard NEC requirements.

Articles 312 through 384 give rules for raceways, boxes, cabinets, and raceway fittings. Outlet boxes vary in size and shape, depending on their use, the size of the raceway, the number of conductors entering the box, the type of building construction, and atmospheric conditions of the areas. Chapter 3 of the NEC should answer most questions on the selection and use of these items.

The NEC does not describe in detail all types and sizes of outlet boxes. But manufacturers of outlet boxes have excellent catalogs showing all of their products. Collect these catalogs. They are essential to your work.

Article 404 covers the switches, push buttons, pilot lamps, receptacles, and convenience outlets you will use to control electric circuits or to connect portable equipment to electric circuits. Again, get the manufacturers' catalogs on these items. They will provide you with detailed descriptions of each of the wiring devices.

Article 408 covers switchboards and panelboards, including their location, installation methods, clearances, grounding, and overcurrent protection.

Equipment for General Use

Chapter 4 of the NEC begins with the use and installation of flexible cords and cables, including the trade name, type letter, wire size,

number of conductors, conductor insulation, outer covering, and use of each. This chapter also includes fixture wires (again giving the trade name), type letter, and other important details.

Article 410 on lighting fixtures is especially important. It gives installation procedures for fixtures in specific locations. For example, it covers fixtures near combustible material and fixtures in closets. The NEC does not describe how many fixtures will be needed in a given area to provide a certain amount of illumination.

Article 430 covers electric motors, including mounting the motor, and making electrical connections to it. Motor controls and overload protection are also covered.

Articles 440 through 460 cover air-conditioning and heating equipment, transformers, and capacitors.

Article 480 gives most requirements related to battery-operated electrical systems. Storage batteries are seldom thought of as part of a conventional electrical system, but they often provide standby emergency lighting service. They may also supply power to security systems that are separate from the main ac electrical system.

Special Occupancies

Chapter 5 of the NEC covers special occupancy areas. These are areas where the sparks generated by electrical equipment may cause an explosion or fire. The hazard may be due to the atmosphere of the area or just the presence of a volatile material in the area. Commercial garages, aircraft hangars, and service stations are typical special occupancy locations.

Articles 500 through 501 cover the different types of special occupancy atmospheres where an explosion is possible. The atmospheric groups were established to make it easy to test and approve equipment for various types of uses.

Articles 501.4, 502.4, and 503.3 cover the installation of explosionproof wiring. An explosionproof system is designed to prevent the ignition of a surrounding explosive atmosphere when arcing occurs within the electrical system.

There are three main classes of special occupancy locations:

- *Class I (Article 501).* Areas containing flammable gases or vapors in the air. Class I areas include paint spray booths, dyeing plants where hazardous liquids are used, and gas generator rooms.
- *Class II (Article 502).* Areas where combustible dust is present, such as grain-handling and storage plants, dust and stock collector areas, and sugar-pulverizing plants. These are areas where, under normal operating conditions, there may be enough combustible dust in the air to produce explosive or ignitable mixtures.

- *Class III (Article 503).* Areas that are hazardous because of the presence of easily ignitable fibers or flyings in the air, although not in large enough quantity to produce ignitable mixtures. Class III locations include cotton mills, rayon mills, and clothing manufacturing plants.

Articles 511 and 514 cover the regulation of garages and similar locations where volatile or flammable liquids are used. While these areas are not always considered critically hazardous locations, there may be enough danger to require special precautions in the electrical installation. In these areas, the NEC requires that volatile gases be confined to an area not more than 4 ft above the floor. So in most cases, conventional raceway systems are permitted above this level. If the area is judged critically hazardous, explosionproof wiring (including seal-offs) may be required. See Fig. I.4.

Article 520 regulates theaters and similar occupancies where fire and panic can cause hazards to life and property. Drive-in theaters do not present the same hazards as enclosed auditoriums, but the projection rooms and adjacent areas must be properly ventilated and wired for the protection of operating personnel and others using the area.

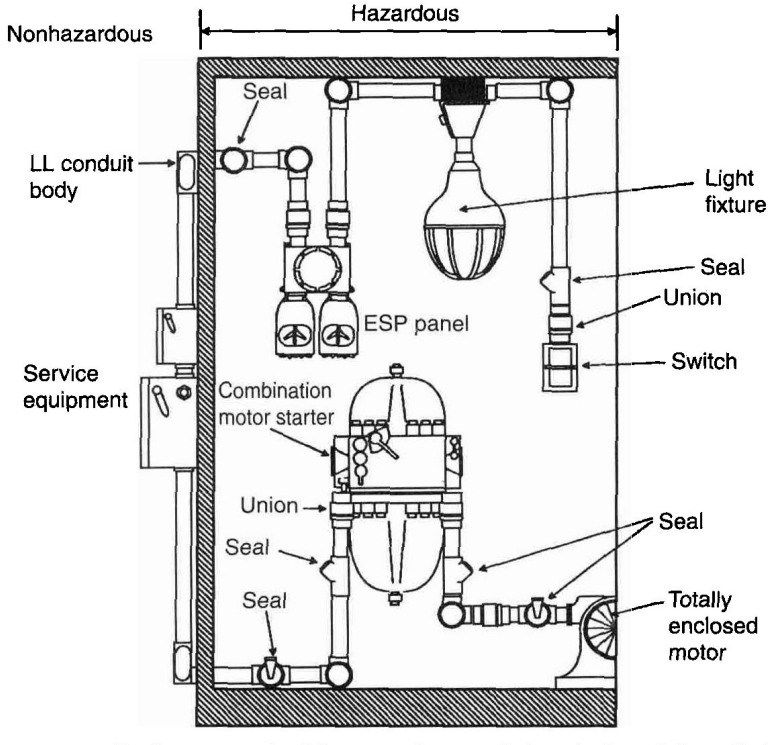


Figure I.4 Seals are required in some classes of electrical work installed in hazardous locations.

Chapter 5 of the NEC also covers garages, aircraft hangars, service stations, bulk-storage plants, health care facilities, mobile homes and parks, and recreational vehicles and parks.

In electrical systems in Class I, Division 1 locations, explosionproof fittings are required and most electrical wiring must be enclosed in rigid steel conduit.

Special Equipment

NEC Article 600 covers electric signs and outline lighting. Article 610 applies to cranes and hoists. Article 620 covers the majority of the electrical work involved in the installation and operation of elevators, dumbwaiters, escalators, and moving walks. The manufacturer is responsible for most of this work. The electrician usually just furnishes a feeder terminating in a disconnect means in the bottom of the elevator shaft. The electrician may also be responsible for a lighting circuit to a junction box midway in the elevator shaft for connecting the elevator cage lighting cable and exhaust fans. Articles in Chapter 6 of the NEC give most of the requirements for these installations.

Article 630 regulates electric welding equipment. It is normally treated as a piece of industrial power equipment requiring a special power outlet. But there are special conditions that apply to the circuits supplying welding equipment. These are outlined in detail in Chapter 6 of the NEC.

Article 640 covers wiring for sound-recording and similar equipment. This type of equipment normally requires low-voltage wiring. Special outlet boxes or cabinets are usually provided with the equipment, but some items may be mounted in or on standard outlet boxes. Some sound-recording electrical systems require direct current, supplied from rectifying equipment, batteries, or motor generators. Low-voltage alternating current comes from relatively small transformers connected on the primary side to a 120-V circuit within the building.

Other items covered in Chapter 6 of the NEC include x-ray equipment (Article 660), induction and dielectric heat-generating equipment (Article 665), and machine tools (Article 670).

Special Conditions

In most commercial buildings, the NEC and local ordinances require special means of lighting public rooms, halls, stairways, and entrances. There must be enough light to allow the occupants to exit from the building if the general building lighting is interrupted. Exit doors must be clearly indicated by illuminated exit signs.

Chapter 7 of the NEC covers the installation of emergency lighting systems. These circuits should be arranged so that they can automatically

transfer to an alternate source of current, usually storage batteries or gasoline-driven generators. As an alternative in some types of occupancies, you can connect them to the supply side of the main service so disconnecting the main service switch would not disconnect the emergency circuits. See Article 700. NEC Chapter 7 also covers a variety of other equipment, systems, and conditions that are not easily categorized elsewhere in the NEC.

Chapter 8 is a special category for wiring associated with electronic communications systems including telephone and telegraph, radio and TV, fire and burglar alarms, and community antenna systems.

Using the NEC

Once you become familiar with the NEC through repeated usage, you will generally know where to look for a particular topic, especially with the help of this book. While this book provides you with an excellent cross-reference index to the NEC, much experience will be needed for you to feel comfortable with the NEC's format. Here's how to locate information on a specific subject:

Step 1. Look through the NEC Contents. You may spot the topic in a heading or subheading. If not, look for a broader, more general subject heading under which the specific topic may appear. Also look for related or similar topics. The Contents will refer you to a specific page number.

Step 2. If you do not find what you're looking for in the Contents, go to the Index at the back of the book. This alphabetic listing is finely divided into different topics. You should locate the subject here. The Index, however, will refer you to either an Article or Section number (not a page number) where the topic is listed.

Step 3. If you cannot find the required subject in the Index, try to think of alternative names. For example, instead of wire, look under conductors; instead of outlet box, look under boxes, outlet, and so on.

The NEC is not an easy book to read and understand at first. In fact, seasoned electrical workers and technicians sometimes find it confusing. Basically, it is a reference book written in a legal, contract-type language and its content does assume prior knowledge of most subjects listed. Consequently, you will sometimes find the NEC frustrating to use because terms aren't always defined, or some unknown prerequisite knowledge is required. To minimize this problem, it is recommended that you obtain one of the several NEC supplemental guides that are designed to explain and supplement the NEC. One of the best is the *National Electrical Code Handbook,* available from the NFPA, Batterymarch Park, Quincy, MA 02269, or from your local bookstore.