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**USA STANDARD**

**ELECTRICAL CODE FOR  
ONE- AND TWO-FAMILY  
DWELLINGS**

**Excerpted from the  
1968 National Electrical Code**

Price: \$1.75

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**National Fire Protection Association**

60 Batterymarch Street

Boston, Mass. 02110

## ABOUT THE SPONSOR

This USA Standard Electrical Code for One- and Two-Family Dwellings is sponsored by the National Fire Protection Association under the auspices of the United States of America Standards Institute. The purpose of this Code is detailed in Section 90-1 and the scope of the Code is outlined in Section 90-2.

The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection. Membership in the Association is open to anyone interested. The annual dues for Associate Members are \$30.00 a year. International, national, and regional organizations, institutes, and societies interested in the protection of life and property against loss by fire may be Organization Members of the Association for which the dues are \$225.00 a year. Full details on membership privileges and benefits are available from the Association's Headquarters.

The National Fire Protection Association has acted as sponsor for the National Electrical Code since 1911. The original Code document was developed in 1897 as a result of the united efforts of various insurance, electrical, architectural, and allied interests. The current 1968 edition of the National Electrical Code was adopted by the Association at its 1968 Annual Meeting held May 20-24. It was subsequently approved as a USA Standard on July 11, 1968. This Electrical Code for One- and Two-Family Dwellings was approved by the National Fire Protection Association on May 14, 1969 and was accepted by the USA Standards Institute on the basis of its content being consistent with the complete 1968 National Electrical Code.

The National Fire Protection Association has an Electrical Section which provides particular opportunity for NFPA members interested in electrical safety to become better informed and to contribute to the development of the National Electrical Code and other NFPA electrical standards. The Electrical Section sponsors, for the above purposes, open meetings that are normally held during the NFPA Annual Meetings. During these Section Meetings, proposals for revisions or additions to NFPA electrical standards are reviewed and discussed. Bulletins and reports on matters affecting the National Electrical Code Committee and other NFPA activities in the electrical field are issued to members of the section periodically. Membership in the Electrical Section is open to any Associate Member of the NFPA and up to four individuals designated by any NFPA Organization Member at no additional cost. The Section is composed of technically interested individuals (not companies, government departments or organizations) and each membership must be in the name of the individual. A folder on the purposes, privileges and personnel of the NFPA Electrical Section is available from the Association.

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NATIONAL FIRE PROTECTION ASSOCIATION

60 Batterymarch St., Boston, Mass. 02110

# **USA Standard Electrical Code for One- and Two-Family Dwellings**

**NFPA No. 70A-1969  
USAS C1.1-1968**

**Excerpted from the 1968 National Electrical Code  
NFPA No. 70-1968, USAS C1-1968**

## **Explanation of this Code**

This Electrical Code for One- and Two-Family Dwellings (NFPA No. 70A-1969; USA Standard C1.1-1968) covers those wiring methods and materials most commonly encountered in the construction of new one- and two-family dwellings. Other wiring methods, materials and subject matter covered in the 1968 National Electrical Code (NFPA No. 70-1968; USA Standard C1-1968) are also recognized by this Code. (See Preface for further information.)

The development of this text was undertaken to meet the expressed need for an electrical code applicable only to dwellings as a convenience to those whose interests are so oriented. With the approval of the Correlating Committee of the National Electrical Code Committee, an Ad Hoc Committee was established of those primarily concerned to guide this project to completion. Those asked to serve on the Ad Hoc Committee included representatives of the following organizations: American Insurance Association, Building Officials Conference of America, Edison Electric Institute, Federal Housing Administration International Association of Electrical Inspectors, International Conference of Building Officials, National Association of Home Builders, the National Electrical Contractors Association, and Underwriters' Laboratories, Inc.

It was decided that the Electrical Code for One- and Two-Family Dwellings should consist of excerpts from the complete current National Electrical Code without any modification of intent and with minimum editorial change. Article and Section numbers have been retained to permit close correlation. Where a Section has been editorially revised, it is identified by the use of the letter E in the margin.

Following decisions made by the Correlating Committee and by the Ad Hoc Committee as to format and content, the excerpted material was formally submitted to members of the concerned Code-Making Panels for letter ballot to determine if the excerpts made and the editorial changes accomplished had been achieved without altering the intent of the complete Code and that the results satisfactorily achieved the purpose of the project. The results of this balloting have been reviewed by the Correlating Committee of the National Electrical Code

Committee and their report presented to the 1969 Annual Meeting of the Association held in New York, N.Y., May 12-16. The Association adopted this Code at the Technical Session of that meeting, May 14, 1969.

The USA Standard Institute through its Electrical and Electronics Standards Board has determined that since there is no modification of the intent of the 1968 National Electrical Code in this document and since the latter Code was approved as a USA Standard under date of July 11, 1968, that there was no requirement for having a duplicate approval. The Institute has thus authorized the publication of this USA Standard Electrical Code for One- and Two-Family Dwellings (Excerpted from the 1968 National Electrical Code, NFPA No. 70-1968, USAS C1-1968) designated C1.1-1968 (NFPA No. 70A-1969). The 1968 date on the USASI C1.1 designation indicates the date of the approval of the basic document. The 1969 date on the NFPA 70A designation reflects the action taken by the sponsor in gaining approval of the document at its 1969 Annual Meeting.

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## ERRATA

### Electrical Code for One- and Two-Family Dwellings NFPA No. 70A-1969; USAS C1.1-1968

- Preface Line 2 Insert page number to read: (See Page 70A-iii)
- 70A-1 Sec.90-1 Insert "E" opposite Section in left margin.
- 70A-2 Sec.90-7 Insert Section unintentionally omitted to read:  
"90-7 Enforcement. This Code is intended to be suitable for mandatory application by governmental bodies exercising legal jurisdiction over electrical installations and for use by insurance inspectors. The administrative authority supervising such enforcement of the Code will have the responsibility for making interpretations of the rules, for deciding upon the approval of equipment and materials, and for granting the special permission contemplated in a number of the rules."
- 70A-3 Sec.110-5 Delete balance of text after "operates" in second line.
- 70A-7 Sec.200-4 Delete entire Section.
- 70A-52 Sec.300-16 Insert "E" opposite Section in left margin.
- 70A-56 Table 310-12 Delete entire fourth column, headed 85°C (185°F).
- 70A-70 Table 346-12 Delete "and larger" in last line.
- 70A-75 Sec.370-4 Delete "knob and tube work or" in first line.
- 70A-75 Sec. 370-5 Insert "E" opposite Section in left margin.
- 70A-114 Table 3 Delete reference to Type "XHHW" conductors in third line of item 1.
- 70A-116 Table 5 Delete columns 10 and 11 with common heading "Type XHHW".
- 70A-117

# **USA Standard Electrical Code for One- and Two-Family Dwellings**

**Excerpted From the 1968 National Electrical Code**

**NFPA No. 70A-1969**

**USAS C1.1-1968**

**(For rules covering wiring methods and equipment not included here, see the 1968 National Electrical Code.)**

## **PREFACE**

This Code has been prepared under the guidance of an Ad Hoc Committee (see page 70A-iii) for preparation of an Electrical Code for One- and Two-Family Dwellings, as authorized by the National Electrical Code Committee through its Correlating Committee. The material included in this Code has been reviewed and processed by the appropriate Code-Making Panels, following the regular rules and procedures, except for the Time Table, used in promulgating the National Electrical Code (NEC).

Only those wiring methods and materials most commonly encountered in construction of new 1- and 2-family dwellings are included in this Code. **Other wiring methods, materials, and subject matter covered in the 1968 National Electrical Code (NFPA 70-1968, USAS C1-1968) are also recognized by this Code.**

In like manner, only current ratings up to and including 225 amperes and voltages up to and including 600 volts are included in this Code. It is the intent that the rules covering any wiring methods, any materials, or any type of equipment, such as motors, not specifically included in this Code are to be covered by the applicable rules in the 1968 National Electrical Code.

Where a reference is made to an article or section not included in this Code, such as to Article 430 or to Section 430-52, the reference is to that article or section appearing in the 1968 National Electrical Code.

The rules in this Code have been excerpted from the 1968 National Electrical Code, but editorially revised where necessary to restrict their applicability to 1- and 2-family dwellings. Where such rules have been editorially revised, they have been identified by the letter E in the margin.

The section numbers assigned to these rules are the same as in the 1968 National Electrical Code. However, there are many paragraphs



in the 1968 National Electrical Code that do not appear in this Code. Consequently, there are instances where gaps appear in the normal sequence of section numbers and alphabetical paragraph designations.

This Code has been formulated for the convenience of inspectors, contractors, builders, and others who are primarily interested in only those NEC rules which apply to 1- and 2-family dwellings. A revised edition will be issued concurrently with revised editions of the National Electrical Code to insure that there is no divergence between the requirements of the Codes as they pertain to 1- and 2-family dwellings.

**USA Standard Electrical Code**  
**for**  
**One- and Two-Family Dwellings**  
**NFPA NO. 70A-1969; USAS C1.1-1968**

**ARTICLE 90 — INTRODUCTION**

**E 90-1. Purpose.**

(a) The purpose of this Code is the practical safeguarding of persons and of 1- and 2-family dwellings and their contents from hazards arising from the use of electricity for light, heat, power, signaling, and for other purposes.

(b) This Code contains basic minimum 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.

Hazards often occur because of overloading of wiring systems by methods or usage not in conformity with the Code. This occurs because initial wiring did not provide for increases in use of electricity. For this reason it is recommended that the initial installation be adequate and that reasonable provisions for system changes be made as may be required for future increase in the use of electricity.

(c) This Code is not intended as a design specification nor an instruction manual for untrained persons.

**E 90-2. Scope.**

(a) **Covered.** Only those wiring methods and materials most commonly encountered in construction of new 1- and 2- family dwellings\* are included in this Code. **Other wiring methods, materials, and subject matter covered in the 1968 National Electrical Code (NFPA 70-1968, USAS C1-1968) are also recognized by this Code.**

(b) **Not Covered.** It does not cover:

(5) Installations under the exclusive control of electric utilities for the purpose of communication and metering; or for the control, transformation, transmission, and distribution of electric energy located outdoors on private property by established rights.

(c) **Special Permission.** The authority having jurisdiction for enforcing this Code may grant exceptions for the installation of conductors and equipment, not under the exclusive control of the electric

\*As used in this Code, 1- and 2-family dwellings do not include mobile homes, travel trailers, buildings containing more than two dwelling units, or buildings used for other than residential occupancies.

utilities and used to connect the electric utility supply system to the service entrance conductors of the premises served, provided such installations are outside a building or terminate immediately inside a building wall.

**E 90-6. Interpretation.** In order to promote uniformity of interpretation and application of this Code, the National Electrical Code Committee of the National Fire Protection Association has established a formal procedure for rendering interpretations in case of question. Applications for interpretations should be addressed to the National Fire Protection Association (see procedure for securing official interpretations of Code appearing in the Appendix of the NEC).

**90-7. Enforcement.** This Code is intended to be suitable for mandatory application by governmental bodies exercising legal jurisdiction over electrical installations and for use by insurance inspectors. The administrative authority supervising such enforcement of the Code will have the responsibility for making interpretations of the rules, for deciding upon the approval of equipment and materials, and for granting the special permission contemplated in a number of the rules.

**90-8. Examination of Equipment for Safety.** For approval of specific items of equipment and materials covered by the Code, examinations for safety should be made under standard conditions, and the record made generally available through promulgation by organizations properly equipped and qualified for experimental testing, inspections of the run of goods at factories, and service-value determination through field inspections. This avoids the necessity for repetition of examinations by different examiners, frequently with inadequate facilities for such work, and the confusion that would result from conflicting reports as to the suitability of devices and materials examined for a given purpose. It is the intent of the Code that factory-installed internal wiring or the construction of equipment need not be inspected at the time of installation of the equipment except to detect alterations or damage if the equipment has been listed by an electrical testing laboratory, which is nationally recognized as having the facilities described above and which requires suitability for installation in accordance with the Code.

## ARTICLE 110 — GENERAL

**110-1. Scope.** This Article provides the general requirements for electrical installations.

**110-3. Mandatory and Advisory Rules.** Mandatory rules of this Code are characterized by the use of the word, "shall." Advisory rules are characterized by the use of the word, "should," or are stated as recommendations of that which is advised but not required.

**110-4. Examination of Equipment.** Materials, devices, fittings, apparatus and appliances designed for use under this Code shall be judged chiefly with reference to the following considerations which also determine the classification by types, size, voltages, current capacities, and specific use.

(a) Suitability for installation and use in conformity with the provisions of this Code.

(b) Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.

(c) Electrical insulation.

(d) Heating effects under normal conditions of use and also under abnormal conditions likely to arise in service.

(e) Arcing effects.

**110-5. Voltages.** Throughout this Code the voltage considered shall be that at which the circuit operates.

**110-6. Conductor Gages.** Conductor sizes are given in American Wire Gage (AWG).

**110-7. Conductors.** Conductors normally used to carry current shall be of copper unless otherwise provided in this Code. Where the conductor material is not specified, the sizes given in this Code shall apply to copper conductors. Where other materials are used, the size shall be changed accordingly.

For aluminum conductors, see Tables 310-14 and 310-15.

**110-8. Wiring Methods.** Only those wiring methods most commonly encountered in 1- and 2-family dwellings are included in this Code. The recognized methods of wiring may be installed in any 1- and 2-family dwellings. Other wiring methods recognized by the NEC for 1- and 2-family dwellings are also recognized under this Code.

**110-9. Interrupting Capacity.** Devices intended to break current shall

have an interrupting capacity sufficient for the voltage employed and for the current which must be interrupted.

**110-11. Deteriorating Agencies.** Unless approved for the purpose, no conductors or equipment shall be located in damp or wet locations; where exposed to gases, fumes, vapors, liquids or other agents having a deteriorating effect on the conductors or equipment; nor where exposed to excessive temperatures.

Control equipment and utilization equipment approved for use in dry locations only, should be protected against permanent damage from weather during building construction.

**110-12. Mechanical Execution of Work.** Electrical equipment shall be installed in a neat and workmanlike manner.

**110-13. Mounting of Equipment.** Electrical equipment shall be firmly secured to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster or similar materials shall not be depended on for security.

**110-14. Connections to Terminals.** Connection of conductors to terminal parts shall insure a thoroughly good connection without damaging the conductors and shall be made by means of pressure connectors (including set screw type), solder lugs or splices to flexible leads except that No. 8 or smaller solid conductors and No. 10 or smaller stranded conductors may be connected by means of clamps or screws with terminal plates having upturned lugs. Terminals for more than one conductor shall be of a type approved for the purpose.

Because of different characteristics of copper and aluminum, devices such as pressure connectors and soldering lugs shall be suitable for the material of the conductor and shall be properly installed and used. Materials such as solder, fluxes, inhibitors, and compounds, where employed, shall be suitable for the use and shall be of a type which will not adversely affect the conductors, installation, or equipment.

**110-15. Splices.** Conductors shall be spliced or joined with splicing devices approved for the use or by brazing, welding or soldering with a fusible metal or alloy. Soldered splices shall first be so spliced or joined as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors.

**E 110-16. Working Space about Electrical Equipment (600 Volts or Less).** Sufficient access and working space shall be provided and maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment.

**(a) Working Clearances.** Except as elsewhere required or permitted in this Code, the dimension of the working space in the direction of access to live parts, operating at not more than 600 volts, which are likely to require examination, adjustment, servicing or maintenance while alive, shall not be less than indicated in Table 110-16(a). Distances are to be measured from the live parts if such are exposed or from the enclosure front or opening when such are enclosed.

**Table 110-16(a). Working Clearances**

Voltage to Ground	Minimum clear distance		
	Condition 1	2	3
0-150	2½ ft.	2½ ft.	3 ft.
151-600	2½	3½	4

Where the "Conditions" are as follows:

1. Exposed live part on one side and no live or grounded part on the other side of the working space or exposed live parts on both sides effectively guarded by suitable wood or other insulating materials. Insulated wire or insulated bus bars operating at not more than 300 volts shall not be considered live parts.

2. Exposed live parts on one side and grounded parts on the other side. Concrete, brick or tile walls shall be considered as grounded.

3. Exposed live parts on both sides of the work space (not guarded as provided in Condition 1) with the operator between.

*Exception No. 1. Working space is not required in back of assemblies such as control centers when there are no renewable or adjustable parts such as fuses or switches on the back and when all connections are accessible from other locations than the back.*

*Exception No. 2. Smaller spaces may be permitted by the authority having jurisdiction where it is judged that the particular arrangement of the installation will provide adequate accessibility.*

**(b) Clear Spaces.** Working space required by this Section shall not be used for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be suitably guarded.

**(c) Access and Entrance to Working Space.** At least one entrance of sufficient area shall be provided to give access to the working space about electrical equipment.

#### **E 110-17. Guarding of Live Parts.** (Not more than 600 Volts)

**(a)** Except as elsewhere required or permitted by this Code, live parts of electrical equipment operating at 50 volts or more shall be guarded against accidental contact by approved cabinets or other forms of approved enclosures.

#### **E 110-18. Arcing Parts.** Parts of electrical equipment which in ordinary operation produce arcs, sparks, flames or molten metal, shall be enclosed unless separated and isolated from all combustible material.

**110-20. Insulation Resistance.** All wiring shall be so installed that when completed the system will be free from short-circuits and from grounds other than as provided in Article 250.

**110-21. Marking.** The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product

may be identified, shall be placed on all electrical equipment. Other markings shall be provided giving voltage, current, wattage, or other ratings as are prescribed elsewhere in this Code.

**110-22. Identification.** Each disconnecting means required by this Code for motors and appliances, and each service, feeder or branch circuit at the point where it originates, shall be legibly marked to indicate its purpose unless located and arranged so the purpose is evident. The marking shall be of sufficient durability to withstand the environment involved.

## ARTICLE 200 — USE AND IDENTIFICATION OF GROUNDED CONDUCTORS

**200-1. Scope.** This Article provides requirements for the use and identification of a grounded conductor in interior wiring systems. (See definitions of "grounded conductor" and "grounding conductor" in Article 100.)

**200-2. General.** All interior wiring systems shall have a grounded conductor which is continuously identified throughout the system except as follows:

*Exception No. 1. A grounded conductor is not required in certain circuits or systems as provided in Sections 200-5, 250-3, 250-5, 250-6, 250-7, and 250-8.*

*Exception No. 2. Continuous identification throughout a length of a conductor between terminals is not required for certain conductors under Section 200-6(a and b).*

**200-3. Connection to Grounded System.** No interior wiring shall be electrically connected to a supply system unless the latter contains, for any grounded conductor of the interior system, a corresponding conductor which is grounded.

Electrically connected implies connection capable of carrying current as distinguished from connection through electromagnetic induction.

**200-5. Unidentified Circuits.**

(a) Two-wire branch circuits and AC circuits of two or more conductors may be tapped from the ungrounded conductors of circuits having identified grounded neutrals. Switching devices in each tapped circuit shall have a pole in each ungrounded conductor. These poles shall manually switch together where the switching devices serve as the disconnecting means required by Sections 422-21 and 422-23.

*Exception: For heating equipment see Section 424-21.*

(b) Polyphase circuits need not have one conductor grounded and identified, except as required by Section 250-5, but where one conductor is grounded it shall be identified.

(c) Other unidentified ungrounded systems or circuits may be used only by special permission.



**E 200-6. Means of Identification of Grounded Conductors.** Identification for grounded conductors shall be as follows:

(a) Insulated conductors of No. 6 or smaller shall have an outer identification of white or natural gray color as specified in 310-2(g).

(b) Insulated conductors larger than No. 6 shall have an outer identification of white or natural gray color, or shall be identified by distinctive white marking at terminals during process of installation.

**200-7. Identified Conductor in Grounded Circuits Only.** Conductors having white or natural gray covering shall not be used other than as conductors for which identification is required by Section 200-2, except under the following conditions, and then only where they are, in other respects, suitable for use as ungrounded conductors in the circuit:

*Exception No. 1. Identified conductors, rendered permanently unidentified by painting or other effective means at each outlet where the conductors are visible and accessible, may be used as unidentified conductors.*

*Exception No. 2. Cable containing an identified conductor may be used for single-pole, three-way or four-way switch loops where the connections are so made that the unidentified conductor is the return conductor from the switch to the outlet.*

This exception makes it unnecessary to paint the terminal of the identified conductor at the switch outlet.

*Exception No. 3. A flexible cord, for connecting a portable appliance, having one conductor identified as required by Section 400-13 may be used even though there is no grounded conductor in the circuit supplying the outlet to which it is connected.*

**200-8. Connections to Screw-Shells.** An identified conductor, where run to a screw-shell lampholder, shall be connected to the screw-shell.

**200-9. Means of Identification of Terminals.** The identification of terminals to which a grounded conductor is to be connected shall be by means of a metallic plated coating substantially white in color, such as nickel or zinc, or the terminals may be of material substantially white in color. The other terminals shall be of a readily distinguishable different color.

**E 200-10. Identification of Terminals.**

(b) **Plugs, Receptacles, and Connectors.** Polarized attachment plugs, receptacles and cord connectors for plugs and polarized plugs shall have the terminal intended for connection to the grounded (white) conductor identified by a metal or metal coating substantially white in color.

If the terminal for the grounded conductor is not visible, the conductor entrance hole for the connection shall be marked with the word "white."

The terminal for the connection of the equipment grounding conductor shall be identified by: (1) A green colored, not readily removable terminal screw with hexagonal head; or (2) A green colored, hexagonal, not readily removable terminal nut; or (3) A green colored

pressure wire connector. If the terminal for the grounding conductor is not visible, the conductor entrance hole shall be marked with the word "green" or otherwise identified by a distinctive green color.

*Exception: Two-wire attachment plugs, unless of the polarity type, need not have their terminals marked for identification.*

**(c) Screw-Shells.** In the case of devices with screw-shells, the identified terminal shall be the one connected to the screw-shell. This does not apply to screw-shells which serve as fuseholders.

**(d) Screw-Shell Devices with Leads.** In the case of screw-shell devices with attached leads, the conductor attached to the screw-shell shall have white or natural gray finish. The outer finish of the other conductor shall be of a solid color that will not be confused with the white or natural-gray finish which is to identify the grounded conductor.

**(e) Fixed Appliances.** The terminals of fixed appliances need not be marked to indicate the proper connection to the grounded conductor unless a single-pole switch forms an integral part, then the terminal connected to the switch shall be the unidentified terminal.

## ARTICLE 210—BRANCH CIRCUITS

**210-1. Scope.** The provisions of this Article shall apply to branch circuits supplying lighting or appliance loads or combinations of such loads. Where motors, or motor-operated appliances, are connected to any circuit supplying lighting or other appliance loads, the provisions of both this Article and Article 430 shall apply. Article 430 shall apply where branch circuit supplies only motor loads.

**E 210-2. Specific Purpose Branch Circuit.** The provisions applying to branch circuits referred to in the following list are exceptions to the provisions of this Article or are supplementary thereto, and shall apply to branch circuits supplying the loads referred to therein:

Fixed Electric Space Heating Equipment . . . . .	Section 424-3
Remote-Control, Low-Energy Power, Low-Voltage Power and Signal Circuits . . . . .	Article 725

**210-3. Classifications.** Branch circuits recognized by this Article shall be classified in accordance with the maximum permitted rating or setting of the overcurrent device, and the classification for other than individual branch circuits shall be 15, 20, 30, 40 and 50 amperes. When conductors of higher capacity are used for any reason, the rating or setting of the specified overcurrent device shall determine the circuit classification.

### A. General Provisions

**210-4. Multiwire Branch Circuits.** Branch circuits recognized by this Article may be installed as multiwire circuits.

See Article 100 for Definition.

**E 210-5. Color Code.** Where installed in raceways, the conductors of multiwire branch circuits and two-wire branch circuits connected to the same system shall conform to the following color code. Three-wire circuits — one black, one white, one red; four-wire circuits — one black, one white, one red, one blue. Where more than one multiwire branch circuit is carried through a single raceway the ungrounded conductors of the additional circuit may be of colors other than those specified. All circuit conductors of the same color shall be connected to the same ungrounded feeder conductor throughout the installation.

Any conductor intended solely for grounding purposes shall be identified by a continuous green color or a continuous green color with one or more yellow stripes unless it be bare. Branch circuit conductors and equipment lead wires to which branch circuit conductors attach having a continuous green color or a continuous green color with one or more yellow stripes shall not be used for other than grounding purposes.

The above is not intended to prohibit the use of a conductor having a continuous green color or a continuous green color with one or more yellow

stripes as insulation for internal wiring of equipment, except where such wiring serves as the lead wires to which the branch circuit conductors attach.

See section 200-7 for use of white or natural gray for grounded or neutral conductors.

#### **E 210-6. Voltage.**

(a) **Voltage to Ground.** The voltage to ground on branch circuits supplying lampholders, fixtures, or standard receptacles of 15-ampere or less rating shall not exceed 150 volts.

(b) **Voltage Between Conductors.** The voltage between conductors supplying lampholders of the screw-shell type, receptacles, or appliances, shall not exceed 150 volts, except as follows:

*Exception: The voltage between conductors may exceed 150 volts when supplying only:*

(1) *Permanently connected appliances,*

(2) *Portable appliances of more than 1,380 watts,*

(3) *Portable motor-operated appliances of  $\frac{1}{4}$  horsepower or greater rating.*

(c) **Voltage Drop.** The size of the conductors for branch circuits as defined in Article 100 should be such that the voltage drop would not exceed 3 per cent to the farthest outlet for power, heating, lighting, or combinations thereof. Providing further that the maximum total voltage drop for feeders and branch circuits should not exceed 5 per cent over all.

#### **E 210-7. Grounding Type Receptacles.** Receptacles and cord connectors equipped with grounding contacts shall have those contacts effectively grounded. The branch circuit or branch circuit raceway shall include or provide a grounding conductor to which the grounding contacts of the receptacle or cord connector shall be connected. The armor of type AC metal-clad cable, or a metallic raceway is acceptable as a grounding conductor. See Sections 210-21(b), 250-45, 250-57(a), 250-59 and 350-5.

*Exception: For extensions only in existing installations which do not have a grounding conductor in the branch circuit, the grounding conductor of a grounding type receptacle outlet may be grounded to a grounded cold water pipe near the equipment.*

### **B. Specific Requirements**

#### **E 210-19. Conductors.** Circuit conductors shall conform to the following:

(a) **Ampacity.** Shall have an ampacity of not less than the rating of the branch circuit and not less than the maximum load to be served.

(b) **Minimum Size.** Shall not be smaller than No. 8 for ranges of  $8\frac{3}{4}$  kw or more rating, nor smaller than No. 14 for other loads.

(c) **Exceptions:**

*Exception No. 1. Range Loads. See Note 5 of Table 220-5. Where the maximum demand of a range of  $8\frac{3}{4}$  kw or more rating is computed*

according to Column A of Table 220-5, the neutral conductor of a three-wire branch circuit supplying a household electric range, a wall-mounted oven or a counter-mounted cooking unit may be smaller than the ungrounded conductors but shall have an ampacity at least 70 per cent of the ampacity of the ungrounded conductors and shall not be smaller than No. 10.

Cable assemblies with the neutral conductor smaller than the ungrounded conductors shall be so marked.

*Exception No. 2. Tap Conductors.* Tap conductors may be of less capacity than the branch circuit rating provided no tap conductor is of less capacity than the load to be served and provided the rating is not less than 20 amperes for 40 or 50 ampere circuits or 15 amperes for circuits rated less than 40 amperes and only when these tap conductors supply either:

(a) Individual lampholders or fixtures with taps extending not longer than 18 inches beyond any portion of the lampholder or fixture, except as required in Section 410-65(b-2); or,

(b) Individual outlets with taps not over 18 inches long or,

(d) Nonheating leads of snow and ice melting cables and mats.

*Exception No. 3. Fixture Wires and Cords.* Fixture wires and cords may be of smaller size, but not less than the size specified in Exception No. 3 of Section 240-5(a).

*Exception No. 4. Outlet Devices.* Outlet devices may have less carrying capacity than the branch circuit rating, but not less than the types and ratings specified in Section 210-21 (a-c).

*Exception No. 5.* Where tap conductors supply electric ranges, wall-mounted electric ovens and counter-mounted electric cooking units from 50 ampere branch circuits they shall be of suitable capacity for the load to be served, not less than 20 amperes in rating and no longer than necessary for servicing the appliance.

**E 210-20. Overcurrent Protection.** The rating or setting of overcurrent devices shall conform to the following:

(a) **Rating.** Shall not be in excess of the value specified in Section 240-5.

*Exception: Tap Conductors and Fixture Wires.* Tap conductors, fixture wire and cords as permitted in Section 210-19 (c) may be considered as protected by the circuit overcurrent device.

(b) **Single Appliance.** Shall not exceed 150 per cent of the rating of the appliance, where the circuit supplies only a single appliance of 10-ampere or more rating.

(c) **Continuous Loads.** Where loads other than motor loads will constitute continuous loads see Sections 210-23(b), 220-2 and 240-2.

**E 210-21. Outlet Devices.** Outlet devices shall have a rating not less than the load to be served and shall conform to the following:

(b) **Receptacles.** Receptacles installed on 15 ampere and 20 ampere branch-circuits shall be of the grounding type and they shall be

installed in accordance with Section 210-7. Grounding type receptacles which are of a type that rejects non-grounding type attachment plugs or which are of the locking type may be used for specific purposes or in special locations.

A single receptacle installed on an individual branch circuit shall have a rating of not less than the rating of the branch circuit.

When grounding type receptacles are used as replacements for existing non-grounding types a grounding conductor installed in accordance with Section 250-57 shall be provided. If it is impractical to reach a source of ground a non-grounding type receptacle shall be used. The installation of grounding type outlets shall not be used as a requirement that all portable equipment be of the grounded type. See Article 250 for requirements for the grounding of portables.

When connected to circuits having two or more outlets, receptacles shall conform to the following:

15-amp. circuits	Not over 15-amp. rating
20-amp. circuits	15 or 20-amp. rating
30-amp. circuits	30-amp. rating
40-amp. circuits	40 or 50 amp. rating
50-amp. circuits	50-amp. rating

Receptacles connected to circuits having different voltages, frequencies or types of current (AC or DC) on the same premises shall be of such design that attachment plugs used on such circuits are not interchangeable.

Grounding type receptacles shall be installed only on circuits of the voltage class and current for which they have been approved.

Receptacles rated at 15 amperes connected to 15 or 20 ampere branch circuits serving two or more outlets shall not supply a total load in excess of 12 amperes for portable appliances. Receptacles rated at 20 amperes connected to 20 ampere branch circuits serving two or more outlets shall not supply a total load in excess of 16 amperes for portable appliances.

(c) Capacity of range receptacles may be based on single range loads as computed from Table 220-5.

**E 210-22. Receptacle Outlets Required.** Receptacle outlets shall be installed as follows:

(a) **General.** Where portable cords are used, except where the attachment of cords by other means is specifically permitted.

A cord connector that is supported by a permanently connected cord pendant is considered a receptacle outlet.

(b) **Where Required.** In every kitchen, family room, dining room, breakfast room, living room, parlor, library, den, sun room, recreation room and bedroom, receptacle outlets shall be installed so that no point along the floor line in any wall space is more than six feet, measured horizontally, from an outlet in that space including any wall space two feet wide or greater and the wall space occupied by sliding panels in exterior walls. The receptacle outlets shall, insofar as practicable, be

spaced equal distances apart. Receptacle outlets in floor shall not be counted as part of the required number of receptacle outlets unless located close to the wall. At least one outlet shall be installed for the laundry.

Outlets in other sections of the dwelling for special appliances such as laundry equipment shall be placed within 6 feet of the intended location of the appliance.

**E 210-23. Maximum Load.** The maximum load shall conform to the following:

(a) **Appliances Consisting of Motors and Other Loads.** Where a circuit supplies only motor operated appliance loads, Article 430 shall apply. For other than a portable appliance, the branch circuit size shall be calculated on the basis of 125 per cent of motor load where the motor is larger than  $\frac{1}{8}$  hp plus the sum of the other loads.

(b) **Other Loads.** The total load shall not exceed the branch circuit rating, and shall not exceed 80 per cent of the rating when load will constitute a continuous load. In computing the load of lighting units which employ ballasts, transformers or auto-transformers, the load shall be based on the total of the ampere rating of such units and not on the wattage of the lamps.

*Exception No. 1. When the assembly including the overcurrent device protecting the branch circuit is approved for continuous operation at 100 per cent of its rating, the total load may equal the branch circuit rating.*

*Exception No. 2. Where branch circuits are derated in accordance with Note 8 of Tables 310-12 and 310-14 the derating factor for continuous loading shall not apply.*

*Exception No. 3. Range Loads. See Note 5 of Table 220-5.*

**E 210-24. Permissible Loads.** Individual branch circuits may supply any loads.

Branch circuits having two or more outlets may supply only loads as follows:

(a) **15- and 20-Ampere Branch Circuits.** Lighting units and/or appliances. The rating of any one portable appliance shall not exceed 80 per cent of the branch circuit rating. The total rating of fixed appliances shall not exceed 50 per cent of the branch circuit rating when lighting units or portable appliances are also supplied. Small appliance branch circuits shall supply only the loads stipulated in Section 220-3(b).

(b) **30-Ampere Branch Circuits.** Appliances.

The rating of any one portable appliance shall not exceed 24 amperes.

(c) **40-Ampere Branch Circuits.** Fixed cooking appliances; or infra-red heating units.

(d) **50-Ampere Branch Circuits.** Fixed cooking appliances; or infra-red heating units.

The term "fixed" as used in this Section recognizes cord connections where otherwise permitted.

Fixed outdoor electric snow melting and deicing installations may be supplied by any of the branch circuits described herein provided the circuit supplies no other load.

**210-25. Table of Requirements.** The requirements for circuits having two or more outlets [other than the receptacle circuits of Section 220-3(b)] as specifically provided for above are summarized in Table 210-25.

**Table 210-25**  
**Branch Circuit Requirements**

(Type FEP, FEPB, RUW, SA, T, TW, RH, RUH, RHW, RHH, THHN, THW, and THWN conductors in raceway or cable.)

CIRCUIT RATING	15 Amp.	20 Amp.	30 Amp.	40 Amp.	50 Amp.
<b>CONDUCTORS:</b> (Min. Size)					
Circuit Wires*	14	12	10	8	6
Taps	14	14	14	12	12
Fixture Wires and Cords	Refer to Section 240-5(a), Exception No. 3				
<b>OVERCURRENT PROTECTION</b>	15 Amp.	20 Amp.	30 Amp.	40 Amp.	50 Amp.
<b>OUTLET DEVICES:</b>					
Lampholders Permitted	Any Type	Any Type	Heavy Duty	Heavy Duty	Heavy Duty
Receptacle Rating	15 Max. Amp.	15 or 20 Amp.	30 Amp.	40 or 50 Amp.	50 Amp.
<b>MAXIMUM LOAD</b>	15 Amp.	20 Amp.	30 Amp.	40 Amp.	50 Amp.
<b>PERMISSIBLE LOAD</b>	Refer to Section 210-24(a)	Refer to Section 210-24(a)	Refer to Section 210-24(b)	Refer to Section 210-24(c)	Refer to Section 210-24(d)

\*These ampacities are for copper conductors where derating is not required. See Tables 310-12 and 310-14.



## ARTICLE 215 — FEEDERS

**215-1. Scope.** This Article deals with installation requirements for, and, the size of conductors in the feeders needed to supply power to branch circuits and, the loads as calculated under Article 220.

**E 215-2. Conductor Size.** Feeder conductors shall have a current rating not smaller than the feeder load as determined by Section 220-4. A 2-wire feeder supplying two or more 2-wire branch circuits, or a 3-wire feeder supplying more than two 2-wire branch circuits, or two or more 3-wire branch circuits, shall be not smaller than No. 10. Where a feeder carries the total current supplied by the service-entrance conductors, such feeder, for services of No. 6 and smaller, shall be of the same size as the service-entrance conductors.

Where at any time it is found that feeder conductors are, or will be, overloaded, the feeder conductors shall be increased in capacity to accommodate the actual load served.

See Examples Nos. 1, 1(a), 1(b), and 1(d).

**215-4. Overcurrent Protection.** Feeders shall be protected against overcurrent in accordance with the provisions of Article 240.

**215-7. Installation Requirements.** Where a feeder supplies branch circuits in which grounding conductors are required, the feeder shall include or provide a grounding means to which the grounding conductor of the branch circuit shall be connected.

## ARTICLE 220 — BRANCH CIRCUIT AND FEEDER CALCULATIONS

**220-1. Scope.** This Article provides the basis for calculating the expected branch circuit and feeder loads and for determining the number of branch circuits required.

**E 220-2. Calculation of Branch Circuit Loads.** The load for branch circuits shall be computed in accordance with the provisions of this Section.

Where in normal operation the maximum load will constitute a continuous load, the minimum unit loads specified in this Section shall be increased by 25 per cent.

*Exception No. 1. Where branch circuits are derated in accordance with Note 8 of Tables 310-12 and 310-14 the unit loads are not required to be increased by 25 per cent.*

*Exception No. 2. When the assembly including the overcurrent devices protecting the branch circuits and feeders are approved for operation at 100 per cent of their rating the minimum unit loads need not be increased over those specified.*

**(a) General Lighting Load.** A load of not less than 3 watts per square foot shall be included for the entire floor area.

In determining the load on the "watts per square foot" basis, the floor area shall be computed from the outside dimensions of the building or area involved, and the number of floors; not including open porches, garages, unfinished spaces, and unused spaces unless adaptable for future use.

All receptacle outlets of 15-ampere or less rating [except those connected to the receptacle circuits specified in Section 220-3 (b)] may be considered as outlets for general illumination, and no additional load need be included for such outlets.

The unit values herein are based on minimum load conditions and 100 per cent power factor, and may not provide sufficient capacity for the installation contemplated.

In view of the trend toward higher intensity lighting systems and increased loads due to more general use of fixed and portable appliances, each installation should be considered as to the load likely to be imposed and the capacity increased to insure safe operation.

Where electric discharge lighting systems are to be installed, high power-factor type should be used or the conductor capacity may need to be increased.

**(b) Other Loads.** For lighting other than general illumination and for appliances other than motors, a load of not less than the unit load specified below shall be included for each outlet.

\*Outlets supplying specific appliances and other loads ..... Amp. rating of appliance

\*For motors, see Sections 430-22 and 430-24.

‡Other outlets ..... 1½ amperes

‡This provision shall not be applicable to receptacle outlets connected to the circuit specified in Section 220-3(b) nor to receptacle outlets provided for the connection of stationary equipment as provided for in Section 400-3.

(c) **Exceptions.** The minimum load for outlets specified in Section 220-2(b) shall be modified as follows:

*Exception No. 1. Ranges. For household electric ranges, the branch circuit load may be computed in accordance with Table 220-5.*

The provisions of Section 220-2(b) shall apply to all other receptacle outlets.

(d) **Existing Installations.** New circuits or extensions to existing circuits may be determined in accordance with Sections 220-2(a or b): except that portions of existing structures not previously wired, or additions to the building structure, either of which exceeds 500 square feet in area, shall be determined in accordance with Section 220-2(a).

## **E 220-3. Branch Circuits Required.** Branch circuits shall be installed as follows:

(a) **Lighting and Appliance Circuits.** For lighting, and for appliances, including motor-operated appliances, not specifically provided for in Section 220-3(b), branch circuits shall be provided for a computed load not less than that determined by Section 220-2.

The number of circuits shall be not less than that determined from the total computed load and the capacity of circuits to be used. In every case the number shall be sufficient for the actual load to be served, and the branch circuit loads shall not exceed the maximum loads specified in Section 210-23.

Where the load is computed on a "watts per square foot" basis, the total load, in so far as practical, shall be evenly proportioned among the branch circuits according to their capacity.

When lighting units to be installed operate at other than 100 per cent power factor, see Section 210-23(b) for maximum ampere load permitted on branch circuits.

For general illumination in dwelling occupancies, it is recommended that not less than one branch circuit be installed for each 500 square feet of floor area in addition to the receptacle circuits called for in Section 220-3(b).

See Examples No. 1, 1a, 1b, 1c, and 1d.

(b) **Small Appliance Branch Circuits.** For the small appliance load in kitchen, pantry, family room, dining room, and breakfast room, two or more 20-ampere appliance branch circuits in addition to the branch circuits specified in Section 220-3(a) shall be provided for all receptacle outlets in these rooms, and such circuits shall have no other outlets.

Receptacle outlets supplied by at least two appliance receptacle branch circuits shall be installed in the kitchen.

At least one 20-ampere branch circuit shall be provided for laundry receptacle(s) required in Section 210-22(b).

Receptacle outlets installed solely for the support of and the power supply for electric clocks may be installed on lighting branch circuits.

A three-wire 115/230 volt branch circuit is the equivalent of two 115 volt receptacle branch circuits.

(c) **Other Circuits.** For specific loads not otherwise provided for in Section 220-3(a or b), branch circuits shall be as required by other sections of the Code.

**E 220-4. Calculation of Feeder Loads.** The computed load of a feeder shall be not less than the sum of all branch circuit loads supplied by the feeder, as determined by Section 220-2, subject to the following provisions:

(a) **General Lighting.** The demand factors listed in Table 220-4(a) may be applied to that portion of the total branch circuit load computed for general illumination. These demand factors shall not be applied in determining the number of branch circuits for general illumination supplied by the feeders.

See Section 220-4 (h).

The demand factors herein are based on minimum load conditions and 100 per cent power factor, and in specific instances may not provide sufficient capacity for the installation contemplated. In view of the trend toward higher intensity lighting systems and increased loads due to more general use of fixed and portable appliances, each installation should be considered as to the load likely to be imposed and the capacity increased to insure safe operation. Where electric discharge lighting systems are to be installed, high power-factor type should be used or the conductor capacity may need to be increased.

**E Table 220-4(a). Calculation of Feeder Loads**

Portion of Lighting Load to which Demand Factor Applies (wattage)	Feeder Demand Factor
First 3000 or less at	100%
Next 3001 to 120,000 at	35%
Remainder over 120,000 at	25%

(c) **Motors.** For motors, a load computed according to the provisions of Sections 430-24, 430-25 and 430-26 shall be included.

(d) **Neutral Feeder Load.** The neutral feeder load shall be the maximum unbalance of the load determined by Section 220-4. The maximum unbalanced load shall be the maximum connected load between the neutral and any one ungrounded conductor. For a feeder supplying household electric ranges, wall-mounted ovens and counter-mounted cooking units, the maximum unbalanced load shall be considered as 70 per cent of the load on the ungrounded conductors, as determined in accordance with Table 220-5. For single-phase and 4-wire 3-phase AC systems, a further demand-factor of 70 per cent may be applied to that portion of the unbalanced load in excess of 200 amperes.

There shall be no reduction of the neutral capacity for that portion of the load which consists of electric discharge lighting.

See Examples 1, 1a, 1b, 1c, and 1d.

**(e) Fixed Electrical Space Heating.** The computed load of a feeder supplying fixed electrical space heating equipment shall be the total connected load on all branch circuits.

*Exception No. 1. Where reduced loading of the conductors results from units operating on duty-cycle, intermittently, or from all units not operating at one time, the authority enforcing this code may grant permission for feeder conductors to be of a capacity less than 100 per cent, provided the conductors are of sufficient capacity for the load so determined.*

*Exception No. 2. Section 220-4(e) does not apply when feeder capacity is calculated in accordance with optional method in Section 220-7 for one-family residences.*

**(f) Noncoincident Load.** In adding the branch circuit loads to determine the feeder load, the smaller of two dissimilar loads may be omitted from the total where it is unlikely that both of the loads will be served simultaneously.

**(h) 1. Small Appliances.** A feeder load of not less than 1500 watts for each two-wire circuit installed as required by Section 220-3(b) shall be included for small appliances (portable appliances supplied from receptacles of 15 or 20 ampere rating) in kitchen, pantry, family room, dining room, and breakfast room. Where the load is subdivided through two or more feeders, the computed load for each shall include not less than 1500 watts for each two-wire circuit for small appliances. These loads may be included with the general lighting load and subject to the demand factors in Section 220-4(a).

**2. Laundry Circuit.** A feeder load of not less than 1500 watts shall be included for each 2-wire laundry circuit installed as required by Section 220-3(c). This load may be included with the general lighting load and subject to the demand factors in Section 220-4(a).

**(i) Electric Ranges.** The feeder load for household electric ranges and other cooking appliances, individually rated more than  $1\frac{3}{4}$  kw, may be calculated in accordance with Table 220-5.

In order to provide for possible future installation of ranges of higher ratings, it is recommended that where ranges of less than  $8\frac{3}{4}$  kw ratings or wall-mounted ovens and counter-mounted cooking units are to be installed, the feeder capacity be not less than the maximum demand value specified in Column A of Table 220-5.

**(j) Fixed Electrical Appliances (Other than Ranges, Clothes Dryers, Air Conditioning Equipment or Space Heating Equipment).** Where four or more fixed electrical appliances other than electric ranges, clothes dryers, air conditioning equipment or space heating equipment are connected to the same feeder, a demand factor of 75 per cent may be applied to the fixed appliance load.

**(k) Space Heating and Air Cooling.** In adding branch circuit loads

for space heating and air cooling, the smaller of the two loads may be omitted from the total where it is unlikely that both of the loads will be served simultaneously.

**Table 220-5. Demand Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units and Other Household Cooking Appliances over 1¼ kw Rating**  
Column A to be used in all cases except as otherwise permitted in Note 4 below.

NUMBER OF APPLIANCES	Maximum Demand (See Notes)	Demand Factors (See Note 4)	
	COLUMN A (Not over 12 kw Rating)	COLUMN B (Less than 3½ kw Rating)	COLUMN C (3½ kw to 8¾ kw Rating)
1	8 kw	80%	80%
2	11 kw	75%	65%
3	14 kw	70%	55%
4	17 kw	66%	50%

(For more than 4; see Table 220-5, NEC.)

Note 1. Over 12 kw to 27 kw ranges all of same rating. For ranges, individually rated more than 12 kw but not more than 27 kw, the maximum demand in Column A shall be increased 5 per cent for each additional kw of rating or major fraction thereof by which the rating of individual ranges exceeds 12 kw.

Note 2. Over 12 kw to 27 kw ranges of *unequal ratings*. For ranges individually rated more than 12 kw and of different ratings but none exceeding 27 kw an average value of rating shall be calculated by adding together the ratings of all ranges to obtain the total connected load (using 12 kw for any range rated less than 12 kw) and dividing by the total number of ranges; and then the maximum demand in Column A shall be increased 5 per cent for each kw or major fraction thereof by which this average value exceeds 12 kw.

Note 4. Over 1¼ kw to 8¾ kw. In lieu of the method provided in Column A, loads rated more than 1¼ kw but not more than 8¾ kw may be considered as the sum of the nameplate ratings of all the loads, multiplied by the demand factors specified in Columns B or C for the given number of loads.

Note 5. Branch Circuit Load. Branch circuit load for one range may be computed in accordance with Table 220-5. The branch circuit load

**Table 220-6(b)**  
**Demand Factors for Household Electric Clothes Dryers**

Number of Dryers	Demand Factor (per cent)
1	100
2	100
3	100
4	100

for one wall-mounted oven or one counter-mounted cooking unit shall be the nameplate rating of the appliance. The branch circuit load for a counter-mounted cooking unit and not more than two wall-mounted ovens, all supplied from a single branch circuit and located in the same room shall be computed by adding the nameplate ratings of the individual appliances and treating this total as equivalent to one range.

- E 220-7. Optional Calculation.** For each dwelling unit served by a 115/230 volt, 3-wire, 100 ampere or larger service where the total load is supplied by one feeder or one set of service entrance conductors, the percentages shown in Table 220-7 may be used in lieu of the method of determining feeder (and service) loads detailed in Section 220-4.

All other loads shall include 1500 watts for each 20 ampere appliance circuit [Section 220-3(b)]; lighting and portable appliances at 3 watts per square foot; all fixed appliances, (including four or more separately controlled space heating units [see Section 220-4(k)], ranges, wall-mounted ovens and counter-mounted cooking units) at nameplate rated load (kva for motors and other low power-factor loads).

See Examples 1(b) and 1(c).

**E**

**Table 220-7**  
**Optional Calculation**

LOAD (in kw or kva)	Per Cent of Load
Air conditioning and cooling including heat pump compressors [see Section 220-4(k)]	100%
Central electrical space heating [see Section 220-4(k)]	100%
Less than four separately controlled electrical space heating units [see Section 220-4(k)]	100%
First 10 kw of all other load	100%
Remainder of other load	40%

**220-8. Optional Calculation for Additional Loads in Existing One-Family Dwelling Occupancy.** Load calculations for an existing one-family dwelling occupancy now served by an existing 115/230 volt or 120/208 volt, 3-wire, 60 ampere service may be computed as follows:

Load in KW or KVA	Per Cent of Load
First 8 KW of load at	100%
Remainder of load at	40%

Load calculation shall include lighting and portable appliances at 3 watts per square foot; 1500 watts for each 20 ampere appliance circuit; range or wall mounted oven and counter-mounted cooking unit, and other fixed or stationary appliances, at nameplate rating.

If air conditioning equipment or electric space heating equipment is

to be installed the following formula shall be applied to determine if the existing service is of sufficient size.

Air conditioning equipment*	100%
Central electrical space heating*	100%
Less than four separately controlled space heating units*	100%
First 8 KW of all other load	100%
Remainder of all other load	40%

Other loads shall include:

1500 watts for each 20 ampere appliance circuit.

Lighting and portable appliances at 3 watts per sq. ft.

Household range or wall-mounted oven and counter-mounted cooking unit.

All other fixed appliances including four or more separately controlled space heating units, at nameplate rating.

\*Use larger connected load of air conditioning and space heating, but not both.



## ARTICLE 230 — SERVICES

### A. General Requirements

**230-1. Scope.** The provisions of this Article shall apply to the conductors and equipment for control and protection of services — circuits that conduct electric power from the supply system to the premises to be served.

**E 230-2. Number of Services to a Building or Other Premises Served.** In general, a building or other premises served shall be supplied through only one set of service conductors, except as follows:

*Exception No. 3. A 2-family dwelling may have two separate sets of service-entrance conductors which are tapped from one service drop or lateral, or two sub-sets of service-entrance conductors may be tapped from a single set of main service-entrance conductors.*

**DEFINITION:** Sub-sets of service-entrance conductors are taps from main service conductors run to service equipment.

*Exception No. 6. Different Characteristics or Classes of Use. Where additional services are required for different voltages, frequency, or phase, or different classes of use. Different classes of use could be because of needs for different characteristics, or because of rate schedule as in the case of controlled water heater service.*

**230-3. Supply to a Building from Another.** The service conductors supplying each building or structure shall not pass through the inside of another building unless these buildings are under single occupancy or management. See Section 230-45.

### B. Insulation and Size of Service Conductors

**230-4. Insulation of Service Conductors.** Service conductors shall normally withstand exposure to atmospheric and other conditions of use without detrimental leakage of current to adjacent conductors, objects, or the ground.

For Service Drops — See Section 230-22.

For Service Entrance Conductors — See Section 230-40.

For Underground Services — See Section 230-30.

**E 230-5. Size of Service Conductors.** Service conductors shall have adequate ampacity to safely conduct the current for the loads supplied without a temperature rise detrimental to the insulation or covering of the conductors, and shall have adequate mechanical strength.

Minimum sizes are given in the following references:

For Service Drops — Section 230-23.

For Service Entrance Conductors — Section 230-41.

For Underground Service Conductors — Section 230-31.

**C. Service Drops**

**230-21. Number of Drops.** No building shall be supplied through more than one service drop, except for the purposes listed in Section 230-2.

**230-22. Service Drop Conductors.**

(a) In multiple conductor cables, conductors shall be insulated or covered with rubber or thermoplastic.

*Exception. A grounded conductor may be without insulation or covering where the nominal voltage to ground of any conductor is not over 300 volts.*

(b) All open, individual conductors shall be insulated or covered.

**E 230-23. Minimum Size of Service Conductors.** Conductors shall have sufficient ampacity to carry the load. They shall have adequate mechanical strength and shall not be smaller than No. 8 copper or No. 6 aluminum.

*Exception. For installations to supply only limited loads of a single branch circuit such as small polyphase power, controlled water heaters and the like, they shall not be smaller than No. 12 hard drawn copper or equivalent.*

Overhead conductors to a building or other structure from a pole on which a meter or disconnecting means is installed shall be considered as a service drop and installed accordingly.

Conductors having extruded covering used for service drops have the same ampacities as covered conductors.

**E 230-24. Clearance of Service Drops.** Service drop conductors shall not be readily accessible and when not in excess of 600 volts, shall conform to the following:

(a) **Clearance Over Roof.** Conductors shall have a clearance of not less than 8 ft. from the highest point of roofs over which they pass with the following exceptions:

*Exception No. 1. Where the voltage between conductors does not exceed 300 and the roof has a slope of not less than 4 inches in 12 inches the clearance may be not less than 3 feet.*

*Exception No. 2. Service drop conductors of 300 volts or less which do not pass over other than a maximum of 4 feet of the overhang portion of the roof for the purpose of terminating at a (through-the-roof) service raceway or approved support may be maintained at a minimum of 18 inches from any portion of the roof over which they pass.*

(b) **Clearance from Ground.** Service drop conductors when not in excess of 600 volts, shall have the following minimum clearance from ground.

10 feet — above finished grade, sidewalks or from any platform or projection from which they might be reached;

12 feet — over residential driveways.

18 feet — over public streets, alleys, and roads.

(c) **Clearance from Building Openings.** Conductors shall have a clearance of not less than 36 inches from windows, doors, porches, fire escapes, or similar locations.

Conductors run above the top level of a window are considered out of reach from that window.

**230-25. Supports Over Buildings.** Where practicable, conductors passing over a building shall be supported on structures which are independent of the building. Where necessary to attach conductors to roof they shall be supported on substantial structures.

**230-26. Point of Attachment.** The point of attachment of a service drop to a building or other structure shall be not less than 10 feet above finished grade and shall be at a height to permit the minimum clearance requirements of Section 230-24.

In the event a mast type riser is required to attain the required height, it shall be of such construction and so supported that it will withstand the strain imposed by the service drop. Raceway fittings shall be of a type approved for the purpose.

**230-27. Means of Attachment.** Multiple-conductor cables used for service drops shall be attached to buildings or other structures by fittings approved for the purpose. Open conductors shall be attached to non-combustible, nonabsorptive insulators securely attached to the building or other structure or by fittings approved for the purpose.

#### **D. Underground Services**

##### **230-30. Insulation — Underground Service Conductors.**

(a) Underground conductors up to the point of connection to service equipment shall be insulated, except:

*Exception No. 1. Where the nominal voltage to ground of any conductor is not over 300 volts, a grounded conductor of copper or aluminum without individual insulation or covering may be installed underground when part of an approved cable assembly.*

*Exception No. 2. Where the nominal voltage to ground of any conductor is not over 300 volts, bare grounded conductors of copper may be installed underground in duct or conduit.*

(b) Insulated service conductors installed underground, or in concrete slabs or masonry in direct contact with earth, shall be lead-covered or of other types specially approved for the purpose.

##### **E 230-31. Size of Underground Service Conductors.**

(a) **Size of Underground Service Lateral.** Conductors shall have sufficient ampacity to carry the load. They shall not be smaller than No. 8 copper or No. 6 aluminum.

*Exception: For installations to supply only limited loads of a single branch circuit such as small polyphase power, controlled water heaters and the like, they shall not be smaller than No. 12 copper or No. 10 aluminum.*

(b) **Size of Underground Service Entrance Conductors.** Same as required for overhead service entrance conductors. See Section 230-41.

**E 230-32. Protection Against Damage.**

(a) **In the Ground.** Underground service conductors shall be protected against physical damage by being installed:

(1) in duct;

(2) in rigid metal conduit or electrical metallic tubing made of a material suitable for the condition, or provided with corrosion protection suitable for the condition;

(4) in cable of one or more conductors approved for direct burial in the earth;

(5) other approved means.

(b) **On Poles.** Where underground service conductors are carried up a pole the mechanical protection shall be installed to a point at least 8 feet above the ground. Such mechanical protection may be provided by the use of approved cable, pipe, or other approved means.

(c) **Where Entering Building.** Underground service conductors shall have mechanical protection in the form of rigid or flexible conduit, electrical metallic tubing, auxiliary gutters, the metal tape of an approved service cable, or other approved means. The mechanical protection shall extend to the enclosure for the service equipment.

**230-33. Raceway Seal.** Where a service raceway or duct enters from an underground distribution system, the end within the building shall be sealed with suitable compound so as to prevent the entrance of moisture or gases. Spare or unused ducts shall also be sealed.

**E. Service-Entrance Conductors****230-40. Insulation of Service-Entrance Conductors.**

(a) Service-entrance conductors entering buildings or other structures shall be insulated. Where only on the exterior of buildings or other structures the conductors shall be insulated or covered.

*Exception: Where the nominal voltage to ground of any conductor is not over 300 volts, a bare grounded conductor may be installed.*

(b) Open individual conductors which enter the building or other structure shall be rubber-covered or thermoplastic-covered.

**230-41. Size of Service-Entrance Conductors, Overhead System and Underground System.** Service-entrance conductors shall have sufficient ampacity to carry the load as determined by Article 220 and in accordance with Table 310-12, 310-13, 310-14, 310-15. Service entrance conductors shall not be smaller than No. 6 except:

*Exception No. 1. For single family residences with an initial load of 10 KW or more computed in accordance with Article 220, or if the initial installation has more than five 2-wire branch circuits, the service-entrance conductors shall have an ampacity of not less than 100 amperes 3-wire.*

It is recommended that a minimum of 100 ampere 3-wire service be provided for all individual residences.

*Exception No. 2. For installations consisting of not more than two 2-wire branch circuits they shall not be smaller than No. 8.*

*Exception No. 3. By special permission due to limitations of supply source or load requirements they shall not be smaller than No. 8.*

*Exception No. 4. For installations to supply only limited loads of a single branch circuit, such as small polyphase power, controlled water heaters and the like, they shall not be smaller than the conductors of the branch circuit and in no case smaller than No. 12.*

*Exception No. 5. The neutral conductor which shall have an ampacity in conformity with Section 220-4(d), but shall not be smaller than the ungrounded conductors when these are No. 8 or smaller.*

**230-42. Service-Entrance Conductors without Splice.** Service-entrance conductors shall be without splice except as follows:

*Exception No. 1. Clamped or bolted connections in a meter enclosure are permitted.*

*Exception No. 2. Taps to main service conductors are permitted as provided in Section 230-2 Exception No. 3(b) or to individual sets of service equipment as provided in Section 230-70(g).*

*Exception No. 3. A connection is permitted, when properly enclosed, where an underground service conductor enters a building and is to be extended to the service equipment or meter in another form of approved service raceway or service cable.*

*Exception No. 4. A connection is permitted where service conductors are extended from a service drop to an outside meter location and returned to connect to the service-entrance conductors of an existing installation.*

**230-43. Other Conductors in Service Raceway.** Conductors other than service conductors, grounding conductors, or control conductors from time switches having overcurrent protection, shall not be installed in the same service raceway or service entrance cable.

#### **F. Installation of Service-Entrance Conductors**

**230-44. Wiring Methods.** Service-entrance conductors extending along the exterior, or entering buildings or other structures may be installed as follows:

(a) As separate conductors, in cables approved for the purpose, or enclosed in rigid conduit;

(b) For circuits not exceeding 600 volts the conductors may be installed in electrical metallic tubing, wireways, auxiliary gutters, busways or as a cablebus installed for services in accordance with Article 365.

Service-entrance conductors should not be run within the hollow spaces of frame buildings unless provided with overcurrent protection at their outer end.

**230-45. Conductor Considered Outside Building.** Conductors placed under at least two inches of concrete beneath a building, or conductors within a building in conduit or duct and enclosed by concrete or brick not less than two inches thick shall be considered outside the building.

**230-46. Mechanical Protection.** Individual open conductors or cables

other than approved service-entrance cables, shall not be installed within 8 feet of the ground or where exposed to physical damage. Service-entrance cables, where liable to contact with awnings, shutters, swinging signs, installed in exposed places in driveways, near coal chutes or otherwise exposed to physical damage, shall be of the protected type or be protected by conduit, electrical metallic tubing or other approved means.

**230-50. Service Cables.** Service cables of a type not approved for mounting in contact with a building shall have insulating supports at intervals not exceeding 15 feet; and maintaining a distance of at least 2 inches from the surface wired over. Service cables mounted in contact with the building shall be supported at intervals not exceeding 4½ feet.

**230-51. Connections at Service Head.**

(a) Service raceways shall be equipped with a raintight service head.

(b) Service cables, unless continuous from pole to service equipment or meter, shall be either:

(1) equipped with a raintight service head or

(2) formed in a gooseneck, taped and painted or taped with a self-sealing weather-resistant thermoplastic.

(c) Service heads and goosenecks in service-entrance cables shall be located above the point of attachment of the service-drop conductors to the building or other structure.

*Exception: Where it is impracticable to locate the service head above the point of attachment, the service head may be located not farther than twenty-four inches from the point of attachment.*

(d) Service cables shall be held securely in place by connection to service-drop conductors below the gooseneck or by a fitting approved for the purpose.

(e) Service heads shall have conductors of opposite polarity brought out through separately bushed holes.

(f) Drip loops shall be formed on individual conductors. To prevent the entrance of moisture, service-entrance conductors shall be connected to the service-drop conductors either:

(1) below the level of the service head, or

(2) below the level of the termination of the service-entrance cable sheath.

(g) Service-drop conductors and service-entrance conductors shall be so arranged that water will not enter service raceway or equipment.

**230-52. Enclosing Raceways Made Raintight.** When rigid metal raceways are installed where exposed to weather the raceways shall be made raintight and arranged to drain.

**E 230-53. Terminating Raceway at Service Equipment.** Where conduit, electrical metallic tubing, or service cable is used for service conductors, the inner end shall enter a terminal box or cabinet, or be made up directly to an equivalent fitting, enclosing all live metal parts.

### G. Service Equipment

**230-61. Service Equipment Grouped.** Where supplied at the same side of the building by more than one overhead service drop or more than one set of underground service conductors, the service equipment, except for services as permitted in Section 230-2, shall be grouped and equipment marked to indicate the load it serves.

### H. Grounding and Guarding

**E 230-62. Guarding.** Live parts of service equipment shall be enclosed so that they will not be exposed to accidental contact.

**230-63. Grounding and Bonding.** Service equipment shall be grounded as follows:

(a) **Equipment.** The enclosure for service equipment shall be grounded in the manner specified in Article 250, unless (1) the voltage does not exceed 150 volts to ground and such enclosures are (2) isolated from conducting surfaces, and (3) unexposed to contact by persons or materials that may also be in contact with other conducting surfaces.

(b) **Raceways and Cable Armor.** Service raceways, cable armor and the metal sheath of service cables, shall be grounded. Conduit and metal pipe from underground supply shall be considered sufficiently grounded where containing lead-sheathed cable bonded to a continuous underground lead-sheathed cable system.

(c) **Flexible Conduit.** Where a service run of rigid metal raceway is interrupted by flexible metal conduit, the sections of rigid metal raceway thus interrupted shall be bonded together by a copper conductor not smaller than specified for grounding conductors in Table 250-94 (a), using clamps or other approved means. The conductor and bonding devices shall be protected from physical damage. Where the flexible conduit runs to the service cabinet, similar bonding shall be installed between the cabinet and the rigid raceway.

### J. Disconnecting Means

**E 230-70. General.**

(a) **Disconnection from Service Conductors.** Means shall be provided for disconnecting all conductors in the building or other structure from the service entrance conductors.

(b) **Location.** The disconnecting means shall be located at a readily accessible point nearest to the entrance of the conductors, either inside or outside the building or structure. Sufficient access and working space shall be provided about the disconnecting means.

Each occupant shall have access to his disconnecting means. A 2-family building having individual occupancy above the second floor shall have service equipment grouped in a common accessible place, the disconnecting means consisting of not more than six switches or six circuit breakers. Two-family dwellings that do not have individual occupancy above the second floor may have service conductors run to each

occupancy in accordance with Section 230-2, Exception No. 3 and each such service may have not more than six switches or circuit breakers.

(c) **Approval.** The disconnecting means shall be of a type approved for service equipment and for prevailing conditions.

(d) **Types Permitted.** The disconnecting means for ungrounded conductors shall consist of either:

(1) A manually operable switch or circuit breaker equipped with a handle or other suitable operating means positively identified and marked for mechanical operation by hand.

(e) **Externally Operable.** An enclosed service switch or circuit breaker shall be externally operable.

(f) **Indicating.** The disconnecting means shall plainly indicate whether it is in the open or closed position.

(g) **Switch and Circuit Breaker.** The disconnecting means for each set or sub-set of service-entrance conductors shall consist of not more than six switches or six circuit breakers in a common enclosure, or group of separate enclosures. Two or three single pole switches or breakers, capable of individual operation, may be installed on multiwire circuits, one pole for each ungrounded conductor, as one multipole disconnect provided they are equipped with "handle ties," "handles within 1/16 inch proximity," a "master handle," or "other means," making it practical to disconnect all conductors of the service with no more than six operations of the hand.

See Section 384-16(a).

(h) **Simultaneous Openings.** The disconnecting means shall simultaneously disconnect all ungrounded conductors, except for single-phase circuits or multiwire circuits that do not supply polyphase motors.

See Section 200-5(a).

(i) **Disconnection of Grounded Conductor.** Where the switch or circuit breaker does not interrupt the grounded conductor, other means shall be provided in the service cabinet or on the switchboard for disconnecting the grounded conductor from the interior wiring.

### **230-71. Rating of Service Equipment.**

(a) The service equipment shall have a rating not less than the load to be carried determined in accordance with Article 220. The service disconnecting means shall have a rating of not less than 60 amperes except:

*Exception No. 1. For single family residences with an initial load of 10 KW or more computed in accordance with Article 220, or if the initial installation has more than five 2-wire branch circuits, the service equipment shall have a rating of not less than 100 amperes 3-wire.*

*Exception No. 2. For installations consisting of not more than two 2-wire branch circuits a service equipment of 30-ampere minimum rating may be used.*

(b) Where multiple switches or circuit breakers are used in accordance with Section 230-70(g) the combined rating shall not be less than required for a single switch or breaker.



**230-72. Connection to Terminals.** The service conductors shall be attached to the disconnecting means by pressure connectors, clamps or other approved means, except that connections which depend upon solder shall not be used.

- E 230-73. Connections Ahead of Disconnecting Means.** The following may be connected ahead of the service disconnecting means:

Service fuses, time switches, surge protectors, meters, and other items specifically permitted by Section 230-73(a), (b), and (c).

**230-76. More than One Building.** In a property comprising more than one building under single management, the conductors supplying each building served shall be provided with a readily accessible means, within or adjacent to the building, of disconnecting all ungrounded conductors from the source of supply. In garages and outbuildings the disconnecting means may consist of a snap switch, suitable for use on branch circuits, including switch controls at more than one point.

#### K. Overcurrent Protection

- E 230-90. Where Required.** Each ungrounded service-entrance conductor shall have overcurrent protection.

**(a) Ungrounded Conductor.** Such protection shall be provided by an overcurrent device in series with each ungrounded service conductor, having a rating or setting not higher than the allowable ampacity of the conductor, except as follows:

*Exception No. 2. Fuses and circuit breakers may have a rating in conformity with Section 240-5(a), Exception No. 1, also Section 240-5(b).*

*Exception No. 3. Not more than six circuit breakers or six sets of fuses may serve as the overcurrent device.*

*Exception No. 4. Each occupant shall have access to his overcurrent protective devices. A 2-family dwelling having individual occupancy above the second floor shall have service equipment grouped in a common accessible place, the overcurrent protection consisting of not more than six circuit breakers or six sets of fuses. Two-family dwellings that do not have individual occupancy above the second floor may have service conductors run to each occupancy and each such service may have not more than six circuit breakers or six sets of fuses.*

A set of fuses is all the fuses required to protect all the ungrounded conductors of a circuit. Single pole breakers may be grouped as in Section 230-70(g) as one multiple protective device.

**(b) Not in Grounded Conductor.** No overcurrent device shall be inserted in a grounded service conductor except a circuit breaker which simultaneously opens all conductors of the circuit.

**(c) More Than One Building.** In a property comprising more than one building under single management, the ungrounded conductors supplying each building served shall be protected by overcurrent devices, which may be located in the building served or in another building on the same property, provided they are accessible to the occupants of the building served.

**230-91. Location.** The service overcurrent device shall be an integral part of the service disconnecting means or shall be located immediately adjacent thereto, unless located at the outer end of the entrance.

**230-92. Location of Branch-Circuit Overcurrent Devices.** Where the service overcurrent devices are locked or sealed, or otherwise not readily accessible, branch-circuit overcurrent devices shall be installed on the load side, shall be mounted in an accessible location and shall be of lower rating than the service overcurrent device.

**E 230-94. Relative Location of Overcurrent Device and Other Service Equipment.** The overcurrent device shall protect all circuits and devices except the service switch, surge protectors, and other items specifically exempted by Section 230-94(a) through (e).

## ARTICLE 240 — OVERCURRENT PROTECTION

### A. Installation

**240-1. Scope.** This Article provides the general requirements for the application of overcurrent protective devices.

**240-2. Purpose of Overcurrent Protection.** Overcurrent protection for conductors and equipment is provided for the purpose of opening the electric circuit if the current reaches a value which will cause an excessive or dangerous temperature in the conductor or conductor insulation.

**E 240-3. Protection of Equipment.** Equipment shall be protected against overcurrent as specified in the references in the following list:

Equipment	Article No.
Appliances	422
Fixed Electric Space Heating Equipment	424
Remote-Control, Low-Energy Power, Low-Voltage Power and Signal Circuits	725
Services	230
Panelboards	384

**240-4. Time-Delay Overcurrent Devices.** Circuit breakers and plug fuses installed in residential occupancies on circuits of 20 ampere or less shall be of the time-delay type.

**E 240-5. Overcurrent Protection.**

(a) **Conductors.** Conductors shall be protected in accordance with their ampacities, as given in Tables 310-12 through 310-15, except as follows:

*Exception No. 1. Rating of Nonadjustable Overcurrent Protection of 800 Amperes or Less. Where the standard ampere ratings of fuses and nonadjustable circuit breakers do not correspond with the allowable ampacities of conductors, the next higher standard rating may be used, only where the rating is 800 amperes or less.*

The effect of the temperature on the operation of thermally controlled circuit breakers should be taken into consideration in the application of such circuit breakers when they are subjected to extremely low or extremely high temperatures.

*Exception No. 3. Fixture Wires and Cords. Fixture wire or flexible cord, Size No. 16 or No. 18, and tinsel cord shall be considered as protected by 20 ampere overcurrent devices. Fixture wires of the sizes permitted for taps in Section 210-19 (c-2) shall be considered as protected by the overcurrent protection of the 30, 40, and 50 ampere branch circuits of Article 210. Flexible cord approved for use with specific appliances shall be considered as protected by the overcurrent device of the branch circuit of Article 210 when conforming to the following:*

20 ampere circuits, No. 18 cord and larger.

30 ampere circuits, cord of 10 amperes capacity and over.

40 ampere circuits, cord of 20 amperes capacity and over.

50 ampere circuits, cord of 20 amperes capacity and over.

#### **E 240-6. Fuses.**

(a) Plug fuses and fuseholders shall not be used in circuits exceeding 125 volts between conductors except in circuits supplied from a system having a grounded neutral and no conductor in such circuits operating at more than 150 volts to ground.

(c) The screw-shell of plug-type fuseholders shall be connected to the load side of the circuit.

#### **E 240-11. Ungrounded Conductors.**

(a) An overcurrent device (fuse or overcurrent trip unit of a circuit breaker) shall be placed in each ungrounded conductor. For motor circuits see Article 430.

(b) Circuit breakers shall open all ungrounded conductors of the circuit, except as follows:

*Exception: Individual single-pole circuit breakers may be used for the protection of each conductor of ungrounded 2-wire circuits, each ungrounded conductor of single-phase circuits, or for each ungrounded conductor of lighting or appliance branch circuits connected to 4-wire three-phase systems, provided such lighting or appliance circuits are supplied from a system having a grounded neutral and no conductor in such circuits operates at a voltage greater than permitted in Section 210-6.*

**240-12. Grounded Conductor.** No overcurrent device shall be placed in any permanently grounded conductor, except as follows:

*Exception No. 1. Where the overcurrent device simultaneously opens all conductors of the circuit.*

*Exception No. 2. For motor-running protection as provided in Sections 430-36 and 430-37.*

**240-13. Change in Size of Grounded Conductor.** Where a change occurs in the size of the ungrounded conductor, a similar change may be made in the size of the grounded conductor.

**240-14. Fuses or Circuit Breakers in Parallel.** Overcurrent devices consisting of fuses and/or circuit breakers shall not be arranged or installed in parallel.

*Exception: Circuit breakers assembled in parallel which are tested and approved as a single unit.*

#### **B. Location**

**240-16. Location in Premises.** Overcurrent devices shall be located where they will be:

(a) Readily accessible, except as provided in Sections 230-91 and 230-92 for service equipment.

(b) Not exposed to physical damage.

(c) Not in the vicinity of easily ignitable material.

**C. Enclosures****E 240-17. Enclosures for Overcurrent Devices.**

(a) **General.** Overcurrent devices shall be enclosed in cutout boxes or cabinets, unless a part of a specially approved assembly which affords equivalent protection, or unless mounted on panelboards or controllers located in rooms or enclosures free from easily ignitable material and dampness. The operating handle of a circuit breaker may be accessible without opening a door or cover.

(b) **Damp or Wet Locations.** Enclosures for overcurrent devices in damp or wet locations shall be of a type approved for such locations and shall be mounted so there is at least one-fourth inch air space between the enclosure and the wall or other supporting surface.

(c) **Vertical Position.** Enclosures for overcurrent devices shall be mounted in a vertical position unless in individual instances this is shown to be impracticable.

## ARTICLE 250 — GROUNDING

### A. General

**250-1. Scope.** This Article treats of protection of electric installations by grounding. Insulation, isolation, and guarding are suitable alternatives under certain conditions. See Section 110-17.

**(a) Systems and Circuits.** Circuits are grounded for the purpose of limiting the voltage upon the circuit which might otherwise occur through exposure to lightning or other voltages higher than that for which the circuit is designed; or to limit the maximum potential to ground due to normal voltage.

**(b) Exposed Enclosures.** Conductive materials enclosing electric conductors or equipment, or forming part of such equipment, are grounded for the purpose of preventing a potential above ground on these materials.

**(c) Operation of Overcurrent Devices.** Circuits and enclosures are grounded to facilitate overcurrent device operation in case of insulation failure or ground faults. See Section 110-10.

**E 250-2. Other Articles.** In other Articles, applying to particular cases of installation of conductors and equipment, there are requirements that are in addition to those of this Article or are modifications of them:

	Article	Section
Appliances .....		422-16
Branch Circuits .....		210-5
Conductors .....	200	
Fixed Electric Space Heating Equipment .....		424-79
Fixtures & Lighting Equipment .....		410-91
Flexible Cords .....		400-13
Grounding Receptacles (Outlets) .....		210-7
Less Than 50 V .....	720	
Lighting Fixtures .....	410	
Outlet, Switch and Junction Boxes, and Fittings .....		370-4
Panelboards .....		384-27
Receptacles & Attachment Plugs .....		410-55
Remote Control Circuits .....		725-21
Services .....	230	
Service Equipment .....		230-63
Swimming Pools .....	680	
Switches .....		380-1

### B. Circuit and System Grounding

**E 250-5. Alternating-Current Systems.** Secondary alternating-current systems supplying interior wiring, and interior alternating-current wiring systems, except those covered in Sections 250-6, 250-7 and 250-8,

shall be grounded when they can be so grounded that the maximum voltage to ground does not exceed 150 volts. Where a service conductor is uninsulated in accordance with Section 230-4, the system shall be grounded.

It is recommended that alternating-current systems be grounded as provided in this article when the voltage to ground does not exceed 300 volts. Higher voltage systems may be grounded.

**E 250-8. Circuits of Less than 50 Volts.** Circuits of less than 50 volts need not be grounded, except as follows:

(a) Where supplied by transformers from systems of more than 150 volts to ground, except as provided in Section 250-45(d).

(c) Where run overhead outside buildings.

### **C. Location of Grounding Connections**

**250-21. Current Over Grounding Conductors.** The grounding of wiring systems, circuits, arresters, cable armor, conduit, or other metal raceways as a protective measure shall be so arranged that there will be no objectionable passage of current over the grounding conductors. The temporary currents set up under accidental conditions, while the grounding conductors are performing their intended protective functions, are not to be considered as objectionable. Where an objectionable flow of current occurs over a grounding conductor, due to the use of multiple grounds, (1) one or more of such grounds shall be abandoned, or (2) their location shall be changed, or (3) the continuity of the conductor between the grounding connections shall be suitably interrupted, or (4) other means satisfactory to the authority having jurisdiction shall be taken to limit the current.

**E 250-23. Grounding Connections for Alternating-Current Systems.**

(a) Secondary alternating-current circuits which are to be grounded shall have a connection to a grounding electrode at each service, except as provided for in Section 250-21. The connection shall be made on the supply side of the service disconnecting means. Each secondary distributing system which is grounded shall have at least one additional grounding conductor connection to a grounding electrode at the transformer or elsewhere. No connection to a grounding electrode shall be made to the grounded circuit conductor on the load side of the service disconnecting means. See Section 250-24 for two or more buildings supplied by a single service and Section 250-26 for separately derived systems.

(b) Where the secondary system is grounded at any point, the grounded conductor shall be run to each service. This conductor shall be not smaller than the required common main grounding conductor specified in Table 250-94 (a).

**250-24. Two or More Buildings Supplied by a Single Service.** Where more than one building is supplied by the same service, the grounded circuit conductor of the wiring system of any building utilizing one branch circuit supplied from such service may be connected to a grounding electrode at such building, and in the case of any building housing equipment required to be grounded or utilizing two or more

branch circuits supplied from such service, and in the case of a building housing live stock, shall be so connected.

**250-25. Conductor to be Grounded.** For alternating-current interior wiring systems the conductor to be grounded shall be as follows:

- (a) Single-phase, 2-wire: the identified conductor;
- (b) Single-phase, 3-wire: the identified neutral conductor;
- (c) Multiphase systems having one wire common to all phases: the identified common conductor;
- (d) Multiphase systems having one phase grounded: the identified conductor;
- (e) Multiphase systems in which one phase is used as in (b): the identified neutral conductor. One phase only can be grounded.

See Article 200.

The identified conductor is commonly known as "the white wire."

#### **D. Enclosure Grounding**

**250-32. Service Conductor Enclosures.** Service raceways, service cable sheaths or armoring, when of metal, shall be grounded.

**250-33. Other Conductor Enclosures.** Metal enclosures for conductors shall be grounded, except they need not be grounded in runs of less than 25 feet which are free from probable contact with ground, grounded metal, metal lath or conductive thermal insulation and which, where within reach from grounded surfaces, are guarded against contact by persons.

#### **E. Equipment Grounding**

**E 250-42. Fixed Equipment—General.** Under any of the following conditions, exposed noncurrent-carrying metal parts of fixed equipment, which are liable to become energized, shall be grounded:

- (a) Where equipment is supplied by means of metal-clad wiring;
- (b) Where equipment is located in a wet location and is not isolated;
- (c) Where equipment is located within reach of a person who can make contact with any grounded surface or object;
- (d) Where equipment is located within reach of a person standing on the ground;
- (f) Where equipment is in electrical contact with metal or metal lath;
- (g) Where equipment operates with any terminal at more than 150 volts to ground, except as follows:

(2) Metal frames of electrically heated devices, exempted by special permission, in which case the frames shall be permanently and effectively insulated from ground.

**E 250-43. Fixed Equipment—Specific.** Exposed, noncurrent-carrying metal parts of the following kinds of equipment, regardless of voltage, shall be grounded:



(i) Equipment supplied by Class 1 and Class 2 remote control and signaling circuits where Part B of this article requires those circuits to be grounded.

**E 250-44. Nonelectrical Equipment.**

Where extensive metal in or on buildings may become energized and is subject to personal contact, adequate bonding and grounding will provide additional safety.

**E 250-45. Equipment Connected by Cord and Plug.** Under any of the following conditions, exposed noncurrent-carrying metal parts of cord and plug connected equipment, which are liable to become energized, shall be grounded:

(b) When operated at more than 150 volts to ground, except:

(1) Motors, where guarded;

(2) Metal frames of electrically heated appliances exempted by Section 422-16.

(c) (1) Refrigerators, freezers, air conditioners, and (2) clothes-washing, clothes-drying and dish-washing machines, sump pumps and (3) portable, hand held, motor operated tools and appliances of the following types: drills, hedge clippers, lawn mowers, wet scrubbers, sanders and saws.

*Exception: Portable tools and appliances covered by Section 250-45(c) (3), protected by an approved system of double insulation, or its equivalent, need not be grounded. Where such an approved system is employed the equipment shall be distinctively marked.*

Portable tools or appliances not provided with special insulating or grounding protection are not intended to be used in damp, wet or conductive locations.

**F. Methods of Grounding**

**250-51. Effective Grounding.** The path to ground from circuits, equipment, and conductor enclosures shall (1) be permanent and continuous and (2) shall have ample carrying capacity to conduct safely any currents liable to be imposed on it, and (3) shall have impedance sufficiently low to limit the potential above ground and to facilitate the operation of the overcurrent devices in the circuit.

**250-52. Location of System Ground Connection.** The grounding conductor may be connected to the grounded conductor of the wiring system at any convenient point on the premises on the supply side of the service disconnecting means.

It is recommended that high capacity services have the grounding conductor connected to the grounded conductor of the system within the service entrance equipment enclosure.

**250-53. Common Use of Grounding Conductor.** The grounding conductor of a wiring system shall also be used for grounding equipment, conduit and other metal raceways or enclosures for conductors, including service conduit or cable sheath and service equipment.

*Exception: The grounding connection as covered in the exception in Section 210-7 may be made to a grounded cold water pipe near the equipment.*

**250-54. Common Grounding Electrode.** Where the alternating-current system is connected to a grounding electrode in or at a building as specified in Sections 250-23 and 250-24, the same electrode shall be used to ground conductor enclosures and equipment in or on that building.

**250-55. Underground Service Cable.** Where served from a continuous underground metal-sheathed cable system, the sheath or armor of underground service cable metallically connected to the underground system, or underground service conduit containing a metal-sheathed cable bonded to the underground system, need not be grounded at the building and may be insulated from the interior conduit or piping.

**250-56. Short Sections of Raceway.** Isolated sections of metal raceway or cable armor, where required to be grounded, shall preferably be grounded by connecting to other grounded raceway or armor, but may be grounded in accordance with Section 250-57.

**E 250-57. Fixed Equipment.**

(a) Metal boxes, cabinets and fittings, or noncurrent-carrying metal parts of other fixed equipment where metallically connected to grounded flexible metal raceways and fittings both approved for grounding purposes; the grounded armor of Type AC cable, or grounded rigid metal raceways are considered to be grounded by such connections.

(b) They may also be grounded in one of the following ways:

(1) By a grounding conductor run with circuit conductors; this conductor may be uninsulated, but where it is provided with an individual covering, the covering shall be finished a continuous green color or a continuous green color with one or more yellow stripes.

(2) By a grounding conductor in the supply cord, when cord connected as permitted in Section 400-3;

(3) By special permission, other means for grounding fixed equipment may be used.

**E 250-58. Equipment on Structural Metal.**

(a) Electric equipment secured to and in contact with the grounded structural metal frame of a building, shall be deemed to be grounded.

**250-59. Portable and/or Cord and Plug-Connected Equipment.** The noncurrent-carrying metal parts of cord and plug-connected equipment required to be grounded may be grounded in any one of the following ways:

(a) By means of the metal enclosure of the conductors feeding such equipment, provided an approved grounding-type attachment plug is used, one fixed contacting member being for the purpose of grounding the metal enclosure, and provided, further, that the metal enclosure of the conductors is attached to the attachment plug and to the equipment by connectors approved for the purpose;

*Exception: The grounding contacting member of grounding type attachment plugs on the power supply cord of portable hand-held, hand-guided or hand-supported tools or appliances may be of the movable self-restoring type.*

Attachment plug caps are not intended to be used as terminations for metal-clad cable or flexible metal conduit.

(b) By means of a grounding conductor run with the power supply conductors in a cable assembly or flexible cord that is properly terminated in an approved grounding-type attachment plug having a fixed grounding contacting member. The grounding conductor in a cable assembly may be uninsulated; but where an individual covering is provided for such conductors it shall be finished a continuous green color or a continuous green color with one or more yellow stripes.

*Exception: The grounding contacting member of grounding type attachment plugs on the power supply cord of portable tools or portable appliances may be of the movable self-restoring type.*

(c) A separate flexible wire or strap, insulated or bare, protected as well as practicable against physical damage may be used only by special permission except where a part of an approved portable equipment.

**250-60. Frames of Electric Ranges and Electric Clothes Dryers.** Frames of electric ranges and electric clothes dryers shall be grounded by any of the means provided for in Sections 250-57 and 250-59; or, where served by a 120/240 volt, single phase, three-wire circuit or a 120/208 volt circuit derived from a three-phase, four-wire supply, they may be grounded by connection to the grounded circuit conductors, provided the grounded circuit conductors are not smaller than No. 10 AWG. Where service-entrance cable having an uninsulated neutral conductor is used, the branch circuit shall originate at the service-entrance equipment. The frames of wall-mounted ovens and counter-mounted cooking units shall be grounded and may be grounded in the same manner as electric ranges. Grounding contacts of receptacles furnished as a part of equipment grounded to the neutral circuit conductor shall be bonded to the equipment which is so grounded.

It is recommended that all branch circuits supplying equipment which is grounded to the grounded circuit conductor originate at the service equipment.

**250-61. Grounding Equipment to Circuit Conductor.** The grounded service conductor on the supply side of the service disconnecting means may be used for grounding meter housing and service equipment and metallic enclosures and guards. The grounded circuit conductor on the load side of the service disconnecting means shall not be used for grounding equipment, cable armor, or metal raceways except as provided in Section 250-57(b) (3), and in Section 250-60.

### G. Bonding.

**250-71. Bonding at Service Equipment.** The electrical continuity of the grounding circuit for the following equipment and enclosures shall be assured by one of the means given in Section 250-72.

(a) The service raceways or service cable armor or sheath, except as provided in Section 230-63(b) and Section 250-55;

(b) All service equipment enclosures containing service entrance conductors, including meter fittings, boxes or the like, interposed in the service raceway or armor;

(c) Any conduit or armor which forms part of the grounding conductor to the service raceway.

**250-72. Continuity at Service Equipment.** Electrical continuity at service equipment shall be assured by one of the following means:

(a) Bonding equipment to the grounded service conductor in a manner provided in Section 250-113.

(b) Threaded couplings and threaded bosses on enclosures with joints shall be made up wrenchtight where rigid conduit is involved.

(c) Threadless couplings made up tight for rigid metal conduit and electrical metallic tubing.

(d) Bonding jumpers meeting the other requirements of this article. Bonding jumpers shall be used around concentric or eccentric knock-outs which are punched or otherwise formed so as to impair the electrical connection to ground.

(e) Other devices (not locknuts and bushings) approved for the purpose.

**250-73. Metal Armor or Tape of Service Cable.** With service cable having an uninsulated grounded service conductor in continuous electrical contact with its metallic armor or tape, the metal covering is considered to be adequately grounded.

**250-74. Bonding at Grounding-Type Receptacles.** Grounding continuity between a grounded outlet box and the grounding circuit of the receptacle shall be established by means of a bonding jumper between the outlet box and the receptacle grounding terminal.

*Exception No. 1: When the box is surface-mounted, direct metal-to-metal contact between the device yoke and the box may be used to establish the grounding circuit.*

*Exception No. 2: Contact devices or yokes designed and approved for the purpose may be used in conjunction with the supporting screws to establish the grounding circuit between the device yoke and flush-type boxes installed in walls.*

**250-75. Continuity at Other Enclosures.** The electrical continuity of metallic raceway systems and cable armor that are to serve as grounding conductors shall be assured. At points where raceway or armor connects to metal enclosures, any nonconducting coating which might interrupt such continuity shall be removed unless fittings are used which are so designed that such removal is unnecessary.

**250-79. Bonding Jumpers.** Bonding jumpers shall conform to the following:

(a) **Material and Size.** Bonding jumpers shall be of copper or other corrosion resistant material. The size shall be as required by Section

250-94 for services and as required by Section 250-95 for raceways and equipment on the load side of the service protective equipment.

(b) **Attachment.** Bonding jumpers shall be attached to cabinets and the like in a manner provided in Section 250-113; where used between grounding electrodes or around water meters and the like, they shall be attached in a manner provided for in Section 250-115.

#### H. Grounding Electrodes

**250-81. Water Pipe.** A metallic underground water piping system, either local or supplying a community, shall always be used as the grounding electrode where such a piping system is available. Where the buried portion of the metallic piping system is less than ten feet (including well casings bonded to the piping system) or there is some likelihood of the piping system being disconnected or isolated through the use of nonmetallic piping or insulated couplings, the piping system shall be supplemented by one or more of the grounding electrodes recognized in Sections 250-82 and 250-83. The interior metallic cold water piping system shall always be bonded to the one or more grounding electrodes.

Expanding use of nonmetallic piping for water systems and insulating couplings on metallic water systems makes it more important that water piping within a building be adequately grounded without depending on connections to an outside piping system. The interior piping system should be electrically continuous. Bonding to gas, sewer, hot water piping and metallic air ducts within the premises will provide additional safety.

**250-82. Other Available Electrodes.** Where a water system as described in Section 250-81 is not available, the grounding connection may be made to any of the following:

(a) The metal frame of the building, where effectively grounded.

(b) Where permitted, a continuous metallic underground gas piping system. Underground gas service piping shall not be used as a grounding electrode except when it is electrically continuous uncoated metallic piping and its use as a grounding electrode is acceptable both to the serving gas supplier and to the authority having jurisdiction, since gas piping systems are often constructed with insulating bushings or joints, or are of coated or nonmetallic piping.

(c) Other local metallic underground systems, such as piping, tanks, and the like.

**250-83. Made Electrodes.** Where electrodes described in Sections 250-81 and 250-82 are not available, the grounding electrode shall consist of a driven pipe, driven rod, buried plate or other device approved for the purpose and conforming to the following requirements:

(a) **Concrete Encased Electrodes.** Not less than twenty feet of bare copper conductor of a size specified in Table 250-94(a), and in no case smaller than No. 4, encased along the bottom of a concrete foundation footing which is in direct contact with the earth.

(b) **Plate Electrodes.** Each plate electrode shall present not less than 2 square feet of surface to exterior soil. Electrodes of iron, or steel

plates shall be at least  $\frac{1}{4}$  inch in thickness. Electrodes of nonferrous metal shall be at least 0.06 inch in thickness.

(c) **Pipe Electrodes.** Electrodes of pipe or conduit shall be not smaller than of the  $\frac{3}{4}$ -inch trade size and, where of iron or steel, shall have the outer surface galvanized or otherwise metal-coated for corrosion protection.

(d) **Rod Electrodes.** Electrodes of rods of steel or iron shall be at least  $\frac{5}{8}$  inch in diameter. Approved rods of nonferrous materials or their approved equivalent used for electrodes shall be not less than  $\frac{1}{2}$  inch in diameter.

(e) **Installation.** Electrodes should, as far as practicable, be imbedded below permanent moisture level. Except where rock bottom is encountered, pipes or rods shall be driven to a depth of at least 8 feet regardless of size or number of electrodes used. Pipes or rods when less than standard commercial length shall preferably be of one piece. Such pipes or rods shall have clean metal surfaces and shall not be covered with paint, enamel or other poorly conducting materials. Where rock bottom is encountered at a depth of less than 4 feet, electrodes shall be buried in a horizontal trench, and where pipes or rods are used as the electrode they shall comply with Section 250-83(b and c) and shall not be less than 8 feet in length. Each electrode shall be separated at least 6 feet from any other electrode, including those used for signal circuits, radio, lightning rods, or any other purpose.

**250-86. Use of Lightning Rods.** Lightning rod conductors and driven pipes, rods or other made electrodes used for grounding lightning rods, shall not be used in lieu of the made grounding electrodes required by this Article for grounding wiring systems and equipment. The foregoing provision shall not be taken to forbid the bonding together of the several made electrodes that are respectively provided for electric wiring systems and equipment, for communication systems, and for lightning protection. See Section 800-31(b)(5).

It is recommended that all separate electrodes be bonded together to limit potential differences between them and between their associated wiring systems.

### J. Grounding Conductors

**E 250-91. Material.** The material for the grounding conductors shall be as follows:

(a) **For System or Common Grounding Conductor.** The grounding conductor of a wiring system shall be of copper or other corrosion-resistant material. The conductor may be solid or stranded, insulated or bare. Except in cases of bus-bars, the grounding conductor shall be without joint or splice throughout its length. Where the grounding conductor is not of copper, its electrical resistance per linear foot shall not exceed that of the allowable copper conductor for such a purpose.

(b) **For Conductor Enclosures and Equipment Only.** The grounding conductor for equipment and for conduit and other metal raceways or enclosures for conductors, may be a conductor of copper or other corrosion-resistant material, stranded or solid, insulated or bare, a bus-

bar or a rigid metal conduit, electrical metallic tubing or flexible metal conduit and fittings both approved for grounding purposes or the armor of Type AC metal-clad cable. Under conditions favorable to corrosion, a suitable corrosion-resistant material shall be used. All bolted and threaded connections at joints and fittings shall be made tight by the use of suitable tools.

**250-92. Installation.** Grounding conductors shall be installed as follows:

(a) **System or Common Grounding Conductor.** A grounding conductor, No. 4 or larger, may be attached to the surface on which it is carried without the use of knobs, tubes or insulators. It need not have protection unless exposed to severe physical damage. A No. 6 grounding conductor, which is free from exposure to physical damage, may be run along the surface of the building construction without metal covering or protection, where it is rigidly stapled to the construction; otherwise, it shall be in conduit, electrical metallic tubing or cable armor. Grounding conductors smaller than No. 6 shall be in conduit, electrical metallic tubing or cable armor. Metallic enclosures for grounding conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode, and shall be securely fastened to the ground clamp or fitting. Metallic enclosures which are not physically continuous from cabinet or equipment to the grounding electrode can be made electrically continuous by bonding each end to the grounding conductor. Where rigid metallic conduit or steel pipe is used as protection for a grounding conductor, the installation shall comply with the requirement of Article 346; where electrical metallic tubing is used, the installation shall comply with the requirements of Article 348. Aluminum grounding conductors shall not be used where in direct contact with masonry or the earth or where subject to corrosive conditions. Where used outside, aluminum grounding conductors shall not be installed within 18 inches of the earth.

(b) **Conductor Enclosures and Equipment Only.** A grounding conductor for conductor enclosures and equipment only shall meet the requirements of Section 250-92(a), except that where smaller than No. 6, as permitted by Section 250-95, it need not be armored or installed in a raceway where run through the hollow spaces of a wall or partition or otherwise run so as to be not subject to physical damage.

## **E 250-94. Alternating Current Systems.**

(a) **Service and Common Grounding Conductor for Grounded Systems.** Where the wiring system is grounded, the size of the grounding conductor for an alternating current system or for a common grounding conductor shall not be less than is given in Table 250-94(a), except that where connected to made electrodes (as in Section 250-83), that portion of the grounding conductor which is the sole connection between the grounding electrode and the grounded system conductor need not be larger than No. 6 copper wire or its equivalent in ampacity.

**250-95. Size of Equipment Grounding Conductors.** The size of copper or aluminum equipment grounding conductors shall be not less than

given in Table 250-95. For permissible use of the enclosing raceway see Sections 250-57(a) and 250-91(b).

*Exception: A conductor not smaller than No. 18 AWG copper which is part of an approved cord assembly may be used to ground cord connected equipment protected at not more than 20 amperes.*

**E** **Table 250-94(a)**  
**Service and Common Main Grounding Conductor for Grounded Systems**

Size of Largest Service Conductor or Equivalent for Multiple Conductors		Size of Grounding Conductor	
Copper	Aluminum	Copper	Aluminum*
2 or smaller	0 or smaller	8	6
1 or 0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250 MCM	4	2

\*See installation restrictions in Section 250-92(a).

See Section 250-23 (b).

**E** **Table 250-95. Size of Equipment Grounding Conductors for Grounding Interior Raceway and Equipment**

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size	
	Copper Wire No.	Aluminum Wire No.*
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4

\*See installation restrictions in Section 250-92(a).

**250-98. Common Raceway.** A grounding conductor may be run in the same metal raceway with other conductors of the system to which it is connected.

**250-99. Continuity.** No automatic cutout or switch shall be placed in the grounding conductor of an interior wiring system unless the opening of the cutout or switch disconnects all sources of energy.

**K. Grounding Conductor Connections**

**250-111. To Raceway or Cable Armor.** The point of connection of the grounding conductor to interior metal raceways, cable armor and



the like shall be as near as practicable to the source of supply and shall be so chosen that no raceway or cable armor is grounded through a run of smaller size than is called for in Section 250-95.

**250-112. To Electrode.** The grounding connection to the electrode shall be located as follows:

(a) **To Water Pipes.** System or common grounding conductors shall be attached to a water piping system on the street side of the water meter or on a cold water pipe as near as practicable to the water service entrance to the building. Where the source of the water supply is from a driven well in the basement of the premises, the connection shall be made as near as practicable to the well. Where practicable, the point of attachment shall be accessible. Where the point of attachment is not on the street side of the water meter, the water piping system shall be made electrically continuous by bonding together all parts between the attachment and the street side of the water meter or the pipe entrance which contain insulating sections or are liable to become disconnected, as at meters, valves and service unions.

(b) **To Gas Pipes.** The point of attachment of a grounding conductor to gas piping where permitted under Section 250-82, shall always be on the street side of the gas meter, and shall be accessible where practicable.

(c) **To Other Electrodes.** The grounding conductor shall be attached to other electrodes permitted in Sections 250-82 and 250-83 at a point which will assure a permanent ground. Where practicable the point of attachment shall be accessible.

**250-113. Attachment to Circuits and Equipment.** The grounding conductor, bond, or bonding jumper shall be attached to circuits, conduits, cabinets, equipment, and the like, which are to be grounded, by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used.

**250-114. Continuity and Attachment of Branch Circuit Grounding Conductors to Boxes.** Where more than one grounding conductor of a branch circuit enters a box, all such conductors shall be in good electrical contact with each other and the arrangement shall be such that the disconnection or removal of a receptacle, fixture, or other device fed from the box will not interfere with or interrupt the grounding continuity.

(a) **Metallic Boxes.** A connection shall be made between the one or more grounding conductors and a metallic box by means of a grounding screw which shall be used for no other purpose, or an approved grounding device.

(b) **Nonmetallic Boxes.** One or more grounding conductors brought into a nonmetallic outlet box shall be so arranged that a connection can be made to any fitting or device in that box which requires grounding.

**250-115. Attachment to Electrodes.** The grounding conductor shall be attached to the grounding electrode by means of (1) an approved bolted clamp of cast bronze or brass or of plain or malleable cast iron,

or (2) a pipe fitting, plug, or other approved device, screwed into the pipe or into the fitting, or (3) other equally substantial approved means. The grounding conductor shall be attached to the grounding fitting by means of suitable lugs, pressure connectors, clamps, or other approved means, except that connections which depend upon solder shall not be used. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting, unless the clamp or fitting is of a type approved for such use.

**250-116. Ground Clamps.** For the grounding conductor of a wiring system the sheet-metal-strap type of ground clamp is not considered adequate unless the strap is attached to a rigid metal base which, when installed, is seated on the water pipe, or other electrode and the strap is of such material and dimensions that it is not liable to stretch during or after installation.

Ground clamps for use on copper water tubing and copper, brass, or lead pipe should preferably be of copper, and those for use on galvanized or iron pipe should preferably be of galvanized iron and so designed as to avoid physical damage to pipe. Ground clamps used with aluminum grounding conductors should be approved for the purpose.

**250-117. Protection of Attachment.** Ground clamps or other fittings, unless approved for general use without protection, shall be protected from ordinary physical damage (1) by being placed where they are not liable to be damaged or (2) by being enclosed in metal, wood, or equivalent protective covering.

**250-118. Clean Surfaces.** Where a nonconductive protective coating, such as paint or enamel, is used on the equipment, conduit, couplings or fittings, such coating shall be removed from threads and other contact surfaces in order to insure a good electrical connection.

## ARTICLE 300 — WIRING METHODS — GENERAL REQUIREMENTS

### 300-1. Scope.

(a) The provisions of Chapter 3 apply to the electrical and mechanical requirements for the various methods of installing fixed electrical conductors for electric light, heat, power, and certain signal systems.

(b) The provisions of this Article shall apply to all wiring installations, except for remote-control, including low voltage relay switching, low-energy power and signal systems as provided in Article 725, and communication systems as provided in Article 800.

(c) On premises where a continuous underground metallic water-piping network system is not available as a grounding electrode, and where it is not practicable otherwise to secure a ground of permanently low resistance, the use of a wiring method which does not employ metal enclosures for the wires is recommended, unless the character or occupancy of the building is such as to require the use of a metal-enclosed wiring system.

(d) The provisions of this Article are not intended to apply to the conductors which form an integral part of equipment such as motors, motor controllers and the like.

**300-2. Voltage Limitations.** Wiring methods specified in Chapter 3 may be used for voltages not exceeding 600, unless specifically limited in some Article of Chapter 3. They may be used for voltages over 600 where specifically permitted elsewhere in this Code.

### **E** 300-3. Conductors of Different Systems.

(a) Conductors of light and power systems of 600 volts or less may occupy the same enclosure, without regard to whether the individual circuits are alternating-current or direct-current, only where all conductors are insulated for the maximum voltage of any conductor within the enclosure.

(c) Secondary wiring to electric discharge lamps of 1,000 volts or less, insulated for the secondary voltage involved, may occupy the same fixture enclosure as the branch conductors.

(d) Primary leads of electric discharge lamp ballasts, insulated for the primary voltage of the ballast, when contained within the individual wiring enclosure may occupy the same fixture enclosure as the branch circuit conductors.

(f) Conductors of signal systems shall not occupy the same enclosure with conductors of light or power systems except as permitted for remote-control, low-energy power and signal circuits in Sections 725-16 and 725-42.

**300-4. Protection Against Physical Damage.** Where subject to physical damage, conductors shall be adequately protected.

**E 300-5. Protection Against Corrosion.** Metal raceways, cable armor, boxes, cable sheathing, cabinets, metallic elbows, couplings, fittings, supports and support hardware shall be of materials suitable for the environment in which they are to be installed.

(a) Ferrous raceways, cable armor, boxes, cable sheathing, cabinets, metallic elbows, couplings, fittings, supports and support hardware shall be suitably protected against corrosion inside and outside (except threads at joints) by a coating of approved corrosion resistant material such as zinc, cadmium, or enamel. Where protected from corrosion solely by enamel, they shall not be used out of doors or in wet locations. When boxes or cabinets have an approved system of organic coatings and are marked "Raintight" or "Outdoor Type" they may be used out of doors.

(b) Unless made of materials judged suitable for the condition, or unless corrosion protection approved for the condition is provided, ferrous or non-ferrous metallic raceways, cable armor, boxes, cable sheathing, cabinets, elbows, couplings, fittings, supports and support hardware shall not be installed in concrete or in direct contact with the earth, or in areas subject to severe corrosive influences.

**300-7. Underground Runs.** Conductors run underground shall comply with the provisions of Section 230-32 as far as mechanical protection is concerned.

Underground cable run under a building shall be in a raceway that is extended beyond the outside wall of the building.

**E 300-8. Through Studs, Joists and Rafters.**

(a) Where exposed or concealed wiring conductors in insulating tubes or cables are installed through bored holes in studs, joists or similar wood members, holes shall be bored at the approximate centers of wood members, or at least two inches from the nearest edge where practical.

(b) Where there is no objection because of weakening the building structure, metal-clad or nonmetallic sheathed cable, may be laid in notches in the studding or joists when the cable at those points is protected against the driving of nails into it by having the notch covered with a steel plate at least 1/16 inch in thickness before building finish is applied.

**300-9. Grounding Metal Enclosures.** Metal raceways, boxes, cabinets, cable armor and fittings shall be grounded if and as prescribed in Article 250.

**300-10. Electrical Continuity of Metal Raceways and Enclosures.** Metal raceways, cable armor, and other metal enclosures for conductors, shall be metallically joined together into a continuous electrical conductor, and shall be so connected to all boxes, fittings and cabinets as to provide effective electrical continuity. Raceways and cable assemblies shall be mechanically secured to boxes, fittings, cabinets and other enclosures, except as provided for nonmetallic boxes in Section 370-7.

**E 300-11. Secured in Place.** Raceways, cable assemblies, boxes, cabinets and fittings shall be securely fastened in place, unless otherwise provided for specific purposes elsewhere in this Code.

**300-12. Mechanical Continuity—Raceways and Cables.** Raceways and cable assemblies shall be continuous from outlet to outlet and from fitting to fitting.

**300-13. Mechanical Continuity—Conductors.** Conductors shall be continuous between outlets, devices, etc., and, except as permitted for auxiliary gutters in Section 374-8, there shall be no splice or tap within a raceway itself.

**300-14. Free Length of Conductors at Outlets and Switch Points.** At least six inches of free conductor shall be left at each outlet and switch point for the making up of joints or the connection of fixtures or devices, except where conductors are intended to loop without joints through lampholders, receptacles and similar devices.

**E 300-15. Boxes or Fittings.** Except as permitted in Sections 336-11 a box or fitting shall be installed at each outlet, switch point, junction point or conductor splice connection joining sections of conduit, electrical metallic tubing or surface raceway. A box shall be installed at each outlet, switch point, or conductor splice connection joining sections of metal-clad cable, aluminum sheathed cable, non-metallic sheathed cable, and at each outlet and switch point of concealed knob-and-tube work.

**E 300-16. Raceway or Cable to Open or Concealed Wiring.**

(a) A box or terminal fitting having a separately bushed hole for each conductor shall be used wherever a change is made from conduit, electrical metallic tubing, nonmetallic sheathed cable, metal-clad cable, or aluminum sheathed cable, and surface raceway wiring to open wiring or to concealed knob-and-tube work. A fitting used for this purpose shall contain no taps or splices and shall not be used at fixture outlets.

(b) A bushing may be used in lieu of a box or terminal fitting at ends of conduit or electrical metallic tubing where conductors leave the conduit or tubing behind a switchboard, or where more than 4 conductors leave the conduit or tubing at control apparatus or in similar locations, in which case the conductors shall be bunched, taped and painted with insulating paint. Such a bushing shall be of the insulating type except for lead-covered conductors.

**300-17. Number of Conductors in Raceway.** In general the percentage of the total interior cross-sectional area of a raceway occupied by conductors shall not be more than will permit a ready installation or withdrawal of the conductors and dissipation of the heat generated without injury to the insulation of the conductors. See the following Sections of this Code: conduit, Section 346-6; electrical metallic tubing, 348-6; flexible metal conduit, 350-3; and Remote-Control, Low-Energy Power, Low-Voltage Power and Signal Circuits, Article 725.

**300-18. Inserting Conductors in Raceways.**

(a) Raceways shall first be installed as a complete raceway system without conductors, except those raceways exposed and having a removable cover or capping.

(b) As far as possible, conductors shall not be inserted until the in-

terior of the building has been physically protected from the weather, and all mechanical work on the building which is likely to injure the conductors has been completed.

(c) Pull wires, if to be used, shall not be installed until the raceway system is in place.

(d) Cleaning agents or materials used as lubricants that might have a deleterious effect on conductor coverings shall not be used.

**300-20. Induced Currents in Metal Enclosures.** When conductors carrying alternating current are installed in metal enclosures they shall be so arranged as to avoid heating the surrounding metal by induction. To accomplish this all phase conductors and the neutral, where one is used, shall be grouped together.

When a single conductor of a circuit passes through metal with magnetic properties the inductive effect shall be minimized by:

(1) Cutting slots in the metal between the individual holes through which the individual conductors pass, or

(2) Passing all the conductors in the circuit through an insulating wall sufficiently large for all of the conductors of the circuit.

*Exception: In the case of circuits supplying electric discharge lighting systems the currents carried by the conductors are so small that the inductive heating effect may be ignored where these conductors are placed in metal enclosures or pass through metal.*

Aluminum being a nonmagnetic metal, there will be no heating due to eddy currents, however, induced currents will be present. These are not considered of sufficient magnitude to require grouping of conductors or special treatment in passing conductors through aluminum wall sections.

**300-21. Prevention of Spread of Fire.** Electrical installations shall be so made that the possible spread of fire through fire-stopped partitions, hollow spaces, fire walls or fire partitions, vertical shafts, ventilating or air-handling ducts is reduced to a minimum.

**300-23. Temporary Wiring.**

(a) Suitable disconnecting switches or plug connectors shall be installed to permit the disconnection of all conductors of the temporary circuit by a single operation.

(b) No bare conductors nor earth returns shall be used for the wiring of any temporary circuit.

**ARTICLE 310 — CONDUCTORS FOR GENERAL WIRING****310-1. General.**

(a) The purpose of this Article is to assure that conductors have mechanical strength, insulation, and ampacity adequate for the particular conditions under which they are to be used.

(b) Conductors shall be insulated, except when covered or bare conductors are specifically permitted in this Code.

(c) The provisions of this Article are not intended to apply to conductors which form an integral part of equipment such as motors, motor controllers, and the like, or which are provided for elsewhere in this Code.

**E 310-2. Application and Construction.**

(c) **Marking.** Insulated wires, cables and cords of all kinds shall have a continuous distinctive marking so that their maker may be readily identified. All wires, cables and cords shall also be plainly tagged or marked as follows:

(1) The maximum working voltage for which the wire was tested or approved.

(2) The words "National Electrical Code Standard," or "NEC Std."

(3) The manufacturer's name, trade-mark, or other distinctive marking, by which the organization responsible for the product may be readily identified.

(4) Month and year when manufactured.

(5) The proper type letter for the particular style of wire or cable as given in the following sections.

(d) **Surface Marking.** A durable marking on the surface shall be provided at intervals not exceeding 24 inches, by which the maker may be identified. Such marking shall be the manufacturer's name, trade-mark, or other distinctive marking by which the organization responsible for the product may be identified. The marking shall also include the type letter or letters as specified in Article 310, Table 310-2(b) and Articles 336, 338 and 339, the size AWG or circular mils and the maximum voltage on the following types of wire and cable rated 600 volts or less:

(1) Single conductor only, rubber insulated and thermoplastic insulated for General Wiring.

(2) Nonmetallic Sheathed Cable.

(3) Service-Entrance Cable.

(4) Underground Feeder and Branch Circuit Cable.

All other types of wire and cable or flexible cords, and any of the above types with a metallic covering are not required to have a marking on the surface.

**310-4. Temperature Limitations.** No conductor shall be used under such conditions that its temperature, even when carrying current, will exceed the temperature specified in Table 310-2(a) for the type of insulation involved.

**E 310-5 Wet Locations.** Insulated conductors used underground, in concrete slabs or other masonry in direct contact with earth, in wet locations, or where condensation or accumulation of moisture within the raceway is likely to occur, shall be moisture- and heat-resistant, rubber-covered (Type RHW); moisture-resistant latex rubber (Type RUW); moisture-resistant, thermoplastic-covered (Type TW); moisture- and heat-resistant, thermoplastic-covered (Type THW); moisture- and heat-resistant thermoplastic (Type THWN); or of a type approved for the purpose.

Such conductors are not suitable for direct burial in the earth unless of a type specifically approved for the purpose.

**310-6. Buried Conductors.** Cables of one or more conductors for direct burial in the earth shall be of a type approved for the purpose and use, such as Types USE and UF. Where single conductor cables are installed, all conductors of each service, feeder, sub-feeder or branch circuit, including the neutral conductor, shall be run continuously in the same trench or raceway. Supplementary mechanical protection, such as a covering board, concrete pad, raceway, etc., may be required by the authority having jurisdiction. See Section 339-3(c).

**E 310-8. Minimum Size of Conductors.** Conductors, whether solid or stranded, shall not be smaller than No. 14, except as provided for flexible cords in Section 400-7; for fixture wire in Section 410-18; for fractional horsepower motors in Section 430-22; and for remote-control, low energy power, low-voltage power, and signal circuits in Section 725-13.

**310-9. Stranded Conductors.** Conductors No. 6 and larger, installed in raceways, shall be stranded.

**310-10. Conductors in Multiple.** Conductors in sizes 1/0 and larger may be run in multiple provided the arrangement is such as to assure equal division of total current among all conductors involved. All of the multiple conductors shall be of the same length, of the same conductor material, circular-mil area, same insulation type and terminated in the same manner. Where run in separate raceways or cables, the raceways or cables shall have the same physical characteristics.

When conductors are used in multiple, space in enclosures should be given consideration.

**E 310-11. Ampacity Reduction Factors.** Where more than three conductors are installed in a raceway or assembled into one or more cables the ampacity of each conductor shall be reduced in accordance with Note 8 to Tables 310-12 and 310-14.



**E Table 310-12. Allowable Ampacities of Insulated Copper Conductors**

Not More than Three Conductors in Raceway or Cable or  
Direct Burial (Based on Ambient Temperature of 30°C. 86°F.)

Size	Temperature Rating of Conductor. See Table 310-2(a)			
AWG MCM	60°C (140°F)	75°C (167°F)	90°C (194°F)	200°C (392°F)
	TYPES RUW (14-2) T, TW	TYPES RH, RHW, RUH (14-2), THW, THWN, THW-MTW	TYPES SA, FEP, FEPB, RHH, THHN	TYPES A (14-8), AA, FEP*, FEPB*
14	15	15	25†	30
12	20	20	30†	40
10	30	30	40†	55
8	40	45	50	70
6	55	65	70	95
4	70	85	90	120
3	80	100	105	145
2	95	115	120	165
1	110	130	140	190
0	125	150	155	225
00	145	175	185	250
000	165	200	210	285
0000	195	230	235	340

\*Special use only. See Table 310-2 (a).

These ampacities relate only to conductors described in Table 310-2(a).

†The ampacities for Types FEP, FEPH, RHH, and THHN, conductors for sizes AWG 14, 12, and 10 shall be the same as designated for 75°C conductors in this Table.

For ambient temperatures over 30°C, see Correction Factors, Note 15.

**E Table 310-14. Allowable Ampacities of Insulated Aluminum Conductors**

Not More than Three Conductors in Raceway or Cable or  
Direct Burial (Based on Ambient Temperature of 30°C. 86°F.)

Size	Temperature Rating of Conductor. See Table 310-2(a)		
AWG MCM	60°C (140°F)	(75°C) (167°F)	90°C (194°F)
	TYPES RUW (12-2), T, TW	TYPES RH, RHW, RUH (12-2), THW, THWN	TYPES SA, RHH, THHN
12	15	15	25 †
10	25	25	30 †
8	30	40	40
6	40	50	55
4	55	65	70
3	65	75	80
*2	75	90	95
*1	85	100	110
*0	100	120	125
*00	110	135	145
*000	130	155	165
*0000	155	180	185
250	170	205	215
300	190	230	240

These ampacities relate only to conductors described in Table 310-2(a).

\*For three wire, single phase service, the allowable ampacity of RH, RHH, RHW, and THW aluminum conductors shall be for sizes #2-100, Amp., #1-110 Amp., #1/0-125 Amp., #2/0-150 Amp., #3/0-170 Amp. and #4/0-200 Amp.

†The ampacities for Types RHH and THHN conductors for sizes AWG 12 and 10 shall be the same as designated for 75°C conductors in this Table.

For ambient temperatures over 30°C, see Correction Factors, Note 15.

## **E Notes to Tables 310-12 and 310-14**

**Ampacity.** The maximum, continuous, ampacities of copper conductors are given in Table 310-12. The ampacities of aluminum conductors are given in Table 310-14.

**1. Explanation of Tables.** For explanation of Type Letters, and for recognized size of conductors for the various conductor insulations, see Sections 310-2 and 310-3. For installation requirements, see Section 310-1 through 310-7, and the various Articles of this Code. For flexible cords see Tables 400-9 and 400-11.

**6. Ultimate Insulation Temperature.** In no case shall conductors be associated together in such a way with respect to the kind of circuit, the wiring method employed, or the number of conductors, that the limiting temperature of the conductors will be exceeded.

(Continued on next page)

**Notes to Tables 310-12 and 310-14 (continued)**

**E 310-20. Simplified Wiring Table.** The Simplified Wiring Table, Table 310-21, may be used for the selection of feeder and branch circuit conductor sizes and insulation types only under the conditions stated in this Section. The Simplified Wiring Table shall be used only when a demand factor of 80 per cent or less exists.

**(a) Application of Table 310-21.**

(1) Determine load amperes, either continuous or noncontinuous. [Sec. 310-20(b).]

(2) Select conductor sizes from Table 310-21.

(3) Determine ambient temperature. Use 30°C (86°F) except where higher ambients may be expected as covered in Section 310-20(c).

(4) Select wire insulation type from Table 310-20(c) and Section 310-2(a).

**(b) Loads.**

(1) **Continuous.** Continuous loads are expected to continue for three hours or longer [see Section 210-23(b).]

(2) **Noncontinuous.** Loads are noncontinuous where 67 per cent or less of the load is expected to be continuous.

(c) **Ambient Temperature.** Ambient temperature is the temperature of the medium, such as air, water or earth, into which the heat of the

**Table 310-20(c). Typical Ambient Temperatures**

Location	Temperature	Minimum Rating of Required Conductor Insulation
Well ventilated, normally heated buildings	30°C (86°F)	*(See note below)
Poorly ventilated spaces such as attics	45°C (113°F)	75°C (167°F)
In thermal insula- tion	45°C (113°F)	75°C (167°F)
Direct solar exposure	45°C (113°F)	75°C (167°F)

\* Note: 60°C for up to and including No. 8 AWG copper and up to and including No. 6 AWG aluminum. 75°C for over No. 8 AWG copper and No. 6 AWG aluminum.

conductor is dissipated. Ambient temperatures vary and values typical of the installation condition shall be used for determining the type of conductor insulation when applying the Simplified Wiring Table. See Table 310-20(c).

**310-21. Conductor Ampacity.** In Table 310-21 the values of amperes apply to actual diversified continuous or noncontinuous connected loads. This Table shall not be used to determine conductor ampacity; use Tables 310-12 and 310-14 for this purpose.

E

**Table 310-21. Simplified Wiring Table**

(See Section 310-20 for use)

**Conductor Size—6 or Fewer Conductors in Raceway or Cable**

Am- peres	Copper				Aluminum			
	Non-Cont.		Continuous		Non-Cont.		Continuous	
	AWG	MCM	AWG	MCM	AWG	MCM	AWG	MCM
15	14		14		12		12	
20	12		12		10		10	
25	10		10		8		8	
30	10		10		8		8	
35	8		8		6		6	
40	8		8		6		6	
45	6		6		4		4	
50	6		6		4		4	
60	4		4		4		4	
70	4		4		3		3	
80	3		3		3		2	
90	3		2		2		1	
100	2		1		1		0	
110	1		0		0		2/0	
125	1		0		2/0		3/0	
150	0		2/0		3/0		4/0	
175	2/0		3/0		4/0			250
200	3/0		4/0			250		300
225	4/0			250		300		350

**ARTICLE 334 — METAL-CLAD CABLE****Type AC Series****E**

**334-1. Definition.** A metal-clad cable is a fabricated assembly of insulated conductors in a flexible metallic enclosure. See Section 334-4.

**E**

**334-2. Voltage.** See Section 300-2.

**334-3. Marking.** The provisions of Section 310-2 shall apply, except that AC cable shall have ready identification of the maker by distinctive external markers in the cable sheath throughout its entire length.

**E**

**334-4. Construction.** Metal-clad cable shall be an approved cable of Type AC Series, with acceptable metal covering. The insulated conductors shall conform with Section 334-5.

(b) **Type AC.** Type AC cables are branch circuit and feeder cables with armor of flexible metal tape. Cables of the AC type, except ACL, shall have an internal bonding strip of copper or aluminum, in intimate contact with the armor for its entire length.

**E**

**334-5. Conductors.** Conductors for metal-clad cable shall conform with the following:

(b) **Type AC.** For cables of Type AC, insulated conductors shall be of a type listed in Table 310-2(b). In addition, the conductors shall have an over-all moisture-resistant and fire-retardant fibrous covering; for Type ACT, a moisture-resistant fibrous covering is required only on the individual conductors.

**E**

**334-6. Use.** Except where otherwise specified elsewhere in this Code, and where not subject to physical damage, metal-clad cable may be installed for branch circuits and feeders in both exposed and concealed work as follows:

(b) **Type AC.** Metal-clad cable of the AC type may be used in dry locations and embedded in plaster finish or brick or other masonry, except in damp or wet locations. This cable may be run or fished in the air voids of masonry block or tile walls; where such walls are exposed or subject to excessive moisture or dampness or are below grade line, Type ACL cable shall be used. This cable shall contain lead-covered conductors (Type ACL), if used where exposed to the weather or to continuous moisture, for underground runs and embedded in masonry, concrete or fill in buildings in course of construction.

See Section 300-5.

**334-7. Other Articles.** In addition to the provisions of this Article, metal-clad cable shall conform to other applicable provisions of this Code. See especially Article 300.

**E**

**334-8. Supports.** Metal-clad cable shall be secured by approved staples, straps, hangers or similar fittings so designed and installed as not to injure the cable.

(b) Type AC cable shall be secured at intervals of not exceeding 4½ feet and within 12 inches from every outlet box or fitting, except where cable is fished and except lengths of not over 24 inches at terminals where flexibility is necessary.

**E 334-9. Bends.** All bends shall be so made that the cable will not be injured, and the radius of the curve of the inner edge of any bend shall not be less than 5 times the diameter of Type AC cable.

**E 334-10. Boxes and Fittings.**

(b) At all points where the armor of AC cable terminates, a fitting shall be provided to protect wires from abrasion, unless the design of the outlet boxes or fittings is such as to afford equivalent protection, and in addition, an approved insulating bushing or its equivalent approved protection shall be provided between the conductors and the armor. The connector or clamp by which the metal-clad cable is fastened to boxes or cabinets shall be of such design that the insulating bushing or its equivalent will be visible for inspection. This bushing is not required with lead-covered cables which shall be so installed that the lead sheath will be visible for inspection. Where change is made from metal-clad cable to other cable or raceway wiring methods, a box shall be installed at junction point as required in Section 300-15.

**334-11. Through Studs, Joists and Rafters.** See Section 300-8.

**E 334-12. Exposed Work.** Exposed runs of cable shall closely follow the surface of the building finish or of running boards, except:

(a) Lengths of not more than 24 inches at terminals where flexibility is necessary.

(c) On the underside of floor joists in basements where supported at each joist and so located as not to be subject to physical damage.

**334-13. In Accessible Attics.** Type AC cables in accessible attics or roof spaces shall be installed as follows:

(a) Where run across the top of floor joists, or within 7 feet of floor or floor joists across the face of rafters or studding, in attics and roof spaces which are accessible, the cable shall be protected by substantial guard strips which are at least as high as the cable. Where this space is not accessible by permanent stairs or ladders, protection will only be required within 6 feet of the nearest edge of scuttle hole or attic entrance.

(b) Where cable is carried along the sides of rafters, studs or floor joists, neither guard strips nor running boards shall be required.

## ARTICLE 336 — NONMETALLIC SHEATHED CABLE

### Types NM and NMC

**336-1. Definition.** A nonmetallic sheathed cable is an assembly of two or more insulated conductors having an outer sheath of moisture-resistant, flame-retardant, nonmetallic material.

**336-2. Construction.** Nonmetallic sheathed cable shall be an approved Type NM or NMC in sizes No. 14 through 2 AWG with copper conductors and in sizes No. 12 through 2 with aluminum conductors. In addition to the insulated conductors, the cable may have an approved size of uninsulated or bare conductor for grounding purposes only.

(a) **Type NM.** The conductors shall comply with the requirements for the type of conductor used. Over-all fibrous coverings shall have a flame-retardant and moisture-resistant finish.

(b) **Type NMC.** The cable shall be of a type approved for the purpose. The over-all covering shall be flame-retardant, moisture-resistant, fungus-resistant and corrosion-resistant.

(c) **Marking.** In addition to the provisions of Section 310-2, the cable shall have a distinctive marking on the exterior for its entire length specifying cable type.

**E 336-3. Use.** Nonmetallic sheathed cable may be installed for both exposed and concealed work as follows:

(a) **Type NM.** This type of nonmetallic sheathed cable may be installed for both exposed and concealed work in normally dry locations. It may be installed or fished in air voids in masonry block or tile walls where such walls are not exposed or subject to excessive moisture or dampness. Type NM cable shall not be installed where exposed to corrosive fumes or vapors; nor shall it be imbedded in masonry, concrete, fill or plaster; nor run in shallow chase in masonry or concrete and covered with plaster or similar finish.

(b) **Moisture and Corrosion-Resistant Type NMC.** This type of nonmetallic sheathed cable may be installed for both exposed and concealed work in dry, moist, damp or corrosive locations, and in outside and inside walls of masonry block or tile. Where embedded in plaster or run in a shallow chase in masonry walls and covered with plaster within 2 inches of the finished surface, it shall be protected against damage from nails by a cover of corrosion-resistant coated steel at least 1/16 inch in thickness and 3/4 inch wide in the chase or under the final surface finish.

(c) **Uses Not Permissible for Either Type NM or NMC Nonmetallic Sheathed Cable.** These types shall not be used as: (1) service-entrance cable, (8) embedded in poured cement, concrete or aggregate.

**336-4. Other Articles.** In addition to the provisions of this Article,



installations of nonmetallic sheathed cable shall conform to the other applicable provisions of this Code. See especially Article 300.

**336-5. Supports.** Nonmetallic sheathed cable shall be secured by approved staples, straps, or similar fittings, so designed and installed as not to injure the cable. Cable shall be secured in place at intervals not exceeding 4½ feet and within 12 inches from every cabinet, box or fitting, except that in concealed work in finished buildings or finished panels for prefabricated buildings where such supporting is impracticable, the cable may be fished between points of access.

**336-6. Exposed Work — General.** In exposed work, except as provided in Sections 336-8 and 336-9, the cable shall be installed as follows:

(a) The cable shall closely follow the surface of the building finish or of running boards.

(b) It shall be protected from physical damage where necessary, by conduit, pipe, guard strips or other means. Where passing through a floor the cable shall be enclosed in rigid metal conduit or metal pipe extending at least 6 inches above the floor.

**336-7. Through Studs, Joists and Rafters.** See Section 300-8.

**336-8. In Unfinished Basements.** Where the cable is run at angles with joists in unfinished basements, assemblies not smaller than two No. 6 or three No. 8 conductors may be secured directly to the lower edges of the joists; smaller assemblies shall either be run through bored holes in the joists or on running boards. Where run parallel to joists, cable of any size shall be secured to the sides or face of the joists.

**336-9. In Accessible Attics.** Cable in accessible attics or roof spaces shall also conform with Section 334-13.

**336-10. Bends.** Bends in cable shall be so made, and other handling shall be such, that the protective coverings of the cable will not be injured, and no bend shall have a radius less than 5 times the diameter of the cable.

**336-11. Devices of Insulating Material.** Switch, outlet, and tap devices of insulating material may be used without boxes in exposed cable wiring, and for concealed work for rewiring in existing buildings where the cable is concealed and fished. Openings in such devices shall form a close fit around the outer covering of the cable and the device shall fully enclose that part of the cable from which any part of the covering has been removed.

Where connections to conductors are by binding screw terminals, there shall be available as many terminals as conductors, unless cables are clamped within the structure and terminals are of a type approved for multiple conductors.

**336-12. Boxes of Insulating Material.** Nonmetallic outlet boxes approved for the purpose may be used as provided in Section 370-3.

## ARTICLE 338 — SERVICE-ENTRANCE CABLE

### Types SE and USE

**338-1. Definition.** Service-entrance cable is a conductor assembly provided with a suitable over-all covering, primarily used for services and of the following types. When consisting of two or more conductors, one may be without individual insulation.

(a) Type SE, having a flame-retardant, moisture-resistant covering, but not required to have inherent protection against mechanical abuse.

(b) Type USE, recognized for underground use, having a moisture-resistant covering, but not required to have a flame-retardant covering or inherent protection against mechanical abuse. Single conductor cables having rubber insulation specifically approved for the purpose do not require an outer covering.

**338-2. Use as Service Entrance Conductors.** Service-entrance cable used as service-entrance conductors shall be installed as required by Article 230.

**338-3. Use as Branch Circuit or Feeders.**

(a) Type SE, service-entrance cables may be used in interior wiring systems where all of the *circuit* conductors of the cable are of the rubber-covered or thermoplastic type.

(b) Type SE, service-entrance cables without individual insulation on the grounded circuit conductor shall not be used as a branch circuit or as a feeder within a building, except a cable which has a final non-metallic outer covering and when supplied by alternating current at not exceeding 150 volts to ground, may be used: (1) As a branch circuit to supply only a range, wall-mounted oven, counter-mounted cooking unit, or clothes dryer as covered in Section 250-60, or (2) as a feeder to supply only other buildings on the same premises. It shall not be used as a feeder terminating within the same building in which it originates.

The above provisions do not intend to deny the use of service-entrance cable for interior use when the fully insulated conductors are used for circuit wiring and the uninsulated conductor is used for equipment grounding purposes.

(c) Type SE, service-entrance cable used to supply appliances shall not be subject to conductor temperatures in excess of the temperature specified for the type of insulation involved.

**338-4. Installation Methods.**

(a) In addition to the provisions of this Article, Type SE service-entrance cable used for interior wiring shall comply with the applicable provisions of Article 300.

(b) Unarmored cable shall be installed in accordance with the applicable provisions of Article 336.

(c) Cables through studs, joists and rafters shall be installed as required in Section 300-8.

**338-5. Marking.** Service-entrance cable shall conform with the marking required in Section 310-2. Cable with the neutral conductor smaller than the ungrounded conductors shall be so marked.

## ARTICLE 339 — UNDERGROUND FEEDER AND BRANCH CIRCUIT CABLE

### Type UF

#### 339-1. Description and Marking.

(a) **Description.** Underground feeder and branch circuit cable shall be an approved Type UF cable in sizes No. 14 to No. 4/0 AWG, inclusive. The conductors shall be Types TW, RHW, or other conductors approved for the purpose. In addition to the insulated conductors, the cable may have an approved size of uninsulated or bare conductor for grounding purposes only. The over-all covering shall be flame-retardant, moisture-resistant, fungus-resistant and corrosive-resistant, and suitable for direct burial in the earth.

(b) **Marking.** In addition to the provisions of Section 310-2, the cable shall have a distinctive marking on the exterior for its entire length specifying cable type.

**339-2. Other Articles.** In addition to the provisions of this Article, installations of underground feeder and branch circuit cable (Type UF) shall comply with other applicable provisions of this Code. See especially Article 300, and Section 310-2(b).

#### **E 339-3. Use.**

(a) Underground feeder and branch circuit cable may be used underground, including direct burial in the earth, as feeder or branch circuit cable when provided with overcurrent protection of the rated ampacity as required in Section 339-4.

(b) Where single conductor cables are installed, all cables of the feeder circuit, sub-feeder circuit, or branch circuit, including the neutral conductor, if any, shall be run together in the same trench or raceway.

(c) A minimum depth of 18 inches shall be maintained for conductors and cables buried directly in the earth. This depth may be reduced to 12 inches provided supplemental protective covering such as a 2 inch concrete pad, metal raceway, pipe or other suitable protection is used.

(d) Type UF cable may be used for interior wiring in wet, dry, or corrosive locations under the recognized wiring methods of this Code, and when installed as nonmetallic sheathed cable it shall conform with the installation provisions of Article 336 and shall be of the multiple conductor type, except where recognized under the provisions of Section 424-43.

(e) This type of cable shall not be used: (1) as service-entrance cables; (8) embedded in poured cement, concrete or aggregate, except where recognized in Article 424; (9) when exposed to direct rays of the sun, unless approved for the purpose.

**339-4. Overcurrent Protection.** Overcurrent protection shall be provided in accordance with provisions of Section 240-5.

**339-5. Rated Ampacity.** The ampacities of conductors in Type UF cable shall be according to Tables 310-12 and 310-14.

## ARTICLE 346 — RIGID METAL CONDUIT

Note: Where conduit is threaded in the field, it is assumed that a standard conduit cutting die providing  $\frac{3}{4}$  inch taper per foot will be employed.

**346-1. Use.** Rigid metal conduit may be used under all atmospheric conditions and occupancies, except that ferrous raceways and fittings protected from corrosion solely by enamel may be used only indoors and in occupancies not subject to severe corrosive influences. Where practicable dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.

Unless made of a material judged suitable for the condition, or unless corrosion protection approved for the condition is provided, ferrous or non-ferrous metallic conduit, elbows, couplings, and fittings shall not be installed in concrete or in direct contact with the earth, or in areas subject to severe corrosive influences.

**346-2. Other Articles.** Installations of rigid metal conduit shall comply with the provisions of the applicable Sections of Article 300.

### A. Installation

**346-3. Cinder Fill.** Conduit, unless of corrosion-resistant material suitable for the purpose shall not be used in or under cinder fill where subject to permanent moisture unless protected on all sides by a layer of noncinder concrete at least 2 inches thick or unless the conduit is at least 18 inches under the fill.

**346-4. Wet Locations.** All supports, bolts, straps, screws, etc., shall be of corrosion-resistant materials or protected against corrosion by approved corrosion-resistant materials.

See Section 300-5.

**E 346-5. Minimum Size.** No conduit smaller than  $\frac{1}{2}$  inch, electrical trade size, shall be used.

**E 346-6. Number of Conductors in Conduit.** The number of conductors permitted in a single conduit shall be as follows:

#### (a) New Work:

(1) Where conductors are all of the same size, use Table 1.

(2) Where conductors are of various sizes to be used in combination, use Tables 3 and 4 and the dimensions in Columns 3, 5, 7, or 9 of Table 5. Where bare conductors are permitted by other Sections of this Code, the dimensions for bare conductors in Table 8 may be used.

**346-7. Reaming.** All cut ends of conduits shall be reamed to remove rough edges.

**346-8. Bushings.** Where a conduit enters a box or other fitting, a bushing shall be provided to protect the wire from abrasion unless the

design of the box or fitting is such as to afford equivalent protection. See Section 373-6(b) for the protection of conductors at bushings.

### 346-9. Couplings and Connectors.

(a) Threadless couplings and connectors used with conduit shall be made tight. Where buried in masonry or concrete, they shall be of the concrete-tight type, or where installed in wet locations, shall be of the raintight type.

(b) Running threads shall not be used on conduit for connection at couplings.

**346-10. Bends — How Made.** Bends of rigid conduit shall be so made that the conduit will not be injured, and that the internal diameter of the conduit will not be effectively reduced. The radius of the curve of the inner edge of any field bend shall not be less than shown in Table 346-10(a).

*Exception: For field bends for conductors without lead sheath and made with a single operation (one shot) bending machine designed for the purpose, the minimum radius may be in accordance with Table 346-10(b).*

**Table 346-10(a)**

**Radius of Conduit Bends**

Size of Conduit	Conductors Without Lead Sheath
½ in.	4 in.
¾ in.	5 in.
1 in.	6 in.
1¼ in.	8 in.
1½ in.	10 in.
2 in.	12 in.
2½ in.	15 in.
3 in.	18 in.

**Table 346-10(b)**

**Radius of Conduit Bends**

Size of Conduit	Radius to Center of Conduit
½ in.	4 in.
¾ in.	4½ in.
1 in.	5¾ in.
1¼ in.	7¼ in.
1½ in.	8¼ in.
2 in.	9½ in.
2½ in.	10½ in.
3 in.	13 in.

**346-11 Bends — Number in One Run.** A run of conduit between outlet and outlet, between fitting and fitting, or between outlet and fitting shall not contain more than the equivalent of 4 quarter bends (360 degrees, total), including those bends located immediately at the outlet or fitting.

**346-12. Supports.** Rigid metal conduit shall be installed as a complete system as provided in Article 300 and shall be securely fastened in place. Conduit shall be firmly fastened within 3 feet of each outlet box, junction box, cabinet, or fitting. Conduit shall be supported at least every ten feet except that straight runs of rigid conduit made up with approved threaded couplings may be secured in accordance with Table 346-12, provided such fastening prevents transmission of stresses to terminus when conduit is deflected between supports.

TABLE 346-12

E

Conduit Size (Inches)	Maximum distance between rigid metal conduit supports (Feet)
$\frac{1}{2}$ – $\frac{3}{4}$	10
1	12
$1\frac{1}{4}$ – $1\frac{1}{2}$	14
2– $2\frac{1}{2}$	16
3	20

## ARTICLE 348 — ELECTRICAL METALLIC TUBING

**348-1. Use.** Electrical metallic tubing may be used for both exposed and concealed work. Electrical metallic tubing protected from corrosion solely by enamel shall not be used. Electrical metallic tubing shall not be used (1) where during installation or afterward, it will be subject to severe physical damage; (2) in cinder concrete or fill where subject to permanent moisture unless protected on all sides by a layer of noncinder concrete at least 2 inches thick or unless the tubing is at least 18 inches under the fill. Where practicable, the use of dissimilar metals throughout the system shall be avoided to eliminate the possibility of galvanic action.

Unless made of material judged suitable for the condition, or unless corrosion protection approved for the condition is provided, ferrous or nonferrous electrical metallic tubing, elbows, couplings and fittings shall not be installed in concrete or in direct contact with the earth, or in areas subject to severe corrosive influences.

**348-2. Other Articles.** Installations of electrical metallic tubing shall comply with the provisions of the applicable sections of Article 300.

### A. Installation

**348-4. Wet Locations.** All supports, bolts, straps, screws, etc. shall be of corrosion-resistant materials or protected against corrosion by approved corrosion-resistant materials. See Section 300-5.

**E 348-5. Minimum and Maximum Sizes.** No tubing smaller than ½ inch, electrical trade size, shall be used.

**348-6. Number of Conductors in Tubing.** One tubing shall not contain more conductors than as provided in Section 346-6.

**348-7. Threads.** Tubing shall not be coupled together nor connected to boxes, fittings, or cabinets by means of threads in the wall of the tubing, except by fittings approved for the purpose. Threads shall not be of the standard pipe thread dimensions.

**348-8. Couplings and Connectors.** Threadless couplings and connectors used with tubing shall be made up tight. Where buried in masonry or concrete, they shall be concrete-tight type, or where installed in wet locations, shall be of the raintight type.

**348-9. Bends — How Made.** Bends in the tubing shall be so made that the tubing will not be injured and that the internal diameter of the tubing will not be effectively reduced. The radius of the curve of the inner edge of any field bend shall not be less than shown in Table 346-10(a).

*Exception: For field bends made with a bending machine designed for the purpose, the minimum radius may be in accordance with the dimensions of Table 346-10(b).*



**348-10. Bends — Number in One Run.** A run of electrical metallic tubing between outlet and outlet, between fitting and fitting, or between outlet and fitting, shall not contain more than the equivalent of four quarter bends (360 degrees, total), including those bends located immediately at the outlet or fitting.

**348-11. Reaming.** All cut ends of electrical metallic tubing shall be reamed to remove rough edges.

**348-12. Supports.** Electrical metallic tubing shall be installed as a complete system as provided in Article 300 and shall be securely fastened in place at least every 10 feet and within 3 feet of each outlet box, junction box, cabinet, or fitting.

## ARTICLE 350 — FLEXIBLE METAL CONDUIT

**350-1. Other Articles.** Installations of flexible metal conduit shall comply with the appropriate (or applicable) provisions of Articles 300, 334, and 346.

**E 350-2. Use.** Flexible metal conduit shall not be used (1) in wet locations, unless conductors are of the lead-covered type or of other type specially approved for the conditions; (5) where rubber-covered conductors are exposed to oil, gasoline, or other materials having a deteriorating effect on rubber.

**350-3. Minimum Size.** No flexible metal conduit less than one-half inch electrical trade size shall be used except (1) as permitted for underplaster extensions by Section 344-2; (2) as permitted for motors by Section 430-145(b); and (3) for connection not over 72 inches in length, or longer on approved assemblies, to equipment where the use of one-half inch or larger size flexible metal conduit is not practicable, in which case flexible metal conduit of three-eighth inch electrical trade size may be used.

**E Table 350-3. Maximum Number of Conductors in  $\frac{3}{8}$  inch Flexible Metal Conduit**

Size AWG	Types RF-2, RH	Type RHW	Types TF, T, TW, THHN, THWN, RUH, RUW
18	4	—	8
16	3	—	6
14	3	2	5
12	2	2	4
10	—	—	3

**350-4. Supports.** When flexible metal conduit is installed it shall be secured by approved means at intervals not exceeding  $4\frac{1}{2}$  feet and within 12 inches on each side of every outlet box or fitting, except where flexible conduit is fished, and except for lengths of not over 36 inches at terminals where flexibility is necessary.

**350-5. Grounding.** Flexible metal conduit may be used as a grounding means where both the conduit and the fittings are approved for the purpose.

## ARTICLE 353 — MULTIOUTLET ASSEMBLY

**353-1. Other Articles.** Installations of multioutlet assembly shall comply with applicable provisions of Article 300. See definition in Article 100.

**E 353-2. Use.** Multioutlet assembly may be installed in dry locations. It shall not be installed (1) where concealed, except that the back and sides of metal multioutlet assembly may be surrounded by the building finish and nonmetallic multioutlet assembly may be recessed in the baseboard; (2) where subject to severe physical damage unless approved for the purpose; or (3) where the voltage is 300 volts or more between conductors unless assembly is of metal having a thickness of not less than .040 inch.

**353-3. Metal Multioutlet Assembly Through Dry Partitions.** Metal multioutlet assembly may be extended through (not run within) dry partitions, providing arrangements are made for removing the cap or cover on all exposed portions and no outlet is located within the partitions.

## ARTICLE 370 — OUTLET, SWITCH AND JUNCTION BOXES, AND FITTINGS

### A. Scope and General

**E 370-1. Scope.** The provisions of this Article shall apply to the installation of outlet, switch and junction boxes, and fittings as required by Section 300-15.

**370-2. Round Boxes.** Round boxes shall not be used where conduits or connectors requiring the use of locknuts or bushings are to be connected to the side of the box.

**370-3. Nonmetallic Boxes.** Nonmetallic boxes approved for the purpose may be used only with open wiring on insulators, concealed knob-and-tube work, nonmetallic sheathed cable, and with approved nonmetallic conduit.

**E 370-4. Metallic Boxes.** Where used with non-metallic sheathed cable, and mounted on metal or metal lath ceilings or walls, such boxes shall be insulated from their supports and from the metal or metal lath, or shall be grounded.

### B. Installation

**E 370-5. Damp or Wet Locations.** In damp or wet locations, boxes and fittings shall be so placed or equipped as to prevent moisture or water from entering and accumulating within the box or fitting. Boxes and fittings installed in wet locations shall be weatherproof. For boxes in floors, see Section 410-53.

It is recommended that approved boxes of nonconductive material be used with nonmetallic sheathed cable or approved nonmetallic conduit when such cable or conduit is used in locations where there is likely to be occasional moisture present.

**E 370-6. Number of Conductors in a Box.** Boxes shall be of sufficient size to provide free space for all conductors enclosed in the box.

The provisions of this Section shall not apply to terminal housings supplied with motors. See Section 430-12.

(a) The maximum number of conductors, including grounding conductors, but not counting fixture wires, permitted in outlet and junction boxes shall be as in Tables 370-6(a-1 and -2) with the exceptions noted.

Tables 370-6(a-1 and -2) apply where no fittings or devices, such as fixture studs, cable clamps, hickeyes, switches or receptacles are contained in the box. Where one or more fixture studs, cable clamps, or hickeyes are contained in the box, the number of conductors shall be one less than shown in the Tables, with a further deduction of one con-

ductor for one or several flush devices mounted on the same strap. A conductor running through the box is counted as one conductor and each conductor originating outside the box and terminating inside the box is counted as one conductor. Conductors of which no part leaves the box are not to be counted in the above computation. If single flush boxes are ganged, and each section is occupied by a flush device or combination of flush devices on the same strap, the limitations will apply to each section individually.

**Table 370-6(a-1). Deep Boxes**

Box Dimensions, Inches Trade Size	Cubic Inch Cap.	Maximum Number of Conductors			
		No. 14	No. 12	No. 10	No. 8
3¼ x 1½ Octagonal	10.9	5	4	4	3
3½ x 1½ " "	11.9	5	5	4	3
4 x 1½ " "	17.1	8	7	6	5
4 x 2½ " "	23.6	11	10	9	7
4 x 1½ Square	22.6	11	10	9	7
4 x 2½ " "	31.9	15	14	12	10
4 11/16 x 1½ Square	32.2	16	14	12	10
4 11/16 x 2½ " "	46.4	23	20	18	15
3 x 2 x 1½ Device	7.9	3	3	3	2
3 x 2 x 2 " "	10.7	5	4	4	3
3 x 2 x 2¼ " "	11.3	5	5	4	3
3 x 2 x 2½ " "	13	6	5	5	4
3 x 2 x 2¾ " "	14.6	7	6	5	4
3 x 2 x 3½ " "	18.3	9	8	7	6
4 x 2½ x 1½ " "	11.1	5	4	4	3
4 x 2½ x 1¾ " "	13.9	6	6	5	4
4 x 2½ x 2½ " "	15.6	7	6	6	5

See Section 370-18 where boxes are used as pull and junction boxes.

**Table 370-6(a-2). Shallow Boxes**

Box Dimensions, Inches Trade Size	Maximum Number of Conductors		
	No. 14	No. 12	No. 10
3¼	4	4	3
4	6	6	4
1¼ x 4 Square	9	7	6
4 11/16	8	6	6

Any box less than 1½ inch deep is considered to be a shallow box.

(b) For combinations or conductor sizes not shown in the above Tables, Table 370-6(b) shall apply.

**Table 370-6(b). Volume Required Per Conductor**

Size of Conductor	Free Space Within Box for Each Conductor
No. 14 .....	2. cubic inches
No. 12 .....	2.25 cubic inches
No. 10 .....	2.5 cubic inches
No. 8 .....	3. cubic inches
No. 6 .....	5. cubic inches

(c) Boxes, other than those described in Tables 370-6(a) (1) and 370-6(a) (2), shall be durably and legibly marked by the manufacturer with their cubic inch content. All boxes shall be durably and legibly marked with the manufacturer's name or trademark.

**E 370-7. Conductors Entering Boxes or Fittings.** Conductors entering boxes or fittings shall be protected from abrasion, and shall conform to the following:

(a) **Openings to Be Closed.** Openings through which conductors enter shall be adequately closed.

(b) **Metal Boxes and Fittings.** Where raceway or cable is installed with metal outlet boxes or fittings, the raceway or cable shall be secured to such boxes and fittings.

(c) **Nonmetallic Boxes.** If nonmetallic sheathed cable is used, the cable assembly shall enter the box through a knockout opening. Clamping of individual conductors or cables to the box is not required where supported within 8 inches of the box. Where nonmetallic conduit is installed the nonmetallic boxes or fittings, the conduit shall be secured to such boxes and fittings in an approved manner.

**370-8. Unused Openings.** Unused openings in boxes and fittings shall be effectively closed to afford protection substantially equivalent to that of the wall of the box or fitting. Metal plugs or plates used with non-metallic boxes or fittings shall be recessed at least  $\frac{1}{4}$  inch from the outer surface.

**370-9. Boxes Enclosing Flush Devices.** Boxes used to enclose flush devices shall be of such design that the devices will be completely enclosed on back and sides, and that substantial support for the devices will be provided. Screws for supporting the box shall not be used in attachment of the device contained therein.

**370-10. In Wall or Ceiling.** In walls or ceilings of concrete, tile or other noncombustible material, boxes and fittings shall be so installed that the front edge of the box or fitting will not set back of the finished surface more than  $\frac{1}{4}$  inch. In walls and ceilings constructed of wood or other combustible material, outlet boxes and fittings shall be flush with the finished surface or project therefrom.

**370-11. Repairing Plaster.** Except on walls or ceilings of concrete, tile or other noncombustible material, a plaster surface which is broken

or incomplete shall be repaired so that there will be no gaps or open spaces at the edge of the box or fitting.

**370-12. Exposed Extensions.** In making an exposed extension from an existing outlet of concealed wiring, a box, extension ring or blank cover shall be mounted over the original box and electrically and mechanically secured to it. The extension shall then be connected to this box in the manner prescribed for the method of wiring employed in making the extension.

**370-13. Supports.** Boxes shall be securely and rigidly fastened to the surface upon which they are mounted, or securely and rigidly embedded in concrete or masonry. Except as otherwise provided in this Section, boxes shall be supported from a structural member of the building either directly or by using a substantial and approved metallic or wooden brace. If of wood the brace shall not be less than nominal 1 inch thickness. If of metal it shall be corrosion resistant and shall be not less than 0.0239 inch thick (No. 24 MSG).

Where mounted in new walls in which no structural members are provided or in existing walls in previously occupied buildings, boxes less than 100 cubic inches in size, specifically approved for the purpose, shall be affixed with approved anchors or clamps so as to provide a rigid and secure installation.

Threaded boxes or fittings less than 100 cubic inches in size, which do not contain devices or support fixtures may be considered adequately supported if two or more conduits are threaded into the box wrench-tight and are supported within three feet of the box on two or more sides as is required by this Section.

**370-14. Depth of Outlet Boxes for Concealed Work.** Outlet boxes for concealed work shall have an internal depth of at least 1½ inches, except that where the installation of such a box will result in injury to the building structure or is impracticable, a box not less than ½ inch internal depth may be installed.

**370-15. Covers and Canopies.** In completed installations each outlet box shall be provided with a cover unless a fixture canopy is used.

(a) Nonmetallic covers and plates or metallic covers and plates may be used with nonmetallic outlet boxes. When metallic covers or plates are used, they shall comply with the grounding requirements of Section 250-42.

See Section 410-95.

(b) Where a fixture canopy or pan is used, any combustible wall or ceiling finish exposed between the edge of the canopy or pan and the outlet box shall be covered with noncombustible material.

(c) Covers of outlet boxes having holes through which flexible cord pendants pass, shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear. So-called hard-rubber or composition bushings shall not be used.

**370-17. Boxes at Lighting Fixture Outlets.** Boxes used at outlets for lighting fixtures shall be designed for the purpose. At every outlet used

exclusively for lighting, the box shall be so designed or installed that a lighting fixture may be attached.

**370-18. Pull and Junction Boxes.** Pull and junction boxes shall conform to the following:

(a) **Minimum Size.** For raceways of 1 inch trade size and larger, containing conductors of No. 6 or larger, and for cables\* containing conductors of No. 6 or larger, the minimum dimensions of a pull or junction box installed in a raceway or cable run shall conform to the following:

(1) **Straight Pulls.** In straight pulls the length of the box shall be not less than 8 times the trade diameter of the largest raceway.

(2) **Angle or U Pulls.** Where angle or U pulls are made, the distance between each raceway entry inside the box and the opposite wall of the box shall not be less than 6 times the trade diameter of the largest raceway. This distance shall be increased for additional entries by the amount of the sum of the diameters of all other raceway entries on the same wall of the box. The distance between raceway entries enclosing the same conductor shall not be less than 6 times the trade diameter of the larger raceway.

(3) Boxes of lesser dimensions than those required in sub-sections (1) and (2) of this Section may be used for installations of combinations of conductors which are less than the maximum conduit fill (of conduits being used) permitted by Table 1, Chapter 9, provided the box has been approved for and is permanently marked with the maximum number of conductors and the maximum AWG size permitted.

*Exception: Terminal housings supplied with motors which shall comply with the provisions of Section 430-12.*

(c) **Covers.** All pull boxes, junction boxes and fittings shall be provided with covers approved for the purpose. Where metallic covers are used, they shall comply with the grounding requirements of Section 250-42.

**370-19. Junction, Pull and Outlet Boxes Be Accessible.** Junction, pull and outlet boxes shall be so installed that the wiring contained in them may be rendered accessible without removing any part of the building, sidewalks or paving.

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\*When transposing cable size into raceway size in (1) and (2) above, the minimum trade size raceway required for the number and size of conductors in the cable shall be used.



## **E** ARTICLE 373 — CABINETS

**E 373-1. Scope.** The provisions of this Article shall apply to the installation of cabinets.

### **A. Installation**

**E 373-2. Damp or Wet Locations.** In damp or wet locations, cabinets of the surface type shall be so placed or equipped as to prevent moisture or water from entering and accumulating within the cabinet and shall be mounted so there is at least  $\frac{1}{4}$  inch air space between the enclosure and the wall or other supporting surface. Cabinets installed in wet locations shall be weatherproof.

It is recommended that boxes of nonconductive material be used with nonmetallic sheathed cable when such cable is used in locations where there is likely to be moisture present.

**373-3. Position in Wall.** In walls of concrete, tile, or other noncombustible material, cabinets shall be so installed that the front edge of the cabinet will not set back of the finished surface more than  $\frac{1}{4}$  inch. In walls constructed of wood or other combustible material, cabinets shall be flush with the finished surface or project therefrom.

**E 373-4. Unused Openings.** Unused openings in cabinet shall be effectively closed to afford protection substantially equivalent to that of the wall of the cabinet. Where metal plugs or plates are used with nonmetallic cabinets they shall be recessed at least  $\frac{1}{4}$  inch from the outer surface.

**E 373-5. Conductors Entering Cabinets.** Conductors entering cabinets shall be protected from abrasion and shall conform to the following:

(a) **Openings to Be Closed.** Openings through which conductors enter shall be adequately closed.

**E 373-6. Deflection of Conductors.** Conductors entering or leaving cabinets or boxes and the like shall conform to the following:

(a) **Width of Gutters.** Conductors shall not be deflected within a cabinet unless a gutter having a width in accordance with Table 373-6(a) is provided.

(b) **Insulation at Bushings.** Where ungrounded conductors of No. 4 or larger enter a raceway in a cabinet, pull box, junction box, or auxiliary gutter, the conductors shall be protected by a substantial bushing providing a smoothly rounded insulating surface, unless the conductors are separated from the raceway fitting by substantial insulating material securely fastened in place. Where conduit bushings are constructed wholly of insulating material, a locknut shall be installed both inside and outside the enclosure to which the conduit is attached.

**E 373-7. Space in Enclosures.** Cabinets shall conform to the following:

**E**      **Table 373-6(a)—Minimum Bending Space in Inches**

AWG or Circular-Mil Size of Wire	Wires per Terminal 1
14-8	Not Specified
6	1-½
4-3	2
2	2½
1	3
0-00	3½
000-0000	4
250 MCM	4½
300-350 MCM	5

NOTE: The distance shall be measured in a straight line from the end of the lug or wire connector (in the direction that the wire leaves the terminal) to the wall or barrier.

**(a) To Accommodate Conductors.** Cabinets shall be selected which have sufficient space to accommodate all conductors installed in them, without crowding.

**373-8. Enclosures for Switches or Overcurrent Devices.** Enclosures for switches or overcurrent devices shall not be used as junction boxes, auxiliary gutters or raceways for conductors feeding through or tapping off to other switches or overcurrent devices, unless designs suitable for the purpose are employed to provide adequate space for this purpose.

## ARTICLE 380 — SWITCHES

### A. Installation

**380-1. Grounded Conductors.** No switch or circuit breaker shall disconnect the grounded conductor of a circuit unless the switch or circuit breaker simultaneously disconnects the ungrounded conductor or conductors, or unless the switch or circuit breaker is so arranged that the grounded conductor cannot be disconnected until the ungrounded conductor or conductors have first been disconnected.

**380-2. Three-Way and Four-Way Switches.** Three-way and four-way switches shall be so wired that all switching is done only in the ungrounded circuit conductor. Wiring between switches and outlets shall, where in metal enclosures, be run with both polarities in the same enclosure.

**E 380-3. Enclosures.** Switches and circuit breakers shall be of the externally operable type enclosed in metal boxes or cabinets, except pendant and surface type snap switches.

**380-4. Wet Locations.** A switch or circuit breaker in a wet location or outside of a building shall be enclosed in a weatherproof enclosure or cabinet installed to conform to Section 373-2.

**E 380-5. Time Switches, Flashers, and Similar Devices.** Time switches, flashers, and similar devices need not be of the externally operable type. They shall be enclosed in metal boxes or cabinets except:

*Exception No. 2. Where enclosed in approved individual housings.*

**380-6. Position of Knife Switches.** Single-throw knife switches shall be so placed that gravity will not tend to close them. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal as preferred, but where the throw be vertical a locking device shall be provided which will insure the blades remaining in the open position when so set.

**380-7. Connection of Knife Switches.** Knife switches, unless of the double-throw type, shall be so connected that the blades are dead when the switch is in the open position.

**380-8. Accessibility and Grouping.** Switches and circuit breakers, so far as practicable, shall be readily accessible and shall be grouped.

Snap switches shall not be grouped or ganged in outlet boxes unless they can be so arranged that the voltage between exposed live metal parts of adjacent switches does not exceed 300 volts.

**380-9. Covers of Flush Snap Switches.** Flush snap switches, that are mounted in ungrounded metal boxes and located within reach of conducting floors or other conducting surfaces, shall be provided with covers of nonconducting, noncombustible material. Metallic faceplates

shall be of ferrous metal not less than 0.030 inch in thickness or of nonferrous metal not less than 0.040 inch in thickness. Faceplates of insulating material shall be noncombustible and not less than 0.10 inch in thickness but may be less than 0.10 inch in thickness if formed or reinforced to provide adequate mechanical strength.

**380-11. Circuit Breakers as Switches.** A circuit breaker operable directly by applying the hand to a lever or handle may serve as a switch provided it has the number of poles required for such switch.

**E 380-12. Grounding of Enclosures.** Enclosures for switches or circuit breakers on circuits of over 150 volts to ground shall be grounded in the manner specified in Article 250.

**E 380-14. Rating of Snap Switches.** Snap switches installed for the following types of loads shall be rated as follows:

(a) **Noninductive Loads.** For noninductive loads other than tungsten-filament lamps, switches shall have an ampere rating not less than the ampere rating of the load.

(c) **Inductive Loads.** Switches controlling inductive loads shall have an ampere rating twice the ampere rating of the load unless they are of a type approved as part of an assembly or for the purpose employed. On alternating-current circuits, general use alternating-current snap switches may be used to control inductive loads other than motors not exceeding the ampere rating of the switch.

For switches controlling motors, see Sections 430-83, 430-109 and 430-110.

**E****ARTICLE 384 — PANELBOARDS**

**E 384-1. Scope.** The requirements of this Article shall apply to all panelboards and distribution boards installed for the control of light and power circuits.

**E 384-2. Application of Other Articles.** Where switches, circuit breakers and overcurrent devices are used on panelboards and distribution boards, the boards and their enclosures, shall conform to the requirements of Articles 240, 250, 370, 380 and other Articles which apply.

**E 384-3. Support and Arrangement of Bus-bars and Conductors.**

(c) Each panelboard, if used as service equipment, shall be provided with an equipment grounding means placed within the service disconnect section for connecting the grounded circuit conductor on its supply side to the panelboard frame. The equipment grounding means shall not be smaller than called for in Table 250-95 nor smaller than No. 8 AWG copper conductor or approved equivalent.

**384-13. General.** All panelboards shall have a rating not less than the minimum feeder capacity required for the load as computed from Article 220. Panelboards shall be durably marked by the manufacturer with the voltage and the current rating and the number of phases for which they are designed and with the manufacturer's name or trademark in such a manner as to be visible after installation, without disturbing the interior parts or wiring.

**384-14. Lighting and Appliance Branch Circuit Panelboard.** For the purposes of this Article, a lighting and appliance branch circuit panelboard is one having more than 10 per cent of its overcurrent devices rated 30 amperes or less, for which neutral connections are provided.

**384-15. Number of Overcurrent Devices on One Panelboard.** Not more than 42 overcurrent devices (other than those provided for in the mains) of a lighting and appliance branch circuit panelboard shall be installed in any one cabinet or cutout box.

A lighting and appliance branch circuit panelboard shall be provided with physical means to prevent the installation of more overcurrent devices than that number for which the panelboard was designed, rated and approved.

For the purposes of this Article a two-pole circuit breaker shall be considered two overcurrent devices; a three-pole breaker shall be considered three overcurrent devices.

**384-16. Overcurrent Protection.**

(a) Each lighting and appliance branch circuit panelboard shall be individually protected on the supply side by not more than two main circuit breakers or two sets of fuses having a combined rating not greater than that of the panelboard.

*Exception No. 1. Individual protection for a lighting and appliance panelboard is not required when the panelboard feeder has overcurrent protection not greater than that of the panelboard.*

*Exception No. 2. Individual protection for lighting and appliance branch circuit panelboards is not required where such panelboards are used as service equipment in supplying an individual residential occupancy and where any bus supplying 15 or 20 ampere circuits is protected on the supply side by an overcurrent device.*

(b) Panelboards equipped with snap switches rated at 30 amperes or less, shall have overcurrent protection not in excess of 200 amperes.

(c) The total load on any overcurrent device located in a panelboard shall not exceed 80% of its rating where in normal operation the load will continue for 3 hours or more.

*Exception. Except where the assembly including the overcurrent device is approved for continuous duty at 100 per cent of its rating.*

**384-17. Panelboards in Damp or Wet Locations.** Panelboards in damp or wet locations shall be installed in conformity to Section 373-2.

**E 384-18. Enclosure.** Panelboards shall be mounted in cabinets.

**384-19. Relative Arrangement of Switches and Fuses.** Panelboards having switches on the load side of any type of fuses shall not be installed except for use as service equipment as provided in Section 230-94.

**384-27. Grounding of Panelboards.** Panelboard cabinets shall be grounded in the manner specified in Section 250-113. Approved means for equipment grounding conductors shall be provided and secured to the cabinet interior for the attachment of all the feeder and branch circuit equipment grounding conductors, when the panelboard is used with nonmetallic raceway or cable wiring. The equipment grounding terminal bar shall be bonded to the panelboard cabinet but shall not be connected to the insulated neutral bar except at service equipment as permitted in Section 250-52.

## ARTICLE 390 — PREFABRICATED BUILDINGS

**390-1. Scope.** The intent and purpose of the following sections is to define approved methods for the wiring of prefabricated building sections, panels, or units designed for later erection or assembly as integral parts of buildings whether wired in the process of manufacture or at the site of erection or assembly.

**390-2. Wiring Methods.** Only wiring methods recognized in this Code shall be used.

**390-3. Code Provisions to Apply.** The provisions of this Code shall apply for the type of wiring method used and the type of construction employed.

## ARTICLE 400 — FLEXIBLE CORDS AND CABLES

### A. General and Types

**400-1. General.** Flexible cords and cables and their associated fittings shall be suitable for the conditions of use and location.

### B. Use and Installation

#### **E 400-3. Use.**

(a) Flexible cord may be used only for (1) pendants; (2) wiring of fixtures; (3) connection of portable lamps or appliances; (6) connection of stationary equipment to facilitate their frequent interchange; or (7) prevention of the transmission of noise or vibration; or (8) facilitating the removal or disconnection of fixed or stationary appliances for maintenance or repair.

(b) Where used as permitted in Sub-sections (a) (3), (a) (6), and (a) (8) of this Section, each flexible cord shall be equipped with an attachment plug and shall be energized from an approved receptacle outlet.

**400-4. Prohibited Uses.** Flexible cord shall not be used (1) as a substitute for the fixed wiring of a structure (2) where run through holes in walls, ceilings, or floors, (3) where run through doorways, windows, or similar openings; (4) where attached to building surfaces; or (5) where concealed behind building walls, ceilings, or floors.

**400-5. Splices.** Flexible cord shall be used only in continuous lengths without splice or tap.

**400-7. Minimum Size.** Flexible cords shall not be smaller than No. 18, except that tinsel cords, or cords having equivalent characteristics, of smaller size may be approved for use with specific appliances.



## ARTICLE 410 — LIGHTING FIXTURES, LAMPHOLDERS, LAMPS, AND RECEPTACLES

### A. General

- E 410-1. Scope.** Lighting fixtures, lampholders, pendants, receptacles, incandescent filament lamps, arc lamps, electric discharge lamps, the wiring and equipment forming part of such lamps, fixtures and lighting installations shall conform to the provisions of this Article, except as otherwise provided in this Code.
- E 410-3. Live Parts.** Fixtures, lampholders, lamps, and receptacles shall have no live parts normally exposed to contact. Lampholders, receptacles and switches which have exposed accessible terminals shall not be installed in metal fixture canopies or in open bases of portable table or floor lamps.

### B. Provisions for Fixture Locations

- E 410-4. Fixtures in Damp or Wet Locations.**

(a) Fixtures installed in damp or wet locations shall be approved for such locations and shall be so constructed or installed that water cannot enter or accumulate in wireways, lampholders or other electrical parts. All fixtures installed in wet locations shall be marked, "Suitable for Wet Locations." All fixtures installed in damp locations shall be marked, "Suitable for Wet Locations" or "Suitable for Damp Locations."

Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as locations exposed to weather and unprotected, vehicle washing areas, and like locations, are considered to be wet locations with respect to the above requirement.

Interior locations protected from weather but subject to moderate degrees of moisture, such as some basements, some barns, some cold storage warehouses and the like, and partially protected locations under canopies, marquees, roofed open porches, and the like, are considered to be damp locations with respect to the above requirement.

See Section 210-21 (b) for receptacles in fixtures.

**410-5. Fixtures near Combustible Material.** Fixtures shall be so constructed, or installed, or equipped with shades or guards that combustible material will not be subjected to temperatures in excess of 90° C (194° F).

**410-6. Fixtures over Combustible Material.** Lampholders installed over highly combustible material shall be of the unswitched type and unless an individual switch is provided for each fixture, shall be located at least 8 feet above the floor, or shall be otherwise so located or guarded that the lamps cannot be readily removed or damaged.

**410-8. Fixtures in Clothes Closets.**

(a) A fixture in a clothes closet shall be installed:

(1) On the wall above the closet door, provided the clearance from the fixture to a storage area where combustible material may be stored within the closet is not less than 18 inches, or

(2) On the ceiling or wall over an area which is unobstructed to the floor, maintaining an 18-inch clearance upward and horizontally from the fixture to a storage area where combustible material may be stored within the closet.

NOTE: A flush recessed fixture equipped with a solid lens is considered to be outside the closet area.

(b) Pendants shall not be installed in clothes closets.

**410-9. Space for Cove Lighting.** Coves shall have adequate space and shall be so located that lamps and equipment can be properly installed and maintained.

**C. Provisions at Fixture Outlet Boxes, Canopies and Pans**

**410-10. Space for Conductors.** Canopies and outlet boxes taken together shall provide adequate space so that fixture conductors and their connecting devices may be properly installed.

**410-11. Temperature Limit of Conductors in Outlet Boxes.** Fixtures shall be of such construction or so installed that the conductors in outlet boxes shall not be subjected to temperatures greater than that for which the conductors are approved.

Branch circuit wiring shall not be passed through an outlet box that is an integral part of an incandescent fixture unless the fixture is approved for the purpose.

**410-12. Outlet Boxes to be Covered.** In a completed installation, each outlet box shall be provided with a cover unless covered by means of a fixture canopy, lampholder, receptacle, or similar device.

**410-13. Covering of Combustible Material at Outlet Boxes.** Any combustible wall or ceiling finish exposed between the edge of a fixture canopy or pan and an outlet box shall be covered with noncombustible material.

**E 410-14. Connection of Electric Discharge Lighting Fixtures.** Electric discharge lighting fixtures when supported independently of the outlet box shall be connected through metal raceways, metal-clad cable or nonmetallic sheathed cable. This requirement may be waived when cord equipped fixtures are suspended directly below the outlet box and the exposed cord is not subject to strain or physical damage. Such cord equipped fixtures shall terminate at the outer end of the cord in a grounding type attachment plug (cap).

**D. Fixture Supports**

**410-15. Supports—General.** Fixtures, lampholders, and receptacles shall be securely supported. A fixture which weighs more than 6 lbs. or

exceeds 16 inches in any dimension shall not be supported by the screw shell of a lampholder.

**410-16. Means of Support.** Where the outlet box or fitting will provide adequate support, a fixture shall be attached thereto; otherwise a fixture shall be supported as required by Section 370-13. A fixture which weighs more than 50 lbs. shall be supported independently of the outlet box.

### **E. Wiring of Fixtures**

**410-17. Fixture Wiring—General.** Wiring on or within fixtures shall be neatly arranged and shall not be exposed to physical damage. Excess wiring shall be avoided. Conductors shall be so arranged that they shall not be subjected to temperatures above those for which they are approved.

#### **410-21. Conductors for Movable Parts.**

(a) Stranded conductor shall be used for wiring on fixture chains and on other movable or flexible parts.

(b) Conductors shall be so arranged that the weight of the fixture or movable parts will not put a tension on the conductors.

#### **E 410-23. Protection of Conductors and Insulation.**

(a) Conductors shall be secured in a manner that will not tend to cut or abrade the insulation.

(b) Conductor insulation shall be protected from abrasion where it passes through metal.

#### **410-25. Connections, Splices and Taps.**

(a) Fixtures shall be so installed that the connections between the fixture conductors and the circuit conductors may be inspected without requiring the disconnection of any part of the wiring, unless the fixture is connected by means of a plug and receptacle.

(b) Splices and taps shall not be located within fixture arms or stems.

(c) No unnecessary splices or taps shall be made within or on a fixture.

(d) For approved means of making connections, see Sections 110-14 and 110-15.

#### **E 410-26. Fixture Raceways.** Fixtures shall not be used as a raceway for circuit conductors unless the fixtures meet the requirements for approved raceways, except that the conductors of the single branch circuit supplying the fixtures may be carried through as follows:

*Exception No. 1. An installation of fixtures approved for end to end assembly to form a continuous raceway, or*

*Exception No. 2. Fixtures which are connected together by approved wiring methods.*

Branch circuit conductors within 3 inches of a ballast within the ballast compartment shall be recognized for use at temperatures not lower

than 90° C (194°F.), such as Type RHH, THHN, FEP, FEPB, and SA. See Table 310-2(a) for Type THW—MTW.

**410-27. Polarization of Fixtures.** Fixtures shall be so wired that the screw-shells of lampholders will be connected to the same fixture or circuit conductor or terminal. For polarity identification of conductors to screw-shells of lampholders, see Section 200-8.

### G. Installation of Lampholders

**410-41. Screw-Shell Type.** Lampholders of the screw-shell type shall be installed for use as lampholders only.

**410-42. Double-Pole Switched Lampholders.** Where used on unidentified 2-wire circuits tapped from the ungrounded conductors of multi-wire circuits, the switching device of lampholders of the switched type shall simultaneously disconnect both conductors of the circuit. See Section 200-5.

**410-43. Lampholders in Damp or Wet Locations.** Lampholders installed in damp or wet locations shall be of the weatherproof type.

### K. Receptacles, Cord Connectors and Attachment Plugs (Caps)

**410-52. Rating and Type.**

(a) Receptacles installed for the attachment of portable cords shall be rated at not less than 15 amperes, 125 volts, or 10 amperes, 250 volts, and shall be of a type not suitable for use as lampholders.

(b) Metallic faceplates shall be of ferrous metal not less than 0.030 inch in thickness or of nonferrous metal not less than 0.040 inch in thickness. Faceplates of insulating material shall be noncombustible and not less than 0.10 inch in thickness but may be less than 0.10 inch in thickness if formed or reinforced to provide adequate mechanical strength.

**E 410-53. Receptacles in Floors.** Receptacles located in floors shall be enclosed in floor boxes especially approved for the purpose.

**410-54. Receptacles in Damp or Wet Locations.** Receptacles installed in damp or wet locations shall be of the weatherproof type.

**E 410-55. Grounding Type Receptacles, Adapters, Cord Connectors and Attachment Plugs.**

(c) In no case shall a grounding terminal or grounding type device be used for purposes other than grounding.

### M. Special Provisions for Flush and Recessed Fixtures

**E 410-62. Approved Type.** Fixtures which are installed in recessed cavities in walls or ceilings shall be of an approved type and shall conform to Sections 410-63 to 410-65 inclusive.

**410-63. Temperature.**

(a) Fixtures shall be so constructed or installed that adjacent com-

bustible material will not be subjected to temperatures in excess of 90°C (194°F).

(b) Where a fixture is recessed in fire-resistant material in a building of fire-resistant construction, a temperature higher than 90°C (194°F), but not higher than 150°C (302°F) is acceptable if the fixture is plainly marked that it is approved for that service.

**410-64. Clearance.** Recessed portions of enclosures, other than at points of support, shall be spaced at least ½ inch from combustible material and thermal insulation.

**410-65. Wiring.**

(a) Conductors having insulation suitable for the temperature encountered shall be used.

(b) Fixtures having branch circuit terminal connections which operate at temperatures higher than 60°C (140°F) shall have circuit conductors as described in Sections 410-65 (b-1 and b-2):

(1) Branch circuit conductors having an insulation suitable for the temperature encountered may be run directly to the fixture.

(2) Tap connection conductors having an insulation suitable for the temperature encountered shall be run from the fixture terminal connection to an outlet box placed at least one foot from the fixture. Such a tap shall extend for at least four feet but not more than six feet and shall be in a suitable metal raceway.

**P. Special Provisions for Electric Discharge Lighting  
Systems of 1,000 Volts or Less**

**410-71. General.**

(a) Equipment for use with electric discharge lighting systems and designed for an open-circuit voltage of 1,000 volts or less shall be of a type approved for such service.

(b) The terminals of an electric discharge lamp shall be considered as alive where any lamp terminal is connected to a potential of more than 300 volts.

(c) Transformers of the oil-filled type shall not be used.

(d) In addition to complying with the general requirements for lighting fixtures, such equipment shall conform to Part P of this Article.

(e) Fluorescent fixtures for indoor installations shall incorporate ballast protection.

*Exception: Fluorescent fixtures for indoor installations need not incorporate ballast protection when they employ simple reactance type ballasts.*

**E 410-73. Voltages.**

(a) Equipment having an open-circuit voltage of more than 1000 volts shall not be installed.

(b) Equipment having an open-circuit voltage of more than 300 volts shall not be installed unless such equipment is so designed that there shall be no exposed live parts when lamps are being inserted, are in place, or are being removed.

**410-74. Fixture Mounting.**

(a) **Exposed Ballasts.** Fixtures having exposed ballasts or transformers shall be so installed that such ballasts or transformers shall not be in contact with combustible material.

(b) **Combustible Low-Density Cellulose Fiberboard.** Where a fixture containing a ballast is to be installed on combustible low-density cellulose fiberboard it shall, where surface mounted:

(1) Be approved for this condition, or

(2) Be spaced not less than 1½ inches from the surface of the fiberboard.

(3) Where such fixtures are partially or wholly recessed, the provisions of Sections 410-62 to 410-70 shall apply.

Combustible low-density cellulose fiberboard is considered to include sheets, panels and tiles which have a density of 20 pounds per cubic foot or less, and which are formed of bonded plant fiber material; but does not include solid or laminated wood, nor fiberboard which has a density in excess of 20 pounds per cubic foot or is an approved material which has been integrally treated with fire retarding chemicals to the degree that the flame spread in any plane of the material will not exceed twenty-five as determined by the method of NFPA No. 255, ASTM Designation E-84 or U.L. No. 723.

**R. Grounding**

**E 410-91. General.** Fixtures and lighting equipment shall be grounded as provided in Sections 410-92 to 410-95 inclusive.

**410-92. Metallic Wiring Systems.** Metal fixtures installed on outlets wired with grounded metal raceway or grounded Type AC metal-clad cable shall be grounded.

**410-93. Nonmetallic Wiring Systems.** Metal fixtures installed on outlets wired with knob-and-tube work, or nonmetallic sheathed cable, on circuits operating at 150 volts or less to ground, shall be grounded.

*Exception No. 1. Fixtures mounted on metal or metal lath ceilings or walls may be insulated from their supports and from the metal lath by the use of insulating joints or fixture supports and canopy insulators. See Section 410-95.*

*Exception No. 2. Fixtures not mounted on metal or metal lath ceilings or walls need not be insulated or grounded. See Section 410-95.*

Fixtures made of insulating materials, and lampholders with shells of insulating material, are recommended for use with wiring systems that do not afford a ready means for grounding the exposed noncurrent-carrying parts of fixtures and lampholders.

**410-95. Equipment Near Grounded Surfaces.**

(a) Ungrounded metal lighting fixtures, lampholders and face plates shall not be installed in contact with conducting surfaces nor within 8 feet vertically or 5 feet horizontally of laundry tubs, bath tubs, shower baths, plumbing fixtures, steam pipes or other grounded metal work or grounded surfaces.

(b) Metal pull chains used at these locations shall be provided with insulating links.

## ARTICLE 422 — APPLIANCES

### A. General

**E 422-1. Scope.** This Article shall apply to electric appliances.

**422-2. Live Parts.** Appliances shall have no live parts normally exposed to contact, except for toasters, grills or other appliances in which the current-carrying parts at high temperatures are necessarily exposed.

### B. Branch Circuit Requirements

**422-5. Branch Circuit Ampacity.** The provisions of this Section specify sizes of conductors capable of carrying appliance current without overheating under the conditions specified (see Article 210). They are not intended to apply to conductors which form an integral part of the appliance.

(a) The branch circuit ampacity of an individual branch circuit shall not be less than the marked ampere rating of the appliance or the marked ampacity rating of an appliance having combined loads (see Section 422-32).

*Exception No. 1. For household cooking appliances, see Table 220-5.*

*Exception No. 2. For motor-operated appliances not having a marked ampacity rating the branch circuit ampacity shall be in accordance with Part B of Article 430.*

*Exception No. 3. Except as noted in Section 210-23(b), Exception No. 1, an appliance, other than a motor-operated appliance, which is continuously loaded, the branch circuit ampacity shall not be less than 125 per cent of the marked rating.*

(b) For branch circuits supplying appliance and other loads, the ampacity rating shall be determined in accordance with Section 210-24.

**422-6. Branch Circuit Overcurrent Protection.** Branch circuits shall be protected in accordance with Section 240-5.

*Exception No. 1. When the branch circuit supplies a single non-motor-operated appliance rated at 10 amperes or more, the overcurrent device rating shall not exceed 150 per cent of the appliance rating.*

*Exception No. 2. When there is a protective device rating marked on an appliance, the branch circuit overcurrent device rating shall not exceed the protective device rating marked on the appliance.*

### C. Installation of Appliances

**E 422-8. Flexible Cords.** Flexible cords used to connect appliances shall comply with the following:

(c) **Other Appliances.** Flexible cord may be used for: (1) connection of portable appliances; (2) connection of stationary appliances to

facilitate their frequent interchange or prevention of the transmission of noise or vibration; or (3) facilitating the removal or disconnection of fixed appliances for maintenance or repair.

**422-10. Protection of Combustible Material.** Each electrically heated appliance that is obviously intended by size, weight and service to be located in a fixed position shall be so placed as to provide ample protection between the appliance and adjacent combustible material.

**422-14. Water Heaters.** Each water heater shall be equipped with temperature-limiting means in addition to the control thermostat to disconnect all ungrounded conductors, and such means shall be: (1) installed to sense maximum water temperature; (2) trip-free, manually reset, or it shall use a replacement element; (3) in addition to any other devices protecting the tank against excessive temperature or pressure, or both.

**422-16. Grounding.** Metal frames of portable, stationary and fixed electrically heated appliances, operating on circuits above 150 volts to ground, shall be grounded in the manner specified in Article 250; provided, however, that where this is impracticable, grounding may be omitted by special permission, in which case the frames shall be permanently and effectively insulated from the ground.

Refrigerators, freezers and air conditioners shall comply with the requirements of Sections 250-42, 43 and 45.

It is recommended that the frames be grounded in all cases. For methods of grounding frames of electric ranges and clothes dryers, see Sections 250-57 and 250-60.

**422-17. Wall-mounted Ovens and Counter-mounted Cooking Units.**

(a) Wall-mounted ovens and counter-mounted cooking units complete with provisions for mounting and for making electrical connections shall be considered as fixed appliances.

(b) A separable connector or a plug and receptacle combination in the supply line to an oven or cooking unit used only for ease in servicing or for installation shall:

(1) Not be installed as the disconnecting means required by Section 422-20;

(2) Be approved for the temperature of the space in which it is located.

#### **D. Control and Protection of Appliances**

**422-20. Disconnecting Means.** Each appliance shall be provided with a means for disconnection from all ungrounded conductors as required by the following Sections. Where an appliance is supplied by more than one source the disconnecting means shall be grouped and identified.

**422-21. Disconnection of Fixed Appliances.**

(a) For fixed appliances rated at not over 300 volt amperes or  $\frac{1}{8}$  hp. the branch circuit overcurrent device may serve as the disconnection means.



(b) For fixed appliances of greater rating the branch circuit switch or circuit breaker may, where readily accessible to the user of the appliance, serve as the disconnecting means.

#### **422-23. Disconnection of Stationary Appliances.**

(a) For stationary appliances rated at not over 300 volt amperes or  $\frac{1}{8}$  horsepower, the branch-circuit overcurrent device may serve as the disconnecting means.

(b) For stationary appliances of greater rating the branch-circuit switch or circuit breaker may, where readily accessible to the user of the appliance, serve as the disconnecting means.

(c) For cord-connected appliances such as freestanding household-type ranges and clothes dryers, a separable connector or an attachment plug and receptacle may serve as the disconnecting means. Attachment plugs and connectors shall conform to Section 422-22(c).

For household electric ranges, a plug and receptacle connection at the rear base of a range, if it is accessible from the front by removal of a drawer, is considered as meeting the intent of this rule.

**E 422-24. Unit Switches as Disconnecting Means.** Unit switches which are a part of an appliance shall not be considered as taking the place of the disconnecting means required by Part D (Control and Protection of Appliances) of this Article, unless there are other means for disconnection as follows:

(b) **Two-Family Dwellings.** In two-family dwellings, the disconnecting means may be outside the apartment in which the appliance is installed. This will permit an individual switch for the apartment to be used.

(c) **Single-Family Dwellings.** In single-family dwellings, the service disconnecting means may be used.

**422-25. Switch and Circuit Breaker to be Indicating.** Switches and circuit breakers used as disconnecting means shall be of the indicating type.

**422-26. Location of Disconnecting Means for Motor-driven Appliances.** When a switch or circuit breaker serves as the disconnecting means for a stationary or fixed motor-driven appliance of more than  $\frac{1}{8}$  horsepower, it shall be located within sight of the motor controller or shall be capable of being locked in the open position.

**E 422-27. Overcurrent Protection.**

(a) Appliances shall be considered as protected against overcurrent when supplied by branch circuits as specified in Sections 422-5 and 422-6.

*Exception: Motors of motor-operated appliances shall be provided with overload protection in accordance with Part C of Article 430. When appliance protective devices separate from the appliance are required, data for selection of these devices shall be marked on the appliance. The minimum marking shall be that specified in Section 430-7.*

(b) A household type appliance with surface heating elements and which has a maximum demand of more than 60 amperes as calculated

in accordance with Table 220-5 shall have its power supply subdivided into two or more circuits, each of which is provided with overcurrent protection rated at not more than 50 amperes.

### E. Marking of Appliances

#### 422-30. Nameplate.

(a) Each electric appliance shall be provided with a nameplate, giving the identifying name and the rating in volts and amperes, or in volts and watts unless marked in accordance with Section 422-32. When the appliance is to be used on a specific frequency or frequencies, it shall be so marked.

Where motor overload protection external to the appliance is required, the appliance shall be so marked. See Section 422-27(a) Exception.

(b) This marking shall be located so as to be visible or easily accessible after installation.

**422-31. Marking of Heating Elements.** All replaceable heating elements rated more than one ampere which are a part of an appliance shall be legibly marked with the rating in volts and amperes, or in volts and watts.

**422-32. Appliance Consisting of Motors and Other Loads.** The marking on an appliance shall specify the rating of the motor in volts and amperes, and the additional load (heaters, lights, etc.) in volts and watts or amperes.

*Exception No. 1 — Portable Appliances.*

*Exception No. 2 — Fixed or stationary appliances employing a motor 1/20 hp or less.*

### F. Provisions for Room Air-Conditioning Units

**422-40. General.** The provisions of Sections 422-41 to -43 inclusive shall apply to electrically energized room air-conditioning units which control temperature and humidity. For the purpose of these Sections a room air-conditioner is an alternating-current hermetic type air-cooled window, console or in-wall air-conditioner which is installed in the conditioned room. It covers equipment rated not greater than 250 volts, single phase. It also applies to such an air-conditioner, if it has provisions for heating.

**422-41. Grounding.** See Sections 250-42, 43 and 45.

**422-42. Branch Circuit Requirements.**

(a) The total marked rating of motor-operated air-conditioning equipment shall not exceed 80 per cent of the rating of a branch circuit which does not supply lighting units or other appliances.

(b) The total marked rating of air-conditioning equipment shall not exceed 50 per cent of the rating of a branch circuit where lighting units or other appliances are also supplied.

(c) The nameplate marking of a room air-conditioner shall be used in determining the branch circuit requirements, and each unit shall be considered as a single-motor unit unless the nameplate is otherwise marked. When marked to indicate two or more motors, see Section 430-53.

**422-43. Disconnecting Means.** A separable connector or an attachment plug and receptacle may serve as the disconnecting means.

**422-44. Supply Cords.** Where flexible cords are used to supply air conditioning equipment the length of such cords shall not exceed: (1) 10 feet for nominal 125 volt rating, and (2) 6 feet for nominal 250 volt rating.

## ARTICLE 424 — FIXED ELECTRIC SPACE HEATING EQUIPMENT

### A. General

**424-1. Scope.** The requirements of this Article shall apply to fixed equipment used for space heating. It also covers fixed outdoor electric de-icing and snow melting installations. Equipment shall be of a type approved for the purpose and location where installed. For the purpose of this Article, heating equipment may be heating cable, unit heaters, boilers, central systems, or other approved fixed heating equipment. This Article does not cover process heating and room air-conditioning.

**E 424-2. Application of Other Articles.** All requirements of the National Electrical Code shall apply where applicable. Motor driven fan forced heaters with motors over  $\frac{1}{8}$  horsepower shall also comply with Article 430.

**E 424-3. (a) Branch Circuit Requirements.** Fixed heating equipment shall be supplied by branch circuits rated 15, 20 or 30 amperes. An individual branch circuit may supply any load.

**(b) Branch Circuit Sizing.** Fixed space heating equipment shall be considered as a continuous load for sizing branch circuits.

The ampacity of branch circuit conductors supplying fixed space heating equipment consisting of resistance elements with or without a motor shall be calculated on the basis of 125 per cent of the total load of the motors and the heaters.

The ampacity of the branch circuit conductors supplying fixed space heating equipment consisting of mechanical refrigeration with or without resistance units shall be calculated as provided for in Section 430-25.

### B. Installation

**424-9. General.** All heating equipment shall be installed in an approved manner.

**424-10. Special Type Heaters.** Fixed electrical space heating systems employing methods of installation other than covered by this Article may be used only by special permission.

**424-11. Supply Conductors.** Equipment requiring supply conductors with over 60°C insulation shall be clearly and permanently marked. This marking shall be plainly visible after installation and may be adjacent to the field connection box.

**424-12. Locations.**

**(a)** Fixed space heating equipment shall not be used where exposed to severe physical damage unless adequately protected.

**(b)** Heaters and related equipment installed in damp or wet locations

shall be approved for such locations and shall be constructed and installed so that water cannot enter or accumulate in wireways, electrical components or duct work.

NOTE: See Section 110-11.

**424-13. Spacing from Combustible Materials.** Heating equipment shall be installed to provide the required spacing between the equipment and adjacent combustible material, unless it has been found to be acceptable when installed in direct contact with combustible material.

**424-14. Grounding.** All exposed metal parts of fixed space heating equipment liable to become energized shall be grounded as required in Article 250.

**C. Control and Protection of Fixed Electrical Space Heating Equipment**

**E 424-19. Disconnection Means.** All fixed electric space heating equipment shall be provided with a means for disconnection from all ungrounded conductors. Where heating equipment is supplied by more than one source, the disconnecting means shall be grouped and identified.

(a) For fixed heating equipment rated at not over 300 volt-amperes or  $\frac{1}{8}$  horsepower, the branch circuit overcurrent device may serve as the disconnecting means.

(b) For fixed heating equipment of greater rating, the branch circuit switch or circuit breaker may, where readily accessible to the user of the equipment, serve as the disconnecting means.

(c) **Motor Driven Heating Equipment** — See Part H, Article 430.

(d) **Unit Switches as Disconnecting Means.** Unit switches with a marked "off" position, which are part of a fixed heater, that disconnect all ungrounded conductors may be used as the disconnecting means required by this Article when other means for disconnection are provided in the following types of occupancies:

(2) **Two-Family Dwellings.** In two-family dwellings, the other disconnecting means may be located either inside or outside of the apartment in which the fixed heater is installed.

(3) **Single-Family Dwellings.** In single-family dwellings, the service disconnecting means may be the other disconnecting means.

**424-20. Location of Disconnecting Means for Motor-Driven Heating Equipment.** A switch or circuit breaker which serves as the disconnecting means for a motor-driven heater having a motor more than  $\frac{1}{8}$  horsepower shall be located within sight of the motor controller or shall be capable of being locked in the open position.

**424-21. Controllers and Disconnecting Means.**

(a) Thermostats and thermostatically controlled switching devices which indicate an off position and which interrupt line current shall open all ungrounded conductors when the control device is in this off position.

(b) Thermostats and thermostatically controlled switching devices

which do not have an off position are not required to open all ungrounded conductors.

(c) Remote control thermostats do not need to meet the requirements of paragraphs (a) and (b). These devices shall not serve as the disconnecting means.

(d) Switching devices consisting of combined thermostats and manually controlled switches which serve both as controllers and disconnecting means shall:

(1) Open all ungrounded conductors when manually placed in the off position.

(2) Be so designed that the circuit cannot be energized automatically after the device has been manually placed in the off position.

**424-22. Switch and Circuit Breaker to be Indicating.** Switches and circuit breakers used as disconnecting means shall be of the indicating type.

#### **E 424-23. Overcurrent Protection.**

(a) Heating equipment, other than such motor-operated equipment as required by Article 430 to have additional overcurrent protection, shall be considered as protected against overcurrent when supplied by one of the circuits of Article 210 and in accordance with the requirements therein specified.

(c) Space heating equipment employing resistance type heating elements rated more than 48 amperes shall have the heating elements subdivided. Each subdivided circuit shall not exceed 48 amperes and shall be protected at not more than 60 amperes.

Where protection is within or on the heater enclosure, overcurrent protection shall be suitable for branch circuit protection meeting accessibility requirements of Section 424-65 but not meeting readily accessibility requirements of branch circuit protection.

#### **D. Marking of Heating Equipment**

**424-28. Name Plate.** Each unit of heating equipment shall be provided with a name plate giving the identifying name and the normal rating in volts and amperes, or in volts and watts.

Heating equipment intended for use on alternating current only or direct current only shall be marked to so indicate. The marking of equipment consisting of motors over  $\frac{1}{8}$  horsepower and other loads shall specify the rating of the motor in volts, amperes, and frequency, and the heating load in volts and watts or amperes.

**424-29. Marking of Heating Elements.** All heating elements which are replaceable in the field, and are a part of an electric heater shall be legibly marked with the ratings in volts and amperes, or in volts and watts.

#### **E. Cables and Panels**

**424-34. Heating Cable Construction.** Heating cable shall be furnished complete with factory assembled nonheating leads at least 7 feet in length.

**424-35. Marking of Heating Cables and Panels.** Each unit shall be marked with the identifying name or identification symbol, catalog number, ratings in volts and watts or amperes.

(a) **Heating Cables.** Each unit length of heating cable shall have a permanent legible marking on each nonheating lead located within 3 inches of the terminal end. The lead wire shall have the following color identification: 120 volt nominal, yellow; 208 volt nominal, blue; 240 volt nominal, red; and 277 volt nominal, brown.

(b) **Heating Panels.** Permanent marking in a location that is readily visible prior to building finishing shall be provided.

**E 424-36. Clearances of Wiring in Ceilings.**

(a) Wiring located above heated ceilings shall be spaced not less than 2 inches above the heated ceiling and shall be considered as operating at an ambient of 50°C. The ampacities of conductors shall be computed on the basis of the correction factors given in Note 15 to Tables 310-12 and 310-14.

*Exception: Wiring located above heated ceilings and over thermal insulation having a minimum thickness of 2 inches requires no correction for temperature.*

**E 424-37. Clearances of Branch Circuit Wiring in Walls.**

(a) Where located in exterior walls, wiring shall be located outside the thermal insulation.

(b) Where located in interior walls or partitions, wiring shall be considered as operating at an ambient of 40°C (104°F); and the ampacities of conductors shall be computed on the basis of the correction factors given in Note 15 to Tables 310-12 and 310-14.

**424-38. Area Restrictions.**

(a) Heating cables and panels shall not extend beyond the room or area in which they originate.

(b) Cables and panels shall not be installed in closets, over walls or partitions that extend to the ceiling, or over cabinets whose clearance from the ceiling is less than the minimum horizontal dimension of the cabinet to the nearest cabinet edge that is open to the room or area.

*Exception: Isolated single runs of cable may pass over partitions where they are embedded.*

(c) This provision shall not prevent the use of cable or panels in closet ceilings as low temperature heat sources to control relative humidity, provided they are used only in those portions of the ceiling which are unobstructed to the floor by shelves, or other permanent fixtures.

**424-39. Clearance from Other Objects and Openings.** Panel and cables shall be separated at least 8 inches from the edge of outlet boxes and junction boxes that are to be used for mounting surface lighting fixtures. Two inches shall be provided from recessed fixtures and their trims, ventilating openings and other such openings in room surfaces. Sufficient area shall be provided to assure that no heating cable or panel will be covered by other surface mounted lighting units.

**424-40. Splices.** Embedded cables may be spliced only where necessary and only by approved means, and in no case shall the length of the heating cable be altered.

**424-41. Installation of Heating Cables on Dry Board, in Plaster and on Concrete Ceilings.**

(a) Cables shall not be installed in walls.

*Exception: Isolated single runs of cable may run down a vertical surface to reach a dropped ceiling.*

(b) Adjacent runs of cable not exceeding  $2\frac{3}{4}$  watts per foot shall be installed not less than  $1\frac{1}{2}$  inches on centers.

(c) Heating cables may be applied only to gypsum board, plaster lath or other fire-resistant material. With metal lath or other electrical conducting surface, a coat of plaster shall be applied to completely separate the metal lath or conducting surface from the cable. (See also Section 424-41(f).)

(d) All the heating cables, the splice between the heating cable and nonheating leads, and 3 inch minimum of the nonheating lead at the splice shall be embedded in plaster or dry board in the same manner as the heating cable.

(e) The entire ceiling surface shall have a finish of thermally non-insulating sand plaster having a nominal thickness of  $\frac{1}{2}$  inch, or other specially approved non-insulating material applied according to specified thickness and directions.

(f) Cables shall be secured at intervals not exceeding 16 inches by means of approved stapling, tape, plaster, nonmetallic spreaders or other approved means. Staples or metal fasteners which straddle the cable shall not be used with metal lath or other electrical conducting surface.

(g) In dry board installations, the entire ceiling below the heating cable shall be covered with gypsum board not exceeding  $\frac{1}{2}$  inch thickness. The void between the upper layer of gypsum board, plaster lath or other fire resistant material and the surface layer of gypsum board shall be completely filled with thermally conducting non-shrinking plaster or other approved material of equivalent thermal conductivity.

(h) Cables shall be kept free from contact with metal or other electrical conducting surfaces.

(i) In dry board applications, cable shall be installed parallel to the joist, leaving a clear space centered under the joist of  $2\frac{1}{2}$  inches (width) between centers of adjacent runs of cable. Crossing of joist by cable shall be kept to a minimum and should be at the ends of the room. Surface layer of gypsum board shall be mounted so that the nails or other fastenings do not pierce the heating cable.

**424-42. Finished Ceilings.** Finished ceilings may be covered with paint, wallpaper or other approved surface finishes.

**424-43. Installation of Nonheating Leads of Cables and Panels.**

(a) Nonheating leads of cables and panels shall be installed in ac-



cordance with approved wiring methods from the junction box to a location within the ceiling. Such installations may be single conductors in approved raceways, single or multi-conductor Type UF, Type NMC, Type MI, or other approved conductors.

(b) Not less than 6 inches of nonheating leads shall be free within the junction box. The marking of the leads shall be visible in the junction box.

(c) Excess leads shall not be cut but shall be secured to the underside of the ceiling and embedded in plaster or other approved material, leaving only a length sufficient to reach the junction box with not less than 6 inches of free lead within the box.

**424-44. Installation of Panels or Cables in Concrete or Poured Masonry Floors.**

(a) Panels or heating units shall not exceed 33 watts per square foot of heated area or  $16\frac{1}{2}$  watts per linear foot of cable.

(b) The spacing between adjacent runs of cable shall not be less than 1 inch on centers.

(c) Cables shall be secured in place by nonmetallic frames or spreaders or other approved means while the concrete or other finish is applied.

Cables, units, and panels shall not be installed where they bridge expansion joints unless protected from expansion and contraction.

(d) Spacings shall be maintained between the heating cable and metal embedded in the floor.

*Exception: Grounded metal-clad cable may be in contact with metal embedded in the floor.*

(e) Leads shall be protected where they leave the floor by rigid metal conduit, electrical metallic tubing, or by other approved means.

(f) Bushings or approved fittings shall be used where the leads emerge within the floor slab.

**424-45. Tests During and After Installation.**

(a) Embedded cable installations shall be made with due care to prevent damage to the cable assembly and shall be inspected and approved before cables are covered or concealed.

(b) Cables should be tested for insulation resistance after plastering the ceiling or the pouring of floors.

**424-46. Panels — General.** Sections 424-46 to 48 cover only heating panels of less than 25 watts per square foot assembled together in the field to form a heating installation in one room or area using approved methods of interconnection. Such an installation shall be connected by a recognized wiring method.

**424-47. Panels to be Complete Units.** Panels shall be installed as complete units unless approved for field cutting in a recognized manner.

**424-48. Installation.** Panels shall be installed in an approved manner. Nails, staples, or other electrically conducting fasteners shall not be used where they penetrate current-carrying parts.

*Exception: Insulated fasteners may be used with systems for which they are recognized.*

#### F. Duct Heaters

**424-57. General.** The provisions in Part F shall apply to any heater mounted in the air stream of a forced air system where the air moving unit is not provided as an integral part of the equipment.

**424-58. Approval.** Heaters installed in an air duct shall be approved for the purpose and installed in the approved manner.

**424-59. Air Flow.** Means shall be provided to assure uniform and adequate air flow over the face of the heater.

Heaters installed near (within 4 feet) a fan outlet, elbows, baffle plates or other obstruction in duct work may require turning vanes, pressure plates or other devices on the inlet side of the duct heater to assure an even distribution of air over the face of the heater.

**424-60. Elevated Inlet Temperature.** Duct heaters intended for use with elevated inlet air temperature (such as heat pumps) shall be approved for the purpose and so marked.

**424-61. Installation of Duct Heaters with Heat Pumps and Air Conditioners.** Heat pumps and air conditioners having duct heaters closer than 4 feet to the heat pump or air conditioner shall be approved for such installation and so marked.

**424-62. Condensation.** Duct heaters used with air conditioners or other air cooling equipment which may result in condensation of moisture shall be approved for use with air conditioners.

**424-63. Fan Circuit Interlock.** Means should be provided to insure that the fan circuit is energized when the first heater circuit is energized.

**424-64. Limit Controls.** Each duct heater shall be provided with an integral approved automatic reset temperature limiting control or controllers to de-energize the circuit or circuits.

In addition, an integral independent supplementary control or controllers shall be provided in each duct heater which will disconnect a sufficient number of conductors to interrupt current flow. This device shall be manually resettable or replaceable.

**424-65. Location of Disconnecting Means.** Duct heater controller equipment shall be accessible with the disconnecting means installed at or within sight of the controller.

**E 424-66. Installation.** See NFPA Pamphlet No. 90B.

## ARTICLE 512 — RESIDENTIAL STORAGE GARAGES

**512-1. Definition.** A residential storage garage is a building or room in which not more than three vehicles of the types described in Section 511-1 are or may be stored, but which will not normally be used for other than minor service or repair operations on such stored vehicles.

**512-2. At or Above Grade.** Where the lowest floor is at or above adjacent ground or driveway level, and where there is at least one outside door at or below floor level, the garage area shall not be classed as a hazardous location.

**512-3. Below Grade.** Where the lowest floor is below adjacent ground or driveway level, the following shall apply:

(a) The entire area of the garage or of any enclosed space which includes the garage shall be classified as a Class I, Division 2 location up to a level 18 inches above the garage floor. All electrical equipment and wiring within such hazardous location shall conform to applicable provisions of Article 501.

(b) Wiring and equipment above the defined hazardous location shall conform to the requirements of this Code for nonhazardous locations.

(c) Adjacent areas in which hazardous vapors or gases are not likely to be released, and having floors elevated at least 18 inches above the garage floor, or separated therefrom by tight curbs or partitions at least 18 inches high, shall not be classed as hazardous.