

# National Electrical Code

1959



One Dollar

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**NATIONAL FIRE PROTECTION ASSOCIATION**

**INTERNATIONAL**

**60 Batterymarch Street, Boston 10, Mass.**

# NATIONAL FIRE PROTECTION ASSOCIATION

INTERNATIONAL

60 BATTERYMARCH STREET, BOSTON 10, MASS.

The National Fire Protection Association in the course of its fire safety activities issues many publications on all aspects of the subject. Standards similar to the National Electrical Code are published in pamphlet form (see inside back cover).

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Compilations of various NFPA standards are issued annually to keep them up to date in six volumes of the National Fire Codes as follows:

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Volume II. Combustible Solids, Dusts, Chemicals and Explosives.

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## ERRATA

Paragraph 240-7(a) on page 70-73:

"Note 9" should read "Note 10."

Table 400-11 on page 70-210:

Under headings Insulation and Outer Covering for Type SP-3, "Thermoplastic" should read "Rubber."

Section 400-15 on page 70-215:

In next to the last line of the Section, "18 to 26" should read "18 to 16."

Section 410-20 on page 70-222:

Add the following after Exception 2 and before the fine print note:

*Exception No. 3. Where temperatures do not exceed 60°C (140°F), Type T thermoplastic wire, Types TF and TFF fixture wire, Type R rubber-covered wire, and Types RF-1, RF-2, FF-1, FF-2 fixture wire may be used, including use in fixtures of decorative type on which lamps of not over 60-watt rating are used in connection with imitation candles.*

Table 430-146 on page 70-276:

In next to the last line of the fine print note under the heading of the Table, "sizes" should read "fuses."

Paragraph 501-16(f) on page 70-321:

"objectional" should read "objectionable."

Section 520-5 on page 70-364:

"40 per cent" should read "20 per cent."

# National Electrical Code

NFPA No. 70 - June 1959

This 1959 Edition of the National Electrical Code (NFPA No. 70) was adopted by the National Fire Protection Association at its 1959 Annual Meeting June 1-5, 1959. It replaces all previous editions.

The adoption of this edition followed the usual procedures of the NFPA, including the publication of the proposed text prior to the Annual Meeting for the review of all those interested. Following the publication of the Proposed Code (issued as Volume II of the 1959 Advance Reports) a number of editorial revisions were found desirable. Many of these revisions were occasioned by the fact that this 1959 Edition incorporates a new numbering system as well as containing many changes in substance. On pages 70-507 through 70-522 there is a Cross Index to the 1956 Edition; the numbers in bold face appearing in this cross index indicate those Sections in which there has been a principal change in substance in the 1959 as compared with the 1956 Edition.

This Code is purely advisory as far as the NFPA is concerned, but is widely used in law and for legal regulatory purposes.

## History

The National Electrical Code was originally drawn in 1897 as the result of the united efforts of various insurance, electrical, architectural and allied interests. This original Code was prepared by the National Conference on Standard Electrical Rules, composed of delegates from various interested national associations.

The National Conference was disbanded in 1911. Since then the National Fire Protection Association has been sponsor. The texts for editions up to 1947 were prepared by the NFPA Electrical Committee. In 1949 the NFPA Electrical Section was organized and the National Electrical Code Committee was created to supersede the Electrical Committee. Currently, proposed revisions are prepared by Panels of the National Electrical Code Committee, under the direction of the Electrical Correlating Committee.

This 1959 Edition of the National Electrical Code replaces all other previous editions, supplements, and printings dated 1897, 1899, 1901, 1903, 1904, 1905, 1907, 1909, 1911, 1913, 1915, 1918, 1920, 1923, 1925, 1926, 1928, 1930, 1931, 1933, 1935, 1937, 1940, 1942, 1943, 1947, 1949, 1951, 1953, 1954, 1955, 1956, 1957 and 1958.

### Other Printings and Adoptions

The 1959 National Electrical Code is also printed by the National Fire Protection Association in Volume V of the National Fire Codes. This Volume also includes a number of other NFPA Electrical Standards. As a feature of this printing, there is included an "Index to Electrical Provisions of NFPA Standards Other Than the National Electrical Code."

This 1959 Edition of the Code is also being submitted for approval by the American Standards Association in conformance with our usual practice. Previous editions of the Code have been adopted by the ASA and have been identified by their Code Symbol ASA C1, UDC 614.825.

The National Board of Fire Underwriters, in continuation of their long standing policy of cooperation with the NFPA in the distribution of successive editions of the National Electrical Code, is also publishing this 1959 Edition.

The Compson Code Company of Lansing, Michigan is also publishing this edition of the Code.

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## NATIONAL FIRE PROTECTION ASSOCIATION INTERNATIONAL

Executive Office: 60 Batterymarch St., Boston 10, Mass.

The National Fire Protection Association was organized in 1896 to promote the science and improve the methods of fire protection and prevention, to obtain and circulate information on these subjects and to secure the cooperation of its members in establishing proper safeguards against loss of life and property by fire. Its membership includes nearly two hundred national and regional societies and associations and seventeen thousand individuals, corporations, and organizations. Anyone interested may become a member; membership information is available on request.

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# National Electrical Code

NFPA No. 70

## ARTICLE 90—INTRODUCTION

### 90-1. Purpose.

(a) The purpose of this Code is the practical safeguarding of persons and of buildings and their contents from hazards arising from the use of electricity for light, heat, power, radio, signalling 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.

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

### 90-2. Scope.

(a) Covered. It covers the electric conductors and equipment installed within or on public and private buildings and other premises, including yards, carnival and parking lots, and industrial substations; also the conductors that connect the installations to a supply of electricity, and other outside conductors adjacent to the premises.

(b) Not Covered. It does not cover installations in mines, ships, railway cars, automotive equipment, or the installations or equipment employed by a railway, electric or communication utility in the exercise of its function as a utility, and located outdoors or in buildings used exclusively for that purpose.

90-3. Code Arrangement. Chapters 1, 2, 3 and 4 of the Code are of general application. Chapters 5, 6 and 7 apply to installations which involve special occupancies, special equipment or other special conditions. These chapters are supplementary to, or amendatory of, the general rules, and the latter apply under such circumstances except as so amended for the particular conditions. Chapter 8 governs installations of communication systems, and is independent of the preceding Chapters except as they may be specifically referred to. Some tables and examples are included in Chapter 9.

**90-4. Definitions.** Article 100 contains definitions of a number of terms that are used in two or more Articles. In general, terms used only in a single Article are defined in the Article concerned. For electrical terms not defined in the Code, refer to the American Standard Definitions of Electrical Terms, ASA C-42.

**90-5. Fundamental Rules.** Throughout the Code are paragraphs which state only fundamentals or objectives of safeguarding. These are followed by paragraphs setting forth the recognized methods and detail by which the purpose and intent of the fundamental may be satisfied. Accordingly, when employed, the rules stating a fundamental only will appear as the first paragraph of an Article or Section.

**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).

**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.

**90-9. Wiring Planning.**

(a) It is recommended that electrical engineers and others when drawing plans and specifications make provision for ample raceways for wiring, spaces for equipment, and allowances for future increases in the use of electricity. In laying out an installation for constant-potential systems, provision should be made for distribution centers located in easily accessible places for convenience and safety of operation.

(b) It is elsewhere provided in this Code that the number of wires and circuits confined in a single enclosure be varyingly restricted. It is strongly recommended that electrical engineers and others who are planning installations provide similar restrictions wherever practicable, to the end that the effects of breakdowns from short-circuits or grounds, even though resulting fire and similar damage are confined to wires, their insulation and enclosures, may not involve entire services to premises nor interruptions of essential and independent services.

**90-10. Revisions.** It is customary to revise this Code periodically to conform with developments in the art and the result of experience, and the latest edition of the Code should always be used.

## Chapter 1. General

### ARTICLE 100 — DEFINITIONS

General guides for this Article on Definitions include: (1) for simplicity, only definitions essential to the proper use of this Code are included; (2) only those terms used in two or more Articles are defined in full in Article 100, other definitions being defined in the individual Article where they apply; (3) in general, NEC definitions will be the same as definitions in the latest revision of ASA C42, "Definitions of Electrical Terms," and are so identified by an asterisk\*.

**\*Accessible:** (As applied to wiring methods.) Not permanently closed in by the structure or finish of the building; capable of being removed without disturbing the building structure or finish. (See "Concealed" and "Exposed.")

**\*Accessible:** (As applied to equipment.) Admitting close approach because not guarded by locked doors, elevation or other effective means. (See "Readily Accessible.")

**Appliance:** Appliances are current-consuming equipment, fixed or portable; for example, heating, cooking and small motor-operated equipment.

**Approved:** Acceptable to the authority enforcing this Code.

**\*Askarel:** A synthetic nonflammable insulating liquid which, when decomposed by the electric arc, evolves only nonflammable gaseous mixtures.

**\*Automatic:** Automatic means self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration. (See "Non-automatic.")

**\*Branch Circuit:** A branch circuit is that portion of a wiring system extending beyond the final overcurrent device protecting the circuit.

A device not approved for branch circuit protection such as a thermal cutout or motor overload protective device is not considered as the overcurrent device protecting the circuit.

**\*Branch Circuit — Appliance:** An appliance branch circuit is a circuit supplying energy to one or more outlets to which appliances are to be connected; such circuits to have no permanently connected lighting fixtures not a part of an appliance.

**Branch Circuit — General Purpose:** A branch circuit that supplies a number of outlets for lighting and appliances.

**Branch Circuit — Individual:** A branch circuit that supplies only one utilization equipment.

**Building:** A structure which stands alone or which is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors.

**\*Cabinet:** An enclosure designed either for surface or flush mounting, and provided with a frame, mat or trim in which swinging doors are hung.

**Circuit Breaker:** A device designed to open under abnormal conditions a current carrying circuit without injury to itself. The term as used in this Code applies only to the automatic type designed to trip on a predetermined overload of current.

**Communication Circuit:** A circuit which is part of a so-called central station system.

Such circuits include telephone, telegraph, fire and burglar alarms, watchman, and sprinkler supervisory circuits.

**\*Concealed:** Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them.

### **Conductor:**

**BARE:** A bare conductor is one having no covering or insulation whatsoever. (See "Conductor, Covered.")

**COVERED:** A covered conductor is one having one or more layers of non-conducting materials that are not recognized as insulation under the Code. (See "Conductor, Bare.")

**\*Connector, Pressure (Solderless):** A pressure wire connector is a device which establishes the connection between two or more conductors or between one or more conductors and a terminal by means of mechanical pressure and without the use of solder.

**\*Controller:** A device, or group of devices, which serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

**Cooking Unit, Counter Mounted:** An assembly of one or more domestic surface heating elements for cooking purposes designed for flush mounting in, or supported by, a counter, and which assembly is complete with inherent or separately mountable controls and internal wiring. (See "Oven, Wall-Mounted.")

**Current Limiting Overcurrent Protective Device:** (See Section 240-27.)

**\*Cutout Box:** An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper. (See "Cabinet.")

**\*Demand Factor:** The demand factor of any system, or part of a system, is the ratio of the maximum demand of the system, or part of a system, to the total connected load of the system, or of the part of the system under consideration.

**Device:** A unit of an electrical system which is intended to carry but not utilize electric energy.

**Disconnecting Means:** A device, or group of devices, or other means whereby the conductors of a circuit can be disconnected from their source of supply.

**Dry:** (See "Location — Dry.")

**\*Dustproof:** So constructed or protected that dust will not interfere with its successful operation.

**\*Dust-Tight:** So constructed that dust will not enter the enclosing case.

**Duty:**

**\*CONTINUOUS:** Continuous duty is a requirement of service that demands operation at a substantially constant load for an indefinitely long time.

**\*INTERMITTENT:** Intermittent duty is a requirement of service that demands operation for alternate intervals of (1) load and no load; or (2) load and rest; or (3) load, no load and rest.

**\*PERIODIC:** Periodic duty is a type of intermittent duty in which the load conditions are regularly recurrent.

**\*SHORT TIME:** Short time duty is a requirement of service that demands operation at a substantially constant load for a short and definitely specified time.

**\*VARYING:** Varying duty is a requirement of service that demands operations at loads, and for intervals of time, both of which may be subject to wide variation.

See Table 430-22 (a—Exception) for illustrations of various types of duty.

**\*Electric Sign:** A fixed or portable, self-contained electrically illuminated appliance with words or symbols designed to convey information or attract attention.

**\*Enclosed:** Surrounded by a case which will prevent a person from accidentally contacting live parts.

**Equipment:** A general term including material, fittings, devices, appliances, fixtures, apparatus and the like, used as a part of, or in connection with, an electrical installation.

**\*Explosion-Proof:** Enclosed in a case which is capable of withstanding an explosion of a specified gas or vapor which may occur within it, and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes or explosion of the gas or vapor within, and it must operate at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby.

**Exposed:** (As applied to live parts.) Exposed means that a live part can be inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated or insulated. (See "Accessible" and "Concealed.")

**\*Exposed:** (As applied to wiring method.) Exposed means not concealed.

**\*Externally Operable:** (As applied to equipment that is enclosed in a case or cabinet.) Capable of being operated without exposing the operator to contact with live parts.

**\*Feeder:** A feeder is the circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the branch circuit overcurrent device.

**\*Fitting:** An accessory such as a locknut, bushing or other part of a wiring system which is intended primarily to perform a mechanical rather than an electrical function.

**Garage:** A building or portion of a building in which one or more self-propelled vehicles carrying volatile, flammable liquid for fuel or power are kept for use, sale, storage, rental, repair, exhibition or demonstrating purposes, and all that portion of a building which is on or below the floor or floors in which such vehicles are kept and which is not separated therefrom by suitable cutoffs.

**\*Ground:** A ground is a conducting connection, whether intentional or accidental, between an electrical circuit or equipment and earth, or to some conducting body which serves in place of the earth.

**\*Grounded:** Grounded means connected to earth or to some conducting body which serves in place of the earth.

**\*Grounded Conductor:** A conductor which is intentionally grounded, either solidly or through a current limiting device.

**\*Grounding Conductor:** A conductor used to connect an equipment, device or wiring system with a grounding electrode or electrodes.

**\*Guarded:** Covered, shielded, fenced, enclosed or otherwise protected, by means of suitable covers or casings, barriers, rails or screens, mats or platforms, to remove the liability of dangerous contact or approach by persons or objects to a point of danger.

**Hazardous Locations:** See Article 500.

**Hoistway:** Any shaftway, hatchway, wall hole, or other vertical opening or space in which an elevator or dumb-waiter is designed to operate.

**Identified:** Identified, as used in this Code in reference to a conductor or its terminal, means that such conductor or terminal is to be recognized as grounded. See Article 200.

**\*Isolated:** Not readily accessible to persons unless special means for access are used.

**\*Lighting Outlet:** An outlet intended for the direct connection of a lampholder, a lighting fixture or a pendent cord terminating in a lampholder.

**Location:**

**DRY LOCATION:** A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

**DAMP LOCATION:** A location subject to a moderate degree of moisture, such as some basements, some barns, some cold storage warehouses, and the like.

**WET LOCATION:** A location subject to saturation with water or other liquids, such as locations exposed to weather, washrooms in garages, and like locations. Installations underground or in concrete slabs or masonry in direct contact with the earth shall be considered as wet locations.

**Low-Energy Power Circuit:** A circuit which is not a remote-control or signal circuit but which has the power supply limited in accordance with the requirements of Class 2 remote control circuits. See Article 725.

Such circuits include electric door openers and circuits used in the operation of coin operated phonographs.

**Multi-Outlet Assembly:** A type of surface or flush raceway designed to hold conductors and attachment plug receptacles, assembled in the field or at the factory.

**\*Non-automatic:** Non-automatic means that the implied action requires personal intervention for its control. (See "Automatic.")

As applied to an electric controller, non-automatic control does not necessarily imply a manual controller, but only that personal intervention is necessary.

**\*Outlet:** A point on the wiring system at which current is taken to supply utilization equipment.

**\*Outline Lighting:** An arrangement of incandescent lamps or gaseous tubes to outline and call attention to certain features such as the shape of a building or the decoration of a window.

**Oven, Wall-Mounted:** A domestic oven for cooking purposes designed for mounting in or on a wall or other surface.

**Panelboard:** A single panel or a group of panel units designed for assembly in the form of a single panel; including buses, and with or without switches and/or automatic over-current protective devices for the control of light, heat or power circuits of small individual as well as aggregate ca-

capacity; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front. (See "Switchboard.")

**Portable Appliance:** An appliance capable of being readily moved where established practice or the conditions of use make it necessary or convenient for it to be detached from its source of current by means of a flexible cord and attachment plug.

**\*Qualified Person:** One familiar with the construction and operation of the apparatus and the hazards involved.

**\*Raceway:** Any channel for holding wires, cables or bus-bars, which is designed expressly for, and used solely for, this purpose.

Raceways may be of metal or insulating material and the term includes rigid metal conduit, flexible metal conduit, electrical metallic tubing, underfloor raceways, cellular metal floor raceways, surface metal raceways, wireways and busways.

**\*Raintight:** So constructed or protected that exposure to a beating rain will not result in the entrance of water.

**\*Readily Accessible:** Capable of being reached quickly, for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See "Accessible.")

**\*Receptacle Outlet:** An outlet where one or more receptacles are installed.

**Remote-Control Circuit:** Any electrical circuit which controls any other circuit through a relay or an equivalent device.

**Sealable Equipment:** Equipment enclosed in a case or cabinet that is provided with means of sealing or locking so that live parts cannot be made accessible without opening the enclosure. The equipment may or may not be operable without opening the enclosure.

**Sealed (Hermetic Type) Refrigeration Compressor:** A mechanical compressor consisting of a compressor and a motor, both of which are enclosed in the same sealed housing, with no external shaft nor shaft seals, the motor operating in the refrigerant atmosphere.

**Service:** The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served.

**\*Service Cable:** Service conductors made up in the form of a cable.

**Service Conductors:** The supply conductors which extend from the street main, or from transformers to the service equipment of the premises supplied.

**Service Drop:** The overhead service conductors between the last pole or other aerial support and the first point of attachment to the building.

**Service-Entrance Conductors, Overhead System:** The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop.

**Service-Entrance Conductors, Underground System:** The service conductors between the terminals of the service equipment and the point of connection to the service lateral.

Where service equipment is located outside the building walls, there may be no service-entrance conductors, or they may be entirely outside the building.

**\*Service Equipment:** The necessary equipment, usually consisting of circuit-breaker or switch and fuses, and their accessories, located near point of entrance of supply conductors to a building and intended to constitute the main control and means of cutoff for the supply to that building.

**Service Lateral:** The underground service conductors between the street main, including any risers at a pole or other structure or from transformers, and the first point of connection to the service entrance conductors in a terminal box inside or outside the building wall. Where there is no terminal box, the point of connection shall be considered to be the point of entrance of the service conductors into the building.

**Service Raceway:** The rigid metal conduit, electrical metallic tubing, or other raceway, that encloses the service entrance conductors.

**Setting: (Of circuit-breaker.)** The value of the current at which it is set to trip.

**Show-Window:** A show-window is any window used or designed to be used for the display of goods or advertising material, whether it is fully or partly enclosed or entirely open at the rear, and whether or not it has a platform raised higher than the street floor level.

**Sign:** See "Electric Sign."

**Signal Circuit:** Any electrical circuit which supplies energy to an appliance which gives a recognizable signal.

Such circuits include circuits for door bells, buzzers, code-calling systems, signal lights, and the like.

**Special Permission:** The written consent of the authority enforcing this Code.

### Switches:

**\*GENERAL USE SWITCH:** A switch intended for use as a switch in general distribution and branch circuits. It is rated in amperes and is capable of interrupting its rated current at its rated voltage.

**GENERAL USE SNAP SWITCH:** A form of general use switch so constructed that it can be installed in flush device boxes, or on outlet box covers, or otherwise used in conjunction with wiring systems recognized by this Code.

**AC GENERAL USE SNAP SWITCH:** A form of general use snap switch suitable only for use on alternating current circuits for controlling the following:

(a) Resistive and inductive loads (including electric discharge lamps) not exceeding the ampere rating at the voltage involved.

(b) Tungsten filament lamp loads not exceeding the ampere rating at 120 volts.

(c) Motor loads not exceeding 80 per cent of the ampere rating of the switches at the rated voltage.

All AC general use snap switches are marked "AC" in addition to their electrical rating.

**AC-DC GENERAL USE SNAP SWITCH:** A form of general use snap switch suitable for use on either direct or alternating current circuits for controlling the following:

(a) Resistive loads not exceeding the ampere rating at the voltage involved.

(b) Inductive loads not exceeding one-half the ampere rating at the voltage involved, except that switches having a marked horsepower rating are suitable for controlling motors not exceeding the horsepower rating of the switch at the voltage involved.

(c) Tungsten filament lamp loads not exceeding the ampere rating at 125 volts, when marked with the letter "T".

AC-DC general use snap switches are not generally marked AC-DC, but are always marked with their electrical rating.

**\*ISOLATING SWITCH:** A switch intended for isolating an electric circuit from its source of power. It has no interrupting rating and is intended to be operated only after the circuit has been opened by some other means.

**MOTOR CIRCUIT SWITCH:** A switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

**Switchboard:** A large single panel, frame, or assembly of panels, on which are mounted, on the face or back or both, switches, overcurrent and other protective devices, buses and usually instruments. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. (See "Panelboard.")

**Thermal Cutout:** An overcurrent protective device which contains a heater element in addition to and affecting a renewable fusible member which opens the circuit. It is not designed to interrupt short circuit currents.

**Thermal Protection:** (As applied to motors.) The words, "Thermal Protection," appearing on the name plate of a motor indicate that the motor is provided with a thermal protector.

**Thermal Protector:** (As applied to motors.) An inherent overheating protective device which is responsive to motor current and temperature and which, when properly applied to a motor, protects the motor against dangerous overheating due to overload or failure to start.

**\*Ventilated:** Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes or vapors.

**\*Voltage (of a circuit):** The greatest effective difference of potential between any two conductors of the circuit concerned.

On various systems such as 3-phase 4 wire, single phase 3 wire and 3 wire direct current, there may be various circuits of various voltages.

**Voltage to Ground:** In grounded circuits the voltage between the given conductor and that point or conductor of the circuit which is grounded; in ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

**Watertight:** So constructed that moisture will not enter the enclosing case.

**\*Weatherproof:** So constructed or protected that exposure to the weather will not interfere with its successful operation.

**Wet:** (See "Location.—Wet.")

## ARTICLE 110 — GENERAL

**110-1. Scope.** This Article includes provisions applicable generally in installations of electric wiring and equipment.

**110-2. Approval.** The conductors and equipment required or permitted by this Code shall be acceptable only when approved. See definition of "Approved" in Article 100.

**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, whether the current is supplied by a battery, generator, transformer, rectifier, or a thermopile.

**110-6. Conductor Gauges.** Conductor sizes are given in American Wire Gauge (AWG).

**110-7. Conductors.** Conductors normally used to carry current shall be of copper unless otherwise provided in this Code. Where conductor sizes are given in this Code, they 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 wiring methods recognized as suitable are included in this Code. The recognized methods of wiring may be installed in any type of building or occupancy except as otherwise provided in 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.

**110-10. Deteriorating Agencies.** Unless approved for the purpose, no conductors or equipment shall be located in damp or wet location; 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.

**110-11. Mechanical Execution of Work.** Electrical equipment shall be installed in a neat and workmanlike manner.

**110-12. 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.

**110-13. 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 the devices and fittings, such as pressure connectors, splices, solder lugs, solder, and fluxes employed where making connections, should be suitable for the material of the conductor.

**110-14. Splices.** Conductors shall be spliced or joined with approved splicing devices 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 on the conductors.

**110-15. Working Space about Electrical Equipment.** Suitable working space shall be provided and maintained about all electrical equipment.

(a) **Horizontal Dimensions.** Except as elsewhere required or permitted in this Code, the horizontal dimensions of the working space in front of live parts, operating at not more than 600 volts, which must be handled while alive, shall not be less than:

(1) For parts of more than 150 volts to ground on one side of the working space and no bare live or grounded parts on the other side of the working space, 2½ feet.

(2) For parts of more than 150 volts to ground on one side of the working space and bare live or grounded parts on the other side of the working space, 4 feet.

(3) For parts of 150 volts or less to ground on one side of the working space and no bare live or grounded parts on the other side of the working space, 1½ feet.

(4) For parts of 150 volts or less to ground on one side of the working space and bare live or grounded parts on the other side of the working space, 2½ feet.

For higher voltages, see Article 710.

(b) **Clear Spaces.** Working spaces adjacent to exposed live parts shall not be used as passageways, or for storage.

(c) **Elevation of Equipment.** The elevation of the equipment at least 8 feet above ordinarily accessible working platforms, usually affords protection at least equivalent to that provided by the horizontal clearances of Paragraph 110-15(a), and may be used in lieu thereof.

**110-16. Guarding of Live Parts.** Except as elsewhere required, or permitted by this Code, exposed live parts of electrical equipment operating at 50 volts or more shall be guarded against accidental contact by enclosure or by locating the equipment as follows:

(a) In a room or enclosure which is accessible only to qualified persons:

(b) On a suitable balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons;

(c) Elevated 8 feet or more above the floor;

(d) So that it will be protected by a guard rail if the equipment operates at 600 volts or less.

For motors see Section 430-132. For voltages above 600 V. see Article 710.

**110-17. 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. For hazardous locations see Articles 500-517 inclusive. For motors see Sections 430-11 and 430-14.

**110-18. Light and Power from Railway Conductors.** Circuits for lighting and power shall not be connected to any system containing trolley wires with a ground return, except in electric railway cars, car houses, power houses, or passenger and freight stations operated in connection with electric railways.

**110-19. 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. In order that a reasonable factor of safety may be provided, the following table of insulation resistances is suggested as a guide where the insulation is subjected to test:

(a) For circuits of No. 14 or No. 12 wire, 1,000,000 ohms. For circuits of No. 10 or larger conductor, a resistance based upon the allowable current-carrying capacity of conductors as fixed in Tables 310-12 through 310-15 as follows:

25 to 50 amperes, inclusive .....	250,000 ohms
51 to 100 amperes, inclusive .....	100,000 ohms
101 to 200 amperes, inclusive .....	50,000 ohms
201 to 400 amperes, inclusive .....	25,000 ohms
401 to 800 amperes, inclusive .....	12,000 ohms
Over 800 amperes .....	5,000 ohms

(b) The above values are to be determined with all switchboards, panelboards, fuseholders, switches, receptacles and overcurrent devices in place.

(c) Where climatic conditions are such that the wiring or equipment is exposed to excessive humidity, it may be necessary to modify the foregoing provisions.

**110-20. Marking.** The maker's name, trademark, or other identification symbol 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.

## Chapter 2. Wiring Design and Protection

### 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, 250-8, 503-13, and 517-6.*

*Exception No. 2. Continuous identification throughout a length of a conductor between terminals is not required for certain conductors under Paragraphs 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.

**200-4. Circuits Derived from Auto-Transformers.** Branch circuits as described in Article 210 shall not be supplied through auto-transformers (transformers in which a part of the winding is common to both primary and secondary circuits) unless the system supplied has an identified grounded conductor which is solidly connected to a similar identified grounded conductor of the system supplying the auto-transformer.

**200-5. Unidentified Circuits.**

(a) Two-wire branch circuits and multi-wire AC circuits may be tapped from the ungrounded conductors of circuits having identified grounded neutrals. Switching

devices in such circuits shall have a pole in each ungrounded conductor, except as provided for motor controllers in Section 430-84 and for heating equipment in Section 422-29.

(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.

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

(a) Insulated conductors of No. 6 or smaller, except conductors of Type MI cable, shall have an outer identification of white or natural gray color as specified in 310-2(f). The grounded conductors of Type MI cable shall be identified by distinctive marking at the terminals during the process of installation.

(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.

(c) Where, on a 4-wire delta-connected secondary, the midpoint of one phase is grounded to supply lighting and similar loads, that phase conductor having the higher voltage to ground shall be indicated by painting or other effective means at any point where a connection is to be made if the neutral conductor is present.

#### **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.*

The foregoing permits the use of two-wire cable having one black and one white conductor on two-wire circuits tapped from the outside legs of a three-wire system or any two conductors of a multi-wire system where the identified conductor of the two-wire cable is rendered permanently unidentified at terminals.

*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.

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

(a) **Device Terminals.** All devices provided with terminals for the attachment of conductors and intended for connection to more than one side of the circuit shall have terminals properly marked for identification except as follows:

*Exception No. 1. Marking may be omitted where the electrical connection of a terminal intended to be connected to the grounded conductor is clearly evident.*

*Exception No. 2. Single-pole Devices.* Devices to the terminals of which only one side of the line is connected need not have terminals marked for identification.

*Exception No. 3. Panelboards and Devices.* The terminals of lighting panelboards and of devices having a normal current rating of over 30 amperes need not be marked for identification, except as required in Paragraph 200-10(b) for polarized receptacles for attachment plugs and polarized attachment-plugs.

(b) **Plugs and Receptacles.** Two-wire polarized receptacles for attachment plugs and polarized attachment plugs shall have the terminal intended for connection to the grounded conductor marked for identification.

*Exception No. 1. Two-wire attachment plugs, unless of the polarity type, need not have their terminals marked for identification.*

*Exception No. 2. Three-wire Receptacles and Plugs. Three-wire attachment-plug receptacles and three-wire attachment plugs, one terminal of which may be used for the connection of a grounding conductor, shall have such terminal indicated in a manner differing from that specified in Section 200-9. The other terminals need not be 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.

(f) **Portable Appliances.** The terminals of portable appliances need not be marked for identification.

## 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.

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

Busways .....	Section 364-8
Cranes and Hoists .....	Section 610-42
Elevators, Dumbwaiters and Escalators ....	Section 620-61
Infra-red Industrial Heating Equipment ....	Section 422-11
Inductive and Dielectric Heat Generating Equipment .....	Article 665
Instruments .....	Section 384-22
Motion Picture Studios and Similar Locations .....	Article 530
Motors and Motor Controllers .....	Article 430
Organs .....	Section 650-6
Remote-Control, Low-Energy Power, Low- Voltage Power and Signal Circuits .....	Article 725
Signs and Outline Lighting .....	Section 600-6
Sound Recording and Reproduction .....	Section 640-6
Space Heating; Panel and Embedded Types ..	Article 422
Systems over 600 Volts .....	Article 710
Systems under 50 Volts .....	Article 720
Theatres and Assembly Halls ....	Sections 520-41, 520-52, and 520-62
Welders .....	Article 630
X-ray Equipment .....	Section 660-3

**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 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. Multi-Wire Branch Circuits.** Branch circuits recognized by this Article may be installed as multi-wire circuits. A multi-wire branch circuit as referred to herein is a circuit consisting of two or more ungrounded conductors having a potential difference between them, and an identified grounded conductor having equal potential difference between it and each ungrounded conductor of the circuit and which is connected to the neutral conductor of the system.

**210-5. Color Code.** Where installed in raceways, as open work, or as concealed knob-and-tube work, the conductors of multi-wire 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; five-wire circuits — one black, one white, one red, one blue, one yellow. Where more than one multi-wire 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 green color unless it be bare. Conductors having a green covering shall not be used for other than grounding purposes.

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

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

(a) The voltage to ground on branch circuits supplying lampholders, fixtures, or standard receptacles of 15-ampere or less rating shall not exceed 150 volts, except as follows:

*Exception No. 1. In industrial establishments the voltage of branch circuits which supply only lighting fixtures that are equipped with mogul-base screw-shell lampholders or with lampholders of other types approved for the applica-*

tion, mounted not less than eight feet from the floor, which do not have switch control as an integral part of the fixture shall not exceed 300 volts to ground;

*Exception No. 2. In industrial establishments, office buildings, schools, stores, and public and commercial areas of other buildings, such as hotels or transportation terminals, the voltage of branch circuits which supply only the ballasts for electric discharge lamps in permanently installed fixtures mounted not less than eight feet from the floor, which do not have manual switch control as an integral part of the fixture shall not exceed 300 volts to ground;*

*Exception No. 3. For infra-red industrial heating appliances as described in Section 422-11;*

*Exception No. 4. In railway properties as described in Section 110-18;*

**(b) Voltage Between Conductors — Dwellings.** In dwelling occupancies, 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.*

**210-7. Grounding Receptacles.** Where a grounding receptacle is installed as specified in Sections 210-22(b) and 250-59, to provide grounding facilities required in Section 250-45, the branch circuit or branch circuit raceway shall include or provide a grounding conductor to which the grounding contacts of the grounding receptacle shall be connected. The metal armor of armored cable or a metallic raceway is acceptable as a grounding conductor.

**210-8. Heavy-Duty Lampholders.** Heavy-duty lampholders referred to in this Article shall include lampholders rated at not less than 750 watts.

*Exception: Admedium lampholders rated at 660 watts shall be considered to be heavy duty type.*

## B. Specific Requirements

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

(a) **Carrying Capacity.** Shall have a carrying capacity 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 a carrying capacity at least 70 per cent of the current-carrying capacity of the ungrounded conductors and shall not be smaller than No. 10.*

Cable assemblies with the neutral conductor smaller than the ungrounded conductor 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 50 ampere circuits or 15 amperes for circuits rated less than 50 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 Paragraph 410-65 (b-2); or,*

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

(c) *Infra-red lamp industrial heating appliances.*

(d) *Tap conductors supplying electric ranges, wall-mounted electric ovens and counter-mounted electric cooking units from 50 ampere branch circuits shall be no longer than necessary for servicing.*

*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.*

See Tables 400-9(b) and 402-4.

*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 Paragraphs 210-21(a-c).*

**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 carrying capacity of the circuit conductor.

*Exception: Tap Conductors and Fixture Wires. Tap conductors, fixture wires and cords as permitted in Paragraph 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.

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

(a) **Lampholders.** Lampholders when connected to circuits having a rating of over 20 amperes shall be of the heavy-duty type.

(b) **Receptacles.** 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
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 receptacles rated at 15 or 20 amperes and installed in circuits of less than 150 volts between con-

ductors shall be approved for use only on potentials less than 150 volts. Grounding receptacles rated at 15 amperes and installed in circuits of 151 to 300 volts between conductors shall be approved for use only on potentials not less than 151 volts.

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.

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

**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) **Dwelling Type Occupancies.** In every kitchen, 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 usable wall space is more than six feet, measured horizontally, from an outlet in that space including any usable 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.

Where an outlet is installed in the kitchen at the sink location this outlet shall be of the grounding type.

Only grounding type outlets shall be installed in laundry rooms, open porches, breezeways, basements, cellars, work shops, garages, on the exterior surfaces of outside walls or in like locations where the outlet may supply equipment used by persons standing on the ground or on grounded conductive materials. These outlets shall be installed in accordance with Section 210-7.

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

(a) **Motor-Operated Appliances.** The total load shall not exceed 80 per cent of the branch circuit rating if motor-operated appliances are supplied. Where circuit supplies only motor-operated appliance loads, Article 430 is to apply.

(b) **Other Loads.** The total load shall not exceed the branch circuit rating, and shall not exceed 80 per cent of the rating where in normal operation the load will continue for long periods such as store lighting and similar loads. 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: Range Loads. See Note 5 of Table 220-5.*

**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.

(b) **30-Ampere Branch Circuits.** Fixed lighting units with heavy duty lampholders in other than dwelling occupancies; or appliances in any occupancy. The rating of any one portable appliance shall not exceed 24 amperes.

(c) **50-Ampere Branch Circuits.** Fixed lighting units with heavy duty lampholders in other than dwelling occupancies; or fixed cooking appliances; or fixed range and water heater; or infra-red lamp industrial heating appliances.

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

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

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

(Type R, RW, RU, RUW, RH-RW, SA, T, TW, RH, RUH, RHW, RHH and THW conductors in raceway or cable.)

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

## ARTICLE 215 — FEEDERS

**215-1. Scope.** This Article deals with the sizes of conductors in the feeders needed to supply power to the loads as calculated under Article 220.

**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. 8 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 to 7 of Chapter 9.

**215-3. Voltage Drop.** The size of the feeder conductors should be such that voltage drop up to the final distribution point for the load as computed by Section 220-4 will not be more than 3 per cent for power or heating loads, and not more than 1 per cent for lighting loads or combined lighting, heating and power loads.

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

**215-5. Common Neutral Feeder.** A common neutral feeder may be employed for two or three sets of 3-wire feeders, or two sets of 4-wire or 5-wire feeders. When in metal enclosures, all conductors of feeder circuits employing a common neutral feeder shall be contained within the same enclosure as provided in Section 300-20.

**215-6. Diagram of Feeders.** If required by the authority enforcing this Code, a diagram showing feeder details shall be supplied previous to installation. This diagram should show: Area in square feet; load (before applying demand-factors); demand-factors selected; computed load (after applying demand-factors); and the size of conductors.

## 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.

**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 of a branch circuit will continue for long periods of time, such as store lighting and similar loads, the minimum unit loads specified in this Section shall be increased by 25 per cent.

### (a) General Lighting Load.

**(1) In Listed Occupancies.** In the occupancies listed in Table 220-2(a), a load of not less than the unit load specified shall be included for each square foot of 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, apartment or area involved, and the number of floors; not including open porches, garages in connection with dwelling occupancies, nor unfinished spaces and unused spaces in dwellings unless adaptable for future use.

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.

**Table 220-2(a). General Lighting Loads by Occupancies**

Type of Occupancy	Unit Load per Sq. Ft. (Watts)
Armories and Auditoriums	1
Banks	2
Barber Shops and Beauty Parlors	3
Churches	1
Clubs	2
Court Rooms	2
*Dwellings (Other Than Hotels)	3
Garages — Commercial (storage)	1½
Hospitals	2
*Hotels, including apartment houses without provisions for cooking by tenants	2
Industrial Commercial (Loft) Buildings	2
Lodge Rooms	1½
Office Buildings	5
Restaurants	2
Schools	3
Stores	3
Warehouses Storage	¼
In any of the above occupancies except single- family dwellings and individual apartments of multi-family dwellings:	
Assembly Halls and Auditoriums	1
Halls, Corridors, Closets	½
Storage Spaces	¼

\*All receptacle outlets of 15-ampere or less rating in single-family and multi-family dwellings and in guest rooms of hotels [except those connected to the receptacle circuits specified in Paragraph 220-3(b)] may be considered as outlets for general illumination, and no additional load need be included for such outlets. The provisions of Paragraph 220-2(b) shall apply to all other receptacle outlets.

(2) **In Other Occupancies.** In other occupancies, a load of not less than the unit load specified in Paragraph 220-2(b) shall be included for each outlet.

(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  
 Outlets supplying heavy-duty lampholders.. 5 amperes  
 ‡Other outlets ..... 1½ amperes

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

‡This provision not applicable to receptacle outlets connected to the circuits specified in Paragraph 220-3(b) nor to receptacle-outlets provided for the connection of fixed lighting units to facilitate servicing and replacement.

(c) **Exceptions.** The minimum load for outlets specified in Paragraph 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.*

*Exception No. 2. Show-Window Lighting. For show-window lighting a load of not less than 200 watts for each linear foot of show-window, measured horizontally along its base, may be allowed in lieu of the specified load per outlet.*

*Exception No. 3. Multi-Outlet Assemblies. Where fixed multi-outlet assemblies are employed, each five feet or fraction thereof of each separate and continuous length shall be considered as one outlet of not less than 1½ ampere capacity; except in locations where a number of appliances are likely to be used simultaneously, when each one foot or fraction thereof shall be considered as an outlet of not less than 1½ amperes. The requirements of this Section are not applicable to dwellings or the guest rooms of hotels.*

*Exception No. 4. Telephone Exchanges. Shall be waived for manual switchboards and switching frames in telephone exchanges.*

(d) **Existing Installations.** Additions to existing installations shall conform to the following:

(1) **Dwelling Occupancies.** New circuits or extensions to existing circuits may be determined in accordance with Paragraphs 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 Paragraph 220-2(a).

(2) **Other Than Dwelling Occupancies.** When adding new circuits or extensions to existing circuits in other than dwelling occupancies, the provisions of Paragraphs 220-2(a or b) shall apply.

**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 Paragraph 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 Paragraph 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 Paragraph 220-3(b).

See Examples No. 1, 1a, 1b, 1c, and 4, Chapter 9.

(b) **Receptacle Circuits, Dwelling Occupancies.** For the small appliance load in kitchen, laundry, pantry, dining-room and breakfast-room of dwelling occupancies, two or more 20 ampere branch circuits in addition to the branch circuits specified in Paragraph 220-3(a) shall be provided for all receptacle outlets (other than outlets for clocks) in these rooms, and such circuits shall have no other outlets.

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 Paragraphs 220-3(a or b), branch circuits shall be as required by other sections of the Code.

**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 Paragraphs 220-4(g and 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.

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

Type of Occupancy	Portion of Lighting Load to which Demand Factor Applies (wattage)	Feeder Demand Factor
Dwellings — other than Hotels	First 3000 or less at	100%
	Next 3001 to 120,000 at	35%
	Remainder over 120,000 at	25%
*Hospitals	First 50,000 or less at	40%
	Remainder over 50,000 at	20%
*Hotels — including Apartment Houses without provision for cooking by tenants	First 20,000 or less at	50%
	Next 20,001 to 100,000 at	40%
	Remainder over 100,000 at	30%
Warehouses (Storage)	First 12,500 or less at	100%
	Remainder over 12,500 at	50%
All Others	Total Wattage	100%

\*The demand factors of this Table shall not apply to the computed load of sub-feeders to areas in hospitals and hotels where entire lighting is likely to be used at one time; as in operating rooms, ballrooms, or dining rooms.

**(b) Show-Window Lighting.** For show-window lighting, a load of not less than 200 watts shall be included for each linear foot of show-window measured horizontally along its base.

(c) **Motors.** For motors, a load computed according to the provisions of Sections 430-6, 430-22, 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; except that the load thus obtained shall be multiplied by 140 per cent for 5-wire, 2-phase systems. 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 Section 220-5. For 3-wire DC or single-phase AC, 4-wire 3-phase and 5-wire 2-phase 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, 2, 3, 4 and 5, Chapter 9.

(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. Paragraph 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) **Non-coincident 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.

(g) **Small Appliances.** The computed branch circuit load for receptacle outlets in other than dwelling occupancies, for which the allowance is not more than  $1\frac{1}{2}$  amperes per outlet, may be included with the general lighting load and subject to the demand factors in Paragraph 220-4(a).

## Dwelling Occupancies

The requirements in following Paragraphs 220-4 (h-k) apply to dwelling type occupancies and are supplemental to the preceding Paragraphs 220-4 (a-g).

**(h) Small Appliances — Dwelling Occupancies.** In single-family dwellings, in individual apartments of multi-family dwellings having provisions for cooking by tenants, and in each hotel suite having a serving pantry, a feeder load of not less than 3,000 watts shall be included for small appliances (portable appliances supplied from receptacles of 15 or 20 ampere rating) in pantry and breakfast-room, dining room, kitchen and laundry. Where the load is subdivided through two or more feeders, the computed load for each shall include not less than 3,000 watts for small appliances. These loads may be included with the general lighting load and subject to the demand factors in Paragraph 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.

Where a number of single-phase ranges are supplied by a 3-phase, 4-wire feeder, the current shall be computed on the basis of the demand of twice the maximum number of ranges connected between any two phase wires.

See Example 7, Chapter 9.

**(j) Fixed Appliances (Other than Ranges, Air Conditioning Equipment or Space Heating Equipment).** Where four or more fixed appliances other than electric ranges, air conditioning equipment or space heating equipment are connected to the same feeder in a single or multi-family dwelling, 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 in dwelling occupancies, 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 1 3/4 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 3 1/2 kw Rating)	COLUMN C (3 1/2 kw to 8 3/4 kw Rating)
1	8 kw	80%	80%
2	11 kw	75%	65%
3	14 kw	70%	55%
4	17 kw	66%	50%
5	20 kw	62%	45%
6	21 kw	59%	43%
7	22 kw	56%	40%
8	23 kw	53%	36%
9	24 kw	51%	35%
10	25 kw	49%	34%
11	26 kw	47%	32%
12	27 kw	45%	32%
13	28 kw	43%	32%
14	29 kw	41%	32%
15	30 kw	40%	32%
16	31 kw	39%	28%
17	32 kw	38%	28%
18	33 kw	37%	28%
19	34 kw	36%	28%
20	35 kw	35%	28%
21	36 kw	34%	26%
22	37 kw	33%	26%
23	38 kw	32%	26%
24	39 kw	31%	26%
25	40 kw	30%	26%
26-30	{15 kw plus 1 kw}	30%	24%
31-40	{for each range}	30%	22%
41-50	{25 kw plus 3/4}	30%	20%
51-60	{kw for each}	30%	18%
61 & over	{range}	30%	16%

Note 1. Over 12 kw to 21 kw ranges all of same kw rating. For ranges, individually rated more than 12 kw but not more than 21 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 21 kw ranges of unequal ratings. For ranges individually rated more than 12 kw and of different ratings but none exceeding 21 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 3. Generally, the demand for commercial ranges should be based on the maximum nameplate rating.

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 for one wall-mounted oven or one counter-mounted cooking unit shall be the nameplate rating of the appliance.

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

Number of Dryers	Demand Factor (per cent)
1	100
2	100
3	100
4	100
5	80
6	70
7	65
8	60
9	55
10	50
11-13	45
14-19	40
20-24	35
25-29	32.5
30-34	30
35-39	27.5
40 up	25

The demand factor permitted in Section 220-4(j) will not apply when this Table is used.

**220-7. Optional Calculation for One-Family Residence.** For a one-family residence served by a 115/230 volt, 3-wire, 100 amp. or larger service where the total load is supplied by one feeder or one set of service entrance conductors, the following percentages may be used in lieu of the method of determining feeder (and service) loads detailed in Section 220-4.

**Table 220-7**  
**Optional Calculation for One-Family Residence**

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%

All other load shall include 1500 watts for each 20 ampere appliance outlet 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) of Chapter 9.

## 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 or plant to the premises to be served.

For over 600 volts see Section 230-100.

**230-2. Number of Services to a Building.** In general, a building shall be supplied through only one set of service conductors, except as follows:

*Exception No. 1. Fire Pumps. Where a separate service is required for fire pumps.*

*Exception No. 2. Emergency Lighting. Where a separate service is required for emergency lighting purposes.*

*Exception No. 3. Multiple-Occupancy Buildings.*

*(a) By special permission, in multiple-occupancy buildings where there is no available space for service equipment accessible to all the occupants.*

*(b) Buildings of multiple occupancy may have two or more separate sets of service-entrance conductors which are tapped from one service drop, or two or more sub-sets of service-entrance conductors may be tapped from a single set of main service conductors. See Section 230-75 and Paragraph 230-90(a-4).*

*Exception No. 4. Capacity Requirements. Where capacity requirements make multiple services desirable.*

*Exception No. 5. Buildings of Large Area. By special permission, where more than one service drop is necessary due to the area over which a single building extends.*

*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.** No overhead service, no underground service and no service from an

isolated plant shall supply one building from another, unless such 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 have an insulating covering which will normally withstand exposure to atmospheric and other conditions of use and which shall prevent any detrimental leakage of current to adjacent conductors, objects, or the ground.

*Exception. Grounded Conductor. In the case of service conductors that have a nominal voltage to ground of not more than 300 volts, a grounded service conductor without an insulating covering may be installed.*

For Service Drops — See Section 230-22.

For Service Entrance Conductors — See Section 230-40.

For Underground Services — See Section 230-30.

**230-5. Size of Service Conductors.** Service conductors shall have adequate current-carrying capacity to safely conduct the current for the loads supplied without a temperature rise detrimental to the insulating 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 230-41.

## 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) Conductors in multiple-conductor cables shall be rubber-covered or thermoplastic-covered except a grounded conductor may be uninsulated where the maximum voltage to ground of any conductor is not over 300 volts.

(b) All open individual conductors shall be rubber-covered, thermoplastic-covered, or weatherproof-covered.

**230-23. Minimum Size of Service Drop Conductors.** Conductors in service drops shall be not smaller than No. 10 when of soft copper, or No. 12 when of medium or hard-drawn copper.

Conductors to a building from a pole on which a meter or service switch is installed shall be considered as a service drop and installed accordingly.

**230-24. Clearances 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, except where the voltage between conductors does not exceed 300 and the roof cannot be readily walked upon, the clearance may be not less than 3 feet.

(b) **Clearance from Ground.** Conductors shall have a clearance of not less than 10 feet from the ground or from any platform or projection from which they might be reached. See Section 730-18.

(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.

For clearances of conductors of over 600 volts see National Electrical Safety Code. (Available from Superintendent of Documents, Government Printing Office, Washington 25, D. C.)

**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 to Buildings.** The point of attachment of a service drop to a building shall be not less than 10 feet above finished grade and shall be at a height to permit a minimum clearance for service drop conductors of 10 feet above sidewalks and 18 feet above driveways, alleys and public roads. The attachment should not be more than 30 feet above ground unless a greater height is necessary for proper clearance. Where it is impractical to get the point of attachment high enough to obtain the

above clearances, the clearance over residential driveways may be reduced, provided a clearance of 10 feet over sidewalks, 18 feet over alleys and public roads, and a minimum of 12 feet over residential driveways is obtained.

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

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

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

(a) Underground conductors up to the point of attachment to service equipment shall be covered with rubber, cambric, thermoplastic, paper or other approved insulating material, except:

*Exception No. 1. Uninsulated grounded neutral conductors of aluminum or copper may be installed underground when part of an approved cable assembly.*

*Exception No. 2. Bare grounded neutral 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.

**230-31. Size of Underground Service Conductors.** Same as required for service entrance conductor. See Section 230-41.

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

(a) **In the Ground.** Underground service conductors shall be protected against physical damage by being installed in duct, conduit, in cable of one or more conductors approved for the purpose, or by other approved means. See Paragraph 310-1(b).

(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 unless the service switch is installed on a switchboard, in which case a bushing shall be provided which, except where lead-covered conductors are used, shall be of the insulating type.

**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.

**230-34. Grounding Raceways and Cable Sheaths.** See Section 230-63.

**230-35. Termination at Service Equipment.** See Section 230-42, Exception No. 3, and Section No. 230-53.

### **E. Service-Entrance Conductors**

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

(a) Service-entrance conductors extending along the exterior of or entering buildings shall be rubber-covered or thermoplastic-covered if in raceways, or in cables approved for the purpose, except a grounded conductor may be uninsulated where the maximum voltage to ground of any conductor is not over 300 volts.

Where on the exterior of the building only, the conductors may be weatherproof-covered.

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

**230-41. Size of Service-Entrance Conductors.** Service-entrance conductors, including underground services, shall have a current-carrying capacity sufficient to carry the load as determined by Article 220 and in accordance with Tables 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 Section 220-4, the service shall be a minimum of 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 a current-carrying capacity in conformity with Paragraph 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 Paragraph 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, may be installed as separate conductors, in cables approved for the purpose, or enclosed in rigid conduit, or, for circuits not exceeding 600 volts, in electrical metallic tubing or as busways.

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 in conduit or duct placed under at least two inches of concrete beneath a building, or buried in two inches of brick masonry or in concrete within a wall, 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.

**230-47. Individual Open Conductors Exposed to Weather.** Individual open conductors exposed to weather shall be supported on insulators, racks, brackets, or other means, placed at intervals not exceeding 9 feet and separating the conductors at least 6 inches from each other and 2 inches from the surface wired over; or at intervals not exceeding 15 feet if they maintain the conductors at least 12 inches apart. For 300 volts or less, conductors may have a separation of not less than 3 inches where supports are placed at intervals not exceeding  $4\frac{1}{2}$  feet and conductors are not less than 2 inches from the surface wired over.

**230-48. Individual Open Conductors Not Exposed to Weather.** Individual open conductors not exposed to the weather may be supported on glass or porcelain knobs placed at intervals not exceeding  $4\frac{1}{2}$  feet and maintaining the conductors at least one inch from the surface wired over and a separation of at least  $2\frac{1}{2}$  inches between conductors.

**230-49. Individual Conductors Entering Buildings.** Individual conductors entering buildings shall pass inward and upward through slanting noncombustible, nonabsorptive insulating tubes, or shall enter through roof bushings, and shall conform to the provisions of Article 324. Drip loops shall be formed on the conductors before entering tubes.

**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. Service Head.** Service raceways shall be equipped with a raintight service head. Service cables, unless continuous from pole to service equipment or meter, shall be equipped with an approved raintight service head, or be formed in a gooseneck, taped and painted or taped with self-sealing weather-resistant thermoplastics and held securely in place by its connection to service-drop conductors below the gooseneck or by a fitting approved for the purpose. 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 below the level of the service head or the termination of service-entrance cable sheaths. Where service heads are used, conductors of opposite polarity shall be brought out through separately bushed holes.

**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.

**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, except that where the service disconnecting means is mounted on a switchboard having exposed bus-bars on the back, the raceway may be equipped with a bushing which shall be of the insulating type unless lead-covered conductors are used.

**230-54. Grounding Service Raceways and Cable Armor.** See Section 230-63.

## G. Service Equipment

**230-60. Hazardous Locations.** Service equipment installed in hazardous locations shall comply with the requirements of Articles 500 to 517 inclusive.

**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 equipments, 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

**230-62. Guarding.** Live parts of service equipment shall be enclosed so that they will not be exposed to accidental contact, unless mounted on a switchboard, panelboard or controller accessible to qualified persons only and located in a room or enclosure free from easily ignitable material. Such an enclosure shall be provided with means for locking or sealing doors giving access to live parts.

**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.** Service raceways, 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

### 230-70. General.

(a) **Disconnection from Service Conductors.** Means shall be provided for disconnecting all conductors in the building 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 wall. See Section 230-45.

(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 be a manually-operable switch or circuit-breaker of the air-break or oil-immersed type, equipped with a handle or other suitable operating means, positively identified and marked, for mechanical operation by the hand.

A push-button type of electrical remote control may be used in addition to the manual handle.

(e) **Externally Operable.** An enclosed service switch or circuit-breaker shall be externally operable. See definition Article 100.

It is recommended that where the current of a single circuit, or group of circuits, is separately metered, as in apartment house installations, devices be installed in a convenient location to control each separately metered installation, such devices being enclosed and the switch or circuit-breaker being externally operable.

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

(g) **Switch and Circuit-Breaker.** It may consist of not more than six switches or six circuit-breakers in a common enclosure, or in a group of separate enclosures. Two or three single pole switches or breakers, capable of individual operation, may be installed on multi-wire circuits, one pole for each ungrounded conductor, as one multi-pole disconnect [where applicable, see Paragraph 230-70(h)] 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.

(h) **Simultaneous Openings.** The disconnecting means shall simultaneously disconnect all ungrounded conductors, except for 3-wire direct-current or single-phase circuits or multi-wire circuits that do not supply polyphase motors.

(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 disconnecting means shall have a rating not less than the load to be carried determined in accordance with Article 220. In general the service disconnecting means shall have a rating of not less than 60 amperes where a switch is used, and not less than 50 amperes where a circuit-breaker is used, except:

*Exception No. 1. For single family residences with an initial load of 10 kw or more computed in accordance with Section 220-4, the service equipment shall have a rating of not less than 100 amperes.*

*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 Paragraph 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.

**230-73. Connections Ahead of Disconnecting Means.** Service fuses, meters, high-impedance shunt circuits (such as potential coils of meters, etc.), supply conductors for time switches, surge protective capacitors, instrument transformers, lighting arresters and circuits for emergency systems, fire pump equipment, fire and sprinkler alarms as

provided in Section 230-94, may be connected on the supply side of the disconnecting means. Taps from service conductors to supply time switches, circuits for emergency lighting, etc., shall be installed in accordance with Section 230-44 and disconnecting means shall be installed as required in Section 230-70.

For detailed service provisions for fire alarm, sprinkler supervisory, or watchman systems, see appropriate Standards of the National Fire Protection Association.

**230-74. Safeguarding Emergency Supply.** Where an emergency supply is provided to feed the conductors controlled by the service disconnecting means, the disconnecter shall be of a design that will open all ungrounded conductors from the usual supply before connection is made to the emergency supply, unless agreed upon arrangements have been made for parallel operation and suitable automatic control equipment provided. See Article 700.

**230-75. Multiple-Occupancy.** In a multiple-occupancy building, each occupant shall have access to his disconnecting means. A multiple-occupancy 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. Multiple-occupancy buildings 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.

**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 on residential property 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**

**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 carrying capacity of the conductor, except as follows:

*Exception No. 1. For motor-starting currents, ratings in conformity with Sections 430-52, 430-62, or 430-63 may be used.*

*Exception No. 2. Circuit-breakers may have a setting in conformity with Sections 240-5, Exception No. 2 and 240-7.*

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

*Exception No. 4. In a multiple occupancy building each occupant shall have access to his overcurrent protective devices. A multiple occupancy building 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. Multiple occupancy buildings 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(b) 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 Paragraph 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.

**230-93. Protection of Specific Circuits.** Where necessary to prevent tampering, an automatic overcurrent device protecting service conductors supplying only a specific load such as a water heater, may be locked or sealed where located so as to be accessible.

**230-94. Relative Location of Overcurrent Device and Other Service Equipment.** The overcurrent device shall protect all circuits and devices except as follows:

(a) The service switch may be placed on the supply side.

(b) High impedance shunt circuits (such as potential coils of meters, etc.), lightning arresters, surge protective capacitors, instrument transformers, may be connected and installed on the supply side of the service disconnecting means as permitted in Section 230-73.

(c) Circuits for emergency supply and time switches may be connected on the supply side of the service overcurrent device where separately provided with overcurrent protection.

(d) Circuits used only for the operation of fire alarm, other protective signalling systems, or the supply to fire pump equipment may be connected on the supply side of the service overcurrent device where separately provided with overcurrent protection.

(e) Meters for alternating current service not in excess of 600 volts, provided the service contains a grounded conductor and the cases and enclosures of such meters are grounded by connection to the grounded circuit conductor (see Section 250-61) or to a common system and equipment ground electrode (see Section 250-54); or meters for alternating current service not containing a grounded service conductor and not in excess of 300 volts.

## **L. Services Exceeding 600 Volts**

**230-100. Scope.** Service conductors and equipment used on circuits exceeding 600 volts shall comply with the ap-

plicable provisions of the preceding sections of this Article and with the following Sections which are additions to or modifications of the preceding Sections.

Secondary conductors, not the primary conductors, are regarded as constituting the service conductors to the building proper in the following cases:

1. Where step-down transformers are located outdoors.
2. Where step-down transformers are located in a separate building from the one served.
3. Where step-down transformers are located in the building served in a transformer vault conforming to the requirements of Sections 450-41 to 450-48, and under the sole control of the supply company.

In no case will the provisions of this Article apply to equipment not directly connected to service conductors, and consequently will not apply to equipment in vaults under the sole control of the supply company.

### **230-101. Service-Entrance Conductors.**

(a) **Conductor Size.** Service conductors shall be not smaller than No. 6 unless in cable. Conductors in cable shall be not smaller than No. 8.

(b) **Wiring Methods.** In locations accessible to other than qualified persons service-entrance conductors of more than 600 volts shall be installed in rigid conduit, or as multiple conductor cable approved for the purpose.

(c) **Open Work.** If open work is employed where not accessible to other than qualified persons, the service conductors shall be rigidly supported on glass, porcelain or other insulators approved for the purpose, which will keep them at least 8 inches apart, except at terminals of equipment. They shall be not less than 2 inches from the surfaces wired over and for voltages exceeding 2,500 not less than 3 inches.

(d) **Supports.** Service conductors and their supports, including insulators, shall have strength and stability sufficient to insure maintenance of adequate clearance with abnormal currents in case of short circuits.

(e) **Guarding.** Open wires shall be guarded where accessible to unqualified persons.

(f) **Service Cable.** Where cable conductors emerge from a metal sheath or raceway, the insulation of the conductors

shall be protected from moisture and physical damage by a pothead or other approved means.

**(g) Draining Raceways.** Unless conductors specifically approved for the purpose are used, raceways embedded in masonry, or exposed to the weather, or in wet locations shall be arranged to drain.

**(h) Over 15,000 Volts.** Where the voltage exceeds 15,000 volts between conductors they shall enter a transformer vault conforming to the requirements of Section 450-41 to 450-48.

**(i) Enclosed by Concrete or Brick.** Conductors in conduit or duct and enclosed by concrete or brick not less than 2 inches thick shall be considered outside the building.

**230-102. Warning Signs.** High voltage signs shall be posted where unauthorized persons might come in contact with live parts.

**230-103. Disconnecting Means.** The circuit-breaker or the alternatives for it specified in Section 230-106 will constitute the disconnecting means required by Section 230-70.

**230-104. Isolating Switches.** Isolating switches shall be provided as follows:

**(a) Air-break isolating switches** shall be installed between oil switches or air or oil circuit-breakers used as service switches and the supply conductor, except where such equipment is mounted on removable truck panels or metal-enclosed switchgear units which cannot be opened unless the circuit is disconnected, and which, when removed from the normal operating position, automatically disconnect the circuit-breaker or switch from all live parts.

**(b) When the fuses used with non-automatic oil switches** in accordance with Section 230-106 are of a type that may be operated as a disconnect switch, they may serve as the isolating switch when they completely disconnect the oil switch and all service equipment from the source of supply.

**(c) Air-break isolating switches** shall be accessible to qualified attendants only. They shall be arranged so that a grounding connection on the load side can readily be made. Such grounding means need not be provided for duplicate isolating switches, if any, installed and maintained by the supply company.

**230-105. Equipment in Secondaries.** Where the primary service equipment supplies one or more transformers whose secondary windings feed a single set of mains, and the primary circuit-breaker is manually operable from a point outside the transformer vault, the disconnecting means and overcurrent protection may be omitted from the secondary circuit, provided the setting of the primary circuit-breaker is such as to protect the secondary circuit. In all other cases the secondary circuit shall be provided with a disconnecting means and overcurrent protection as required by this Article.

"Manually operable" calls for a mechanical, rather than only electrical, linkage between the circuit-breaker and the point of operation, and refers to both the opening and closing operations.

**230-106. Overcurrent Protection.** Overcurrent devices shall be provided in accordance with the following:

(a) **In Vault or Consisting of Metal-Enclosed Switchgear.** Where the service equipment is installed in a transformer vault meeting the provisions of Sections 450-41 to 450-48, or consists of metal-enclosed switchgear, the requirements for overcurrent protection and disconnecting means may be fulfilled by the following:

(1) On circuits of 15,000 volts or less, oil-filled or other fuses of suitable rating and type may be used without switch or circuit-breaker provided they may be operated as a disconnecting means.

(2) Where the voltage is 25,000 or less, a non-automatic oil switch, an air load-interrupter switch, or other approved switches, capable of interrupting the rated circuit load and suitable fuses may be used.

(3) Automatic-trip circuit-breakers may also be used under the limitations outlined in Paragraphs 230-106(a) (1) and (2). Where these limitations are exceeded, an automatic-trip circuit-breaker shall be installed in compliance with the requirements of Paragraph 230-106(b).

(4) Where the voltage is 15,000 or less, a switch capable of interrupting the no-load current of the transformer and suitable fuses may be used, provided the switch is interlocked with a circuit-breaker in the secondary circuit of the transformer so that the switch cannot be opened when the circuit-breaker is closed.

(5) Vaults shall conform to the provisions of Sections 450-41 to 450-48.

(6) Metal-enclosed switchgear shall consist of a substantial steel structure and a steel enclosure of thickness not less than 1/8 inch, over the sides and top. The enclosure shall be furnished as an integral part of the equipment. Where installed over a wood floor, suitable protection thereto shall be provided.

(b) Where the service equipment is not in a vault or metal enclosure, requirement for the overcurrent protection and disconnecting means may be fulfilled by the following:

(1) Circuits of not over 25,000 volts, air load-interrupter switches or other approved switches, capable of interrupting the rated circuit load may be used with suitable fuses on a pole outside the building.

(2) On circuits of any voltage, an automatic trip circuit-breaker of suitable current-carrying and interrupting capacity with an overcurrent unit in each ungrounded conductor and so arranged that the operation of any one device will open all ungrounded conductors may be used. The circuit-breaker shall be located as near as possible to where the service conductors enter the building, or else on a pole outside the building.

(c) Fuses. Fuses used as permitted in Paragraphs 230-106(a) and (b) shall have an interrupting rating at least equal to the maximum short-circuit current possible in the circuit.

(d) Circuit-Breakers. Circuit-breakers shall be free to open in case the circuit is closed on an overload. This can be accomplished by means such as trip-free breakers or by multiple breakers having an operating handle per pole. A service circuit-breaker shall indicate clearly whether it is open or closed, and shall be capable of interrupting the maximum short-circuit current to which it may be subjected.

**230-107. Lightning Arresters.** Lightning arresters installed in accordance with the requirements of Article 280 shall be placed on each ungrounded overhead service conductor on the supply side of the service equipment, when called for by the authority enforcing this Code.

## 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.

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

Equipment	Article No.
Appliances .....	422
Capacitors .....	460
Cranes and Hoists .....	610
Elevators, Dumbwaiters and Escalators .....	620
Emergency Systems .....	700
Generators .....	445
Inductive and Dielectric Heat Generating Equipment .....	665
Machine Tools .....	670
Motion Picture Studios and Similar Locations ..	530
Motors .....	430
Organs .....	650
Over 600 Volts .....	710
Remote-Control, Low-Energy Power, Low- Voltage Power and Signal Circuits .....	725
Services .....	230
Signs and Outline Lighting .....	600
Sound Equipment .....	640
Switchboards and Panelboards .....	384

Equipment	Article No.
Theaters and Assembly Halls .....	520
Transformers .....	450
Welders .....	630
X-ray Equipment .....	660

**240-4. Time-Delay Overcurrent Protection.** Overcurrent devices installed in residential occupancies on circuits of 20 amperes or less shall be of the time-delay type.

**240-5. Overcurrent Protection of Conductors.** Conductors shall be protected in accordance with their current-carrying capacities, as given in Tables 310-12 through 310-15, except as follows:

*Exception No. 1. Rating of Overcurrent Protection. When the standard ampere ratings and settings of overcurrent devices do not correspond with the allowable current-carrying capacities of conductors, the next higher standard rating and setting may be used.*

*Exception No. 2. Adjustable-Trip Circuit-Breakers. Adjustable-trip circuit-breakers of the thermal trip, magnetic time-delay trip or instantaneous-trip types shall be set to operate at not more than 125 per cent of the allowable current-carrying capacity of the conductor.*

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, sizes No. 16 or No. 18, and tinsel cord shall be considered as protected by 20-ampere overcurrent devices except as provided in Section 620-61. Fixture wires of the sizes permitted for taps in Paragraph 210-19(c-2) shall be considered as protected by the overcurrent protection of the 30-ampere 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.*

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

*Exception No. 4. Motor Circuits. The conductors supplying motors and motor-operated appliances shall be considered as protected by the overcurrent protective devices specified in Sections 430-32, 430-34, 430-52, 430-53 and 430-62.*

*Exception No. 5. Remote Control. Except as provided in Article 725, the conductors of the control circuits of remote-control switches shall be considered as protected from overcurrent by overcurrent devices that are not of the so-called time-lag type and are rated or set at not more than 500 per cent of the carrying capacity of the remote-control conductors, as specified in Tables 310-12 through 310-15.*

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

(a) If the allowable current-carrying capacity of a conductor does not correspond to the rating of a standard-size fuse, the next larger size or rating of fuse may be used.

(b) Standard ampere ratings for fuses are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000 and 6000. Fuses with ampere rating other than the standard rating listed may be used when they are of an ampere rating smaller than those included in the standard list.

(c) Plug fuses and fuse holders 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.

(d) The screw-shell of plug-type fuse holders shall be connected to the load side of the circuit.

#### **240-7. Non-Adjustable-Trip Circuit-Breakers.**

(a) Non-adjustable-trip circuit-breakers, except as otherwise permitted in Note 9 to Tables 310-12 through 310-15 shall be rated in accordance with the current-carrying capacity of the conductor. When the allowable current-carrying capacity of a conductor does not correspond to the rating of a standard-size circuit-breaker, the next larger size or rating of circuit-breaker may be used.

(b) Standard ampere ratings for circuit breakers are 15, 20, 30, 40, 50, 60, 70, 100, 125, 150, 175, 200, 225, 250, 300, 350, 400, 500, 600, 700 and 800.

**240-8. Thermal Devices.** Thermal cutouts, thermal relays and other devices not designed to open short-circuits, shall not be used for protection of conductors against overcurrent due to short-circuits or grounds but may be used to protect motor branch circuit conductors from overload if protected in accordance with Section 430-40.

**240-9. Feeders at Supply Stations.** Each conductor of a constant-potential circuit entering or leaving a supply station, except grounded neutral conductors, shall be protected from excessive current by a circuit-breaker, or by an equivalent device of approved design. Such protective devices shall be located as near as practicable to the point where the conductors enter or leave the building. For the outgoing circuits not connected with other sources of power, the protective devices may be placed on the supply side of transformers or similar devices.

**240-11. Ungrounded Conductors.**

(a) An overcurrent device (fuse or overcurrent trip unit of a circuit-breaker) shall be placed in each ungrounded conductor. The number and position of the overcurrent units such as trip coils or relays shall be as given in Table 240-28.

(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 3-wire direct-current or single-phase circuits, or for each ungrounded conductor of lighting or appliance branch circuits connected to 4-wire three-phase systems, or 5-wire 2-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 in Multiple.** For the protection of conductors having allowable carrying capacities exceeding the rated capacity of the largest approved cartridge type fuse in Paragraph 240-23 (a-1), such cartridge fuses arranged in multiple may be used, provided as few fuses as possible are used and the fuses are of the same type, characteristics, and rating, and provided the fuseholder terminals are mounted on a single continuous pair of bus-bars, or have an equivalent arrangement that will eliminate any potential difference between the terminals of the fuses.

## B. Location

**240-15. Location in Circuit.** Overcurrent devices shall be located at the point where the conductor to be protected receives its supply, except as follows:

*Exception No. 1. Service Conductors.* An overcurrent protective device for service conductors may be located as specified in Section 230-91.

*Exception No. 2. Smaller Conductor Protected.* Where the overcurrent device protecting the larger conductors also protects the smaller conductors in accordance with Tables 310-12 through 310-15.

*Exception No. 3. Branch Circuits.* Taps to individual outlets and circuit conductors supplying a single household electric range shall be considered as protected by the branch circuit overcurrent devices when in accordance with the requirements of Sections 210-19 and 210-20.

*Exception No. 4. Taps.* A conductor tapped from a feeder shall be considered as properly protected from overcurrent when installed in accordance with Sections 210-25, 364-8 and 430-58.

*Exception No. 5. Taps Not Over 10 Feet Long.* Where (1) the smaller conductor has a current-carrying capacity of not less than the sum of the allowable current-carrying capacities for the conductors of the one or more circuits or loads supplied, and (2) the tap is not over 10 feet long and does not extend beyond the switchboard, panelboard, or control devices which it supplies, and (3) except at the point

*of connection to the feeder, the tap is enclosed in conduit, electrical metallic tubing, or in metal gutters when not a part of the switchboard or panelboard.*

*Exception No. 6. Taps Not Over 25 Feet Long. Where the smaller conductor has a current-carrying capacity at least one-third that of the conductor from which it is supplied, and provided the tap is suitably protected from physical damage, is not over 25 feet long, and terminates in a single circuit-breaker or set of fuses which will limit the load on the tap to that allowed by Tables 310-12 through 310-15. Beyond this point the conductors may supply any number of circuit-breakers or sets of fuses.*

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

- (a) Readily accessible, except as provided in Section 230-91 for service equipment and Section 364-11 for busways.
- (b) Not exposed to physical damage.
- (c) Not in the vicinity of easily ignitable material.

### C. Enclosures

**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 switchboards, 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.

(d) **Rosettes.** Fuses shall not be mounted in rosettes.

### D. Disconnecting and Guarding

**240-18. Disconnection of Fuses and Thermal Cutouts Before Handling.** Disconnecting means shall be provided on the

supply side of all fuses or thermal cutouts in circuits of more than 150 volts to ground and cartridge fuses in circuits of any voltage, where accessible to other than qualified persons, so that each individual circuit containing fuses or thermal cutouts can be independently disconnected from the source of electrical energy, except as provided in Section 230-73 and except that a single disconnecting means may be used to control a group of circuits each protected by fuses or thermal cutouts under the conditions described in Section 430-112.

**240-19. Arcing or Suddenly-Moving Parts.** Arcing or suddenly-moving parts shall comply with the following:

(a) **Location.** Fuses and circuit-breakers shall be so located or shielded that persons will not be burned or otherwise injured by their operation.

(b) **Suddenly-Moving Parts.** Handles or levers of circuit-breakers, and similar parts which may move suddenly in such a way that persons in the vicinity are liable to be injured by being struck by them, shall be guarded or isolated.

### **E. Plug Fuses and Fuseholders**

**240-20. Plug Fuses of the Edison-Base Type.** Plug fuses of the Edison-base type shall conform to the following:

(a) **Classification.** Plug fuses of this type shall be classified at not over 125 volts, 0 to 30 amperes.

(b) **Live Parts.** Fuses and fuseholders when installed and assembled together shall have no live parts exposed.

(c) **Marking.** Plug fuses of 15 amperes rating or less shall be distinguished from those of larger rating by an hexagonal opening in the cap through which the mica or similar window shows, or by some other prominent hexagonal feature such as the form of the top or cap itself, or an hexagonal recess or projection in the top or cap.

**240-21. Fuseholders for Plug Fuses.** Fuseholders for plug fuses of 30 amperes or less shall not be installed unless they comply with Section 240-22 or are made to comply with Section 240-22 by the insertion of an adapter.

**Note:** The provisions of Section 240-21 shall become effective on January 1, 1961.

**240-22. Plug Fuses and Fuseholders of Type S.** Where Type S plug fuses are to be used as the overcurrent device required by this Code, the fuses and fuseholders shall conform to the following requirements:

(a) **Classification.** Plug fuses and fuseholders of Type S shall be classified at not over 125 volts; 0 to 15 amperes, 16 to 30 amperes.

(b) **Fuses Usable Only in Fuseholders of the Same Classification.** Fuses of the 16 to 30 ampere classification shall not be usable with fuseholders or adapters of the 0 to 15 ampere classification.

(c) **Fuseholders and Adapters.** Fuses, fuseholders, and adapters shall be so designed that a fuse other than a Type S fuse cannot be used in a fuseholder or adapter designed for Type S fuses.

(d) **Tamperability.** Fuses, fuseholders and adapters shall be so designed as to be subject to tampering or bridging only with difficulty.

(e) **Adapters to be Non-Removable.** Fuse adapters shall be so designed that when once inserted in a fuseholder they cannot be removed.

(f) **Interchangeability.** Fuses, fuseholders and adapters of various manufacturers shall be interchangeable with each other, and the plugs with adapters shall be suitable for use in the Edison-base type fuseholder.

(g) **Plug Type.** Fuses and fuseholders shall be of the plug type.

(h) **Ampere Rating.** Each fuse, fuseholder and adapter shall be marked with its ampere rating.

(i) **Marking.** Fuses of the 0 to 15 ampere rating shall be distinguished from those of larger rating by an hexagonal opening in the cap through which the mica or similar window shows, or some other prominent hexagonal feature such as the form of the top or cap itself, or an hexagonal recess or projection in the top or cap.

## **F. Cartridge Fuses and Fuseholders**

**240-23. Cartridge Fuses and Fuseholders.** Cartridge fuses and fuseholders shall conform to the following:

**(a) Classification.**

(1) 0-600 ampere cartridge fuses and fuseholders shall be classified as regards current and voltage as follows:

Not over 250 volts Amperes	Not over 600 volts Amperes
0- 30	0- 30
31- 60	31- 60
61-100	61-100
101-200	101-200
201-400	201-400
401-600	401-600

(2) 601-6000 ampere cartridge fuses and fuseholders shall be classified at 600 volts as follows:

601 - 1200 amperes
1201 - 1600
1601 - 2000
2001 - 3000
3001 - 4000
4001 - 6000

There are no 250 volt ratings over 600 amperes, but 600 volt fuses may be used for lower voltages.

(b) **Non-interchangeable.** 0-6000 ampere cartridge fuses and fuseholders shall be so designed that it will be impossible to put a fuse of any given class into a fuseholder which is designed for a current lower, or voltage higher, than that of the class to which it belongs. Fuseholders for current limiting fuses shall not permit insertion of fuses which are not current limiting.

(c) **Marking.** Fuses shall be plainly marked with the ampere rating, voltage rating, interrupting rating when greater than 10,000 amperes, current-limitation where it applies, and the name or trademark of the maker. The marking shall be either by direct printing on the fuse barrel or by means of an attached label.

## **G. Link Fuses and Fuseholders**

**240-24. Link Fuses and Fuseholders.** Link fuses and fuseholders shall be used only by special permission and shall conform to the following:

(a) **Mounting.** Link fuses shall be mounted on approved fuseholders.

(b) **Dimensions.** Link fuses and fuseholders shall have the following dimensions in inches:

<u>Amperes Capacity</u>	<u>Minimum Separation of Nearest Metal Parts of Opposite Polarity</u>	<u>Minimum Break Distance</u>
Not over 125 volts 601-1500	1½	1½
Not over 250 volts 601-1500	2¾	2

For 3-wire systems, link fuses, and fuseholders shall have the break distance required for circuits of the potential of the outside wires, except that in 125-250-volt systems with grounded neutral the fuses and fuseholders in 2-wire, 125-volt branch circuits may have the spacing specified for not over 125 volts.

(c) **Spacing.** A space shall be maintained between the fuse terminals of link fuses of the same polarity of at least ½ inch for voltages up to 125, and of at least ¾ inch for voltages from 126 to 250. This is the minimum distance allowable and greater separation shall be provided where practicable.

(d) **Material.** Contact surfaces or tops of link fuses shall be of copper or aluminum having good electrical connections with the fusible part of the strip.

(e) **Minimum Rating.** Link fuses and fuseholders shall be used only in sizes rated at more than 600 amperes, and only by special permission.

(f) **Marking.** Link fuses shall be stamped with 80 per cent of the maximum current which they can carry indefinitely.

## H. Circuit-Breakers

**240-25. Circuit-Breakers.** Circuit-breakers shall conform to the following:

(a) **Method of Operation.** In general, circuit-breakers shall be capable of being closed and opened by hand without employing any other source of power, although normal

operation may be by other power such as electrical, pneumatic, and the like. Large circuit-breakers which are to be closed and opened by electrical, pneumatic, or other power shall be capable of being closed by hand for maintenance purposes and shall also be capable of being tripped by hand under load without the use of power.

**(b) Type of Operation.** Circuit-breakers of the 0 to 30 ampere class should be of the time-delay type.

**(c) Injury to Operator.** Circuit-breakers shall be arranged and mounted so that their operation is not likely to injure the operator.

**(d) Indication.** Circuit-breakers shall indicate whether they are in the open or closed position.

**(e) Non-Tamperable.** An air circuit-breaker, used for the branch circuits described in Article 210, shall be of such design that any alteration of its trip point (calibration), or in the time required for its operation, will be difficult.

**(f) Marking.** Circuit-breakers shall be marked with their rating in such a manner that the marking will be visible after installation. Each circuit-breaker intended to interrupt fault currents greater than 10,000 amperes shall have its interrupting rating shown on the label or on the product.

**(g) Non-interchangeable Circuit-Breakers.** Circuit-breakers used for lighting and appliance branch circuits in residential and other occupancies except where the conditions of maintenance and supervision assure that overcurrent protective devices and branch circuit wiring will be maintained at proper rating, shall be non-interchangeable in accordance with the following provisions:

**(1)** Circuit-breakers rated within the range of 0-250 volts, alternating current and not more than 100 amperes shall be classified as regards current as follows:

Amperes

0-20

21-50

51-100

**(2)** Such circuit-breakers or their multiple mounting and bussing means shall be so arranged that it will be difficult, after a circuit-breaker has been installed, to replace it with a breaker of a higher ampere classification.

(3) Such circuit-breakers of higher than 0-20 ampere classification shall be difficult to install in the spare spaces which are left for future additions.

Note: The provisions of Paragraph 240-25(g) shall become effective on July 1, 1960.

**240-27. Current Limiting Overcurrent Protective Device.** A current limiting overcurrent protective device is a device which, when interrupting a specified circuit, will consistently limit the short-circuit current in that circuit to a specified magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

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### Notes to Table 240-28

\*1. An overcurrent unit may consist of a series overcurrent tripping device or the combination of a current transformer and a secondary overcurrent tripping device. Either two or three secondary overcurrent tripping devices may be used with three current transformers on a 3-phase system similar to those shown in Diagrams 15 and 18.

\*\*2. When three current transformers are used instead of three series overcurrent tripping devices shown in Diagrams 13, 15, 17 and 18, the secondary tripping devices may consist of three secondary overcurrent tripping devices or two secondary overcurrent tripping devices with a residual current tripping device of a lower range. See Diagram 16.

3. Where standard devices are not available with three or four overcurrent units as required in the Table, it is permissible to substitute two overcurrent units and one fuse where three overcurrent units are called for, two overcurrent units and two fuses where four overcurrent units are called for. The fuse or fuses are to be placed in the conductors not containing an overcurrent unit. This practice, however, of substituting fuses for overcurrent units is to be discouraged for obvious reasons.

# Table 240-28. Number of Overcurrent Units, Such as Trip Coils or Relays, for Protection of Circuits

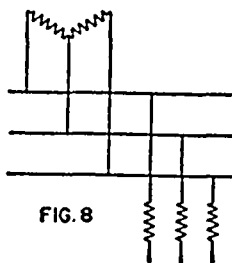
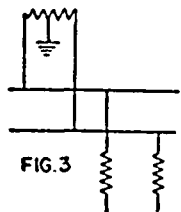
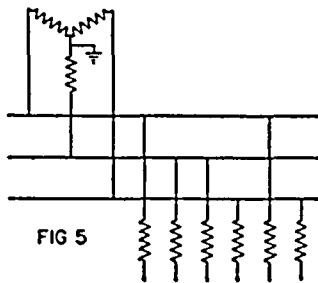
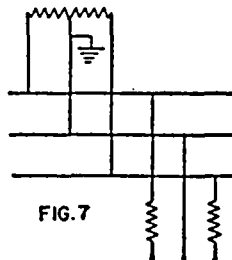
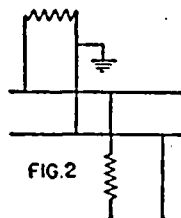
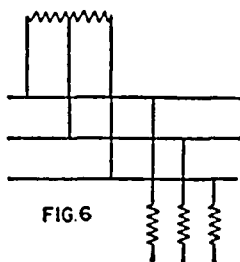
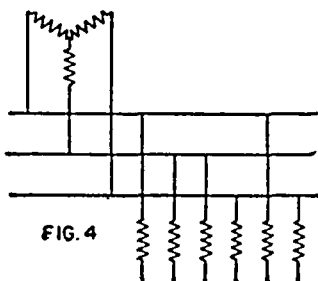
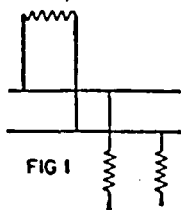
(See Diagrams 1 to 19 following this Table)

(See Section 240-11 for the overcurrent protection of conductors in general, Section 230-90 for services, and Section 430-37 for motors).

SYSTEMS	*Number and Location of Overcurrent Units.
2-Wire, Single-phase A.C. or D.C. Ungrounded.	Two (one in each conductor. Diagram 1).
2-Wire, Single-phase A.C. or D.C., One Wire Grounded.	One (in ungrounded conductor. Diagram 2).
2-Wire, Single-phase A.C. or D.C., Mid-point Grounded.	Two (one in each conductor. Diagram 3).
2-Wire, Single-phase A.C. Derived from 3-Phase, with Ungrounded Neutral.	Two (one in each conductor. Diagram 4).
2-Wire, Single-phase Derived from 3-Phase, Grounded Neutral System by Using outside Wires of 3-Phase Circuit.	Two (one in each conductor. Diagram 5).
3-Wire, Single-phase A.C. or D.C. Ungrounded Neutral.	Three (one in each conductor. Diagram 6).
3-Wire, Single-phase A.C. or D.C. Grounded Neutral.	Two (one in each conductor except neutral conductor. Diagram 7).
3-Wire, 2-Phase, A.C. Common Wire Ungrounded.	Three (one in each conductor. Diagram 8).
3-Wire, 2-Phase, A.C., Common Wire Grounded.	Two (one in each conductor except common conductor. Diagram 9).
4-Wire, 2-Phase Ungrounded, Phases Separate.	Four (one in each conductor. Diagram 10).
4-Wire, 2-Phase, Grounded Neutral, or 5-Wire, 2-Phase, Grounded Neutral.	Four (one in each conductor except neutral conductor. Diagrams 11 and 12).
3-Wire, 3-Phase, Ungrounded.	Three (one in each conductor. Diagram 13**).
3-Wire, 3-Phase, 1 Wire Grounded.	Two (one in each ungrounded conductor. Diagram 14).
3-Wire, 3-Phase, Grounded Neutral.	Three (one in each conductor. Diagram 15**).
3-Wire, 3-Phase, Mid-point of one phase grounded.	Three (one in each conductor. Diagram 17**).
4-Wire, 3-Phase, Grounded Neutral.	Three (one in each ungrounded conductor. Diagram 18**).
4-Wire, 3-Phase, Ungrounded Neutral.	Four (one in each conductor. Diagram 19).

## Diagrams 240-29

Diagrams 1 to 19 showing Number of Overcurrent Units such as Trip Coils or Relays for the Protection of Circuits as required by Table 240-28.



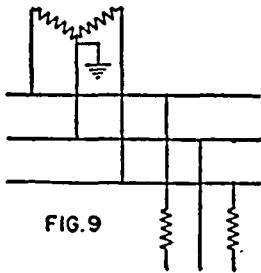


FIG. 9

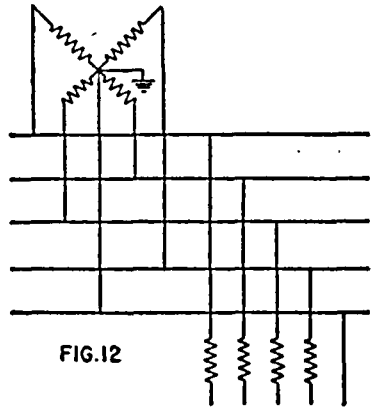


FIG. 12

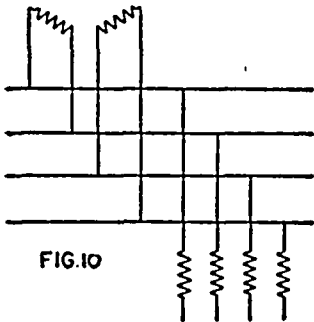


FIG. 10

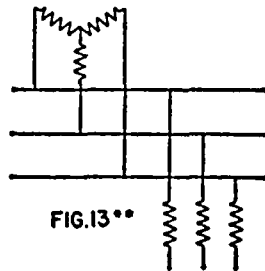


FIG. 13\*\*

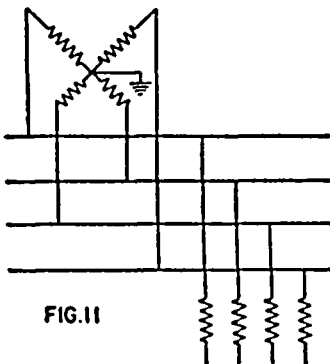


FIG. 11

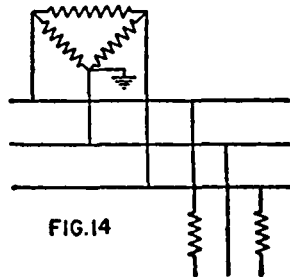
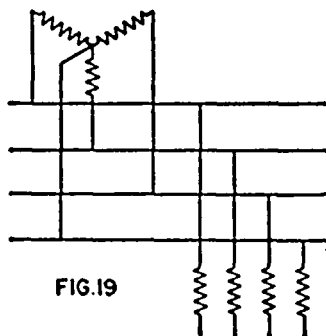
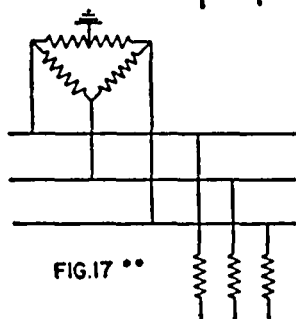
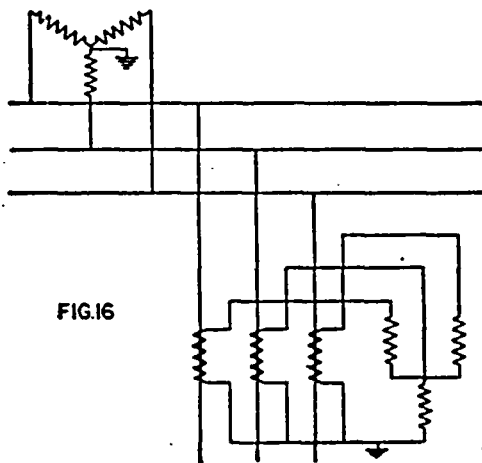
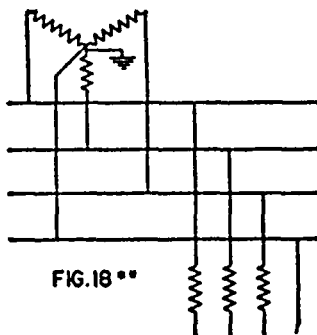
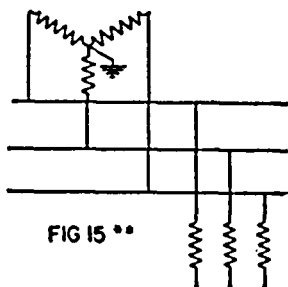


FIG. 14

\*\*See Note 2 of Table 240-28.



\*\*See Note 2 of Table 240-28.

## 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 110-16.

**(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 Conductor Enclosures.** Exposed conductive materials enclosing electric conductors are grounded for the purpose of preventing a potential above ground on the enclosures.

**(c) Exposed Equipment Enclosures.** Exposed conductive materials enclosing electric equipment, or forming a part of such equipment, are grounded for the purpose of preventing a potential above ground on the equipment.

**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:

	Articles
Appliances .....	422
Cranes and Hoists .....	610
Elevators .....	620
Hazardous Locations .....	500-517
Inductive and Dielectric Heat Generating .....	665
Less Than 50 V .....	720
Lighting Fixtures .....	410
Motion Picture Studios .....	530
Motors and Controllers .....	430
Organs .....	650
Radio and Television .....	810
Services .....	230

Signs and Outline Lighting .....	600
Sound Recording, etc. ....	640
X-ray Equipment .....	660

## **B. Circuit and System Grounding**

**250-3. Two-Wire Direct-Current Systems.** Two-wire direct-current systems supplying interior wiring, and operating at not more than 300 volts between conductors, shall be grounded, unless such system is used for supplying industrial equipment in limited areas and the circuit is equipped with a ground detector.

It is recommended that 2-wire direct-current systems operating at more than 300 volts between conductors be grounded when a neutral point can be established such that the maximum difference of potential between the neutral point and any other point on the system does not exceed 300 volts. It is recommended that 2-wire direct-current systems be not grounded when the voltage to ground of either conductor would exceed 300 volts after grounding.

**250-4. Three-Wire Direct-Current Systems.** The neutral conductor of all 3-wire direct-current systems supplying interior wiring shall be grounded.

**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.

It is also recommended that ungrounded systems supplying industrial equipment and operating at more than 150 volts and less than 600 volts be equipped with ground detectors.

**250-6. Furnace Circuits.** Electric furnace circuits need not be grounded.

**250-7. Electric Crane Circuits.** Circuits for electric cranes operating over combustible fibers in Class III hazardous locations shall not be grounded. See Section 503-13.

**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 Paragraph 250-45(d).

(b) Where supplied by transformers from ungrounded systems.

(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 enforcing this Code shall be taken to limit the current.

**250-22. Grounding Connection for Direct-Current Systems.** Direct-current systems which are to be grounded shall have the grounding connection made at one or more supply stations but not at individual services nor elsewhere on interior wiring.

**250-23. Grounding Connections for Alternating-Current Systems.** Secondary alternating-current circuits which are to be grounded shall have a connection to a grounding electrode at each individual 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 distribution system which is grounded shall have at least one additional 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, except as provided for in Section 250-24.

**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) Multi-phase systems having one wire common to all phases: the identified common conductor;
- (d) Multi-phase systems having one phase grounded: the identified conductor;
- (e) Multi-phase 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."

**250-26. Isolated Systems.** For an interior wiring system or circuit which is required to be grounded and which is not electrically connected to an exterior secondary distribution system, the grounding connection shall be made at the transformer, generator, or other source of supply, or at the switchboard, on the supply side of the first switch controlling the system. See fine print note after Section 200-3.

#### **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.

**250-34. Spacing from Lightning Rods.** Metal enclosures of conductors shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. Where it is not practicable to secure 6 feet separation, they shall be bonded together.

### **E. Equipment Grounding**

**250-42. Fixed Equipment—General.** Under any of the following conditions, exposed, non-current-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;

(e) Where equipment is in a hazardous location; see Articles 500-517 inclusive;

(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:

(1) Enclosures for switches or circuit breakers where accessible to qualified persons only;

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

(3) Transformers mounted on wooden poles at a height of more than 8 feet from the ground.

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

- (a) Frames of motors as specified in Section 430-142;
- (b) Controller cases for motors, except lined covers of snap switches;
- (c) Electric equipment of elevators and cranes;
- (d) Electric equipment in garages, theatres and motion picture studios, except pendent lampholders on circuits of not more than 150 volts to ground;
- (e) Motion-picture projection equipment;
- (f) Electric signs and associated equipment, unless these are inaccessible to unauthorized persons and are also insulated from ground and from other conductive objects;
- (g) Generator and motor frames in an electrically operated organ, unless the generator is effectively insulated both from ground and from the motor driving it;
- (h) Switchboard frames and structures supporting switching equipment, except that frames of direct-current, single-polarity switchboards need not be grounded where effectively insulated.

**250-44. Non-Electrical Equipment.** The following metal parts shall be grounded:

- (a) Frames and tracks of electrically operated cranes;
- (b) The metal frame of a non-electrically driven elevator car to which electric conductors are attached;
- (c) Hand-operated metal shifting ropes or cables of electric elevators;
- (d) Metal enclosures such as partitions, grill work, etc., around equipment carrying voltages in excess of 750 volts between conductors, unless in substations or vaults under the sole control of the supply company.

**250-45. Portable Equipment.** Under any of the following conditions, exposed non-current-carrying metal parts of portable equipment shall be grounded:

(a) In hazardous locations (see Articles 500 to 517) ;

(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 422-12.

(c) In residential occupancies, (1) clothes-washing, clothes-drying, and dish-washing machines, and (2) portable, hand held, motor operated tools and appliances of the following types: drills having a chuck capacity exceeding  $\frac{1}{8}$  inch, hedge clippers, lawn mowers, wet scrubbers, sanders and saws.

(d) In other than residential occupancies, (1) portable appliances used in damp or wet locations, or by persons standing on the ground or on metal floors or working inside of metal tanks or boilers, and (2) portable tools which are likely to be used in wet and conductive locations shall be grounded except where supplied through an insulating transformer with ungrounded secondary of not over 50 volts.

This paragraph shall not be construed to prohibit the use of an insulating transformer with a secondary voltage greater than 50 volts, where the exposed metal parts of the appliance connected to such a transformer are grounded, and provided other conditions of this Article are fulfilled.

It is recommended that the frames of all portable motors which operate at more than 50 volts and less than 150 volts to ground be grounded, where this can be readily accomplished.

**250-46. Spacing from Lightning Rods.** Metal frames and enclosures of electric equipment shall, wherever practicable, be kept at least 6 feet away from lightning rod conductors. Where it is not practicable to secure 6 feet separation, they shall be bonded together. See Sections 250-34 and 250-86.

## F. Methods of Grounding

**250-51. Effective Grounding.** The path to ground from circuits, equipment, or 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. Grounding a Circuit Conductor.** The grounding conductor may be connected to the grounded circuit conductor at any convenient point on the premises on the supply side of the service disconnecting means.

**250-53. Common Grounding Conductor.** The grounding conductor for circuits may also be used for grounding equipment, conduit and other metal raceways or enclosures for conductors, including service conduit or cable sheath and service 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.

**250-57. Fixed Equipment.**

(a) Metal boxes, cabinets and fittings, or non-current-carrying metal parts of other fixed equipment, where metallically connected to grounded cable armor or metal raceway, are considered to be grounded by such connection.

(b) Where not so connected they may 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 pro-

vided with an individual covering, the covering shall be finished to show a green color.

(2) By a separate grounding conductor installed the same as a grounding conductor for conduit and the like;

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

#### **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.

(b) Metal car frames supported by metal hoisting cables attached to or running over sheaves or drums of elevator machines shall be deemed to be grounded where the machine is grounded in accordance with this Code.

#### **250-59. Portable Equipment.** Non-current-carrying metal parts of portable equipment 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 plug is used, one fixed contacting member for the purpose of grounding the metal enclosure, and provided, further, that the metal enclosure is attached to the plug and to the equipment by connectors approved for the purpose;

(b) By means of a grounding conductor run with the circuit conductors in cable assemblies or flexible cords, provided an approved plug is used, one fixed contacting member for the purpose of connecting such grounding conductor to the grounded metal raceway or cable armor or to a grounding conductor installed only for equipment grounding purposes; the grounding conductor in a cable assembly may be uninsulated; but where an individual covering is provided for such conductors it shall be finished to show a green color;

(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 120-240 volt, three-wire branch circuits, they may be grounded by connection to the grounded circuit conductors, provided the grounded circuit conductors are not smaller than No. 10 AWG. 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.

**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. 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 Paragraph 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 Paragraph 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 made up tight where rigid conduit is involved.

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

(d) Bonding jumpers meeting the other requirements of this article. Bonding jumpers shall be used around concentric or eccentric knockouts which are punched or other-

wise 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. 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 non-conducting coating which might interrupt such continuity shall be removed unless fittings are used which are so designed that such removal is unnecessary.

**250-75. Voltages Exceeding 250 Volts.** The electrical continuity of metal raceway or metal sheathed cable which contains any conductor other than service entrance conductors of more than 250 volts to ground shall be assured by one of the methods specified in Paragraphs 250-72(b-e), or by one of the following methods:

(a) Threadless fittings, made up tight, with conduit or armored cable;

(b) Two locknuts, one inside and one outside of boxes and cabinets.

**250-76. Loosely-Jointed Metal Raceways.** Expansion joints and telescoping sections of raceways shall be made electrically continuous by bonding jumpers or other approved means. Metal trough raceways used in connection with sound recording and reproducing, made up in sections, shall contain a grounding conductor to which each section shall be bonded.

**250-77. Hazardous Locations.** In hazardous locations, regardless of the voltage involved, the electrical continuity of metallic raceway, boxes and the like, shall be assured by one of the methods specified in Paragraphs 250-72(b-e).

**250-78. Bonding Jumpers.** Bonding jumpers shall conform to the following:

(a) **Material and Size.** Bonding jumpers shall be of copper or other corrosion-resistant material and shall be of sufficient size to have current-carrying capacity not less than is required for the corresponding grounding conductor;

(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 250-114.

## 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, it shall be supplemented by one or more of the grounding electrodes recognized in Sections 250-82 and 250-83.

**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) A continuous metallic underground gas piping system.

(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) **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 non-ferrous metal shall be at least 0.06 inch in thickness.

(b) **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.

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

(d) **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 Paragraphs 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.

**250-84. Resistance.** Made electrodes shall, where practicable, have a resistance to ground not to exceed 25 ohms. Where the resistance is not as low as 25 ohms, two or more electrodes connected in parallel shall be used.

Continuous metallic underground water or gas piping systems in general have a resistance to ground of less than 3 ohms. Metal frames of buildings and local metallic underground piping systems, metal well casings, and the like, have, in general, a resistance substantially below 25 ohms. It is recommended that in locations where it is necessary to use made electrodes for grounding interior wiring systems, additional grounds, such as connections to a system ground conductor be placed on the distribution circuit. It is also recommended that single electrode grounds when installed, and periodically afterwards, be tested for resistance.

**250-85. Railway Tracks.** Rails or other grounded conductors of electric railway circuits shall not be used (a) as a ground for other than railway lightning arresters and railway equipment, conduit, armored cable, metal raceway, and the like, where other effective grounds are available; and (b) in no case shall such rails or other grounded conductors of railway circuits be used for grounding interior wiring systems other than those supplied from the railway circuit itself.

**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 Paragraph 800-31(b-5).

## **J. Grounding Conductors**

**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, and its tensile strength shall not be less than 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 conduit, steel pipe, electrical metallic tubing or the armor of armored cable, except that under conditions favorable to corrosion a grounding conductor of copper or other corrosion-resistant material shall be used.

**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. Where rigid metallic conduit or steel pipe is used as protection for a grounding conductor, the installation shall comply with the requirements of Article 346; where electrical metallic tubing is used, the installation shall comply with the requirements of Article 348.

(b) **Conductor Enclosures and Equipment Only.** A grounding conductor for conductor enclosures and equipment only shall meet the requirements of Paragraph 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.

**250-93. Direct-Current Circuits.** The carrying capacity of the grounding conductor for a direct-current supply system or generator shall be not less than that of the largest conductor supplied by the system, except that where the grounded circuit conductor is a neutral derived from a balancer winding or a balancer set protected in accordance with requirements of Paragraph 445-4(d), the size of the grounding conductor shall not be less than that of the neutral conductor. The grounding conductor shall in no case be smaller than No. 8 copper.

**250-94. Alternating-Current and Service Equipment.**

(a) **Wiring System and Common Grounding Conductor.** 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) the conductor need not be larger than No. 6 copper wire or its equivalent in carrying capacity.

(b) Where the wiring system is not grounded at the premises, the size of a grounding conductor for a service raceway, for the metal sheath or armor of a service cable, and for service equipment shall be not less than is given in

Table 250-94(b), except that where connected to made electrodes (as in Section 250-83) the conductor need not be larger than No. 6 copper or its equivalent in carrying capacity.

**Table 250-94(a). Sizes of Grounding Conductors**

Size of Largest Service Conductor or Equivalent for Multiple Conductors	Size of Copper Grounding Conductor AWG. No.
2 or smaller .....	8
1 or 0 .....	6
00 or 000 .....	4
Over 000 to 350,000 c.m. ....	2
Over 350,000 c.m. to 600,000 c.m. ....	0
Over 600,000 c.m. to 1,100,000 c.m. ....	00
Over 1,100,000 c.m. ....	000

**Table 250-94(b). Sizes of Grounding Conductors**

Size of Largest Service Conductor or Equivalent for Multiple Conductors	Size of Grounding Conductor		
	Copper Wire AWG. No.	Conduit or Pipe Trade Size (Inch)	Electrical Metallic Tubing Trade Size (Inch)
2 or smaller .....	8	$\frac{1}{2}$	$\frac{1}{2}$
1 or 0 .....	6	$\frac{1}{2}$	1
00 or 000 .....	4	$\frac{3}{4}$	1 $\frac{1}{4}$
Over 000 to 350,000 c.m. ....	2	$\frac{3}{4}$	1 $\frac{1}{4}$
Over 350,000 c.m. to 600,000 c.m. ...	0	1	2
Over 600,000 c.m. to 1,100,000 c.m. ..	00	1	2
Over 1,100,000 c.m. ....	000	1	2

**250-95. Interior Raceway and Equipment.** The size of the grounding conductor for conduit, cable sheath or armor, and other metal raceways or enclosures for conductors, and for equipment, shall be not less than given in Table 250-95, except that where connected to electrodes as described in Section 250-83, the grounding conductor need not be larger than No. 6 copper or its equivalent.

**250-96. Portable and Pendent Equipment.** For grounding portable or pendent equipment, the conductors of which are protected by fuses or circuit-breakers rated or set at not exceeding 20 amperes, No. 18 copper wire may be used. Conductors of Nos. 16 or 18 copper which are used for

**Table 250-95. Sizes of Grounding Conductors**

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size of Grounding Conductor		
	Copper Wire No.	Conduit or Pipe (Inch)	Electrical Metallic Tubing (Inch)
20	16*	$\frac{1}{2}$	$\frac{1}{2}$
30	14	$\frac{1}{2}$	$\frac{1}{2}$
40	12	$\frac{1}{2}$	$\frac{1}{2}$
60	10	$\frac{1}{2}$	$\frac{1}{2}$
100	8	$\frac{1}{2}$	$\frac{1}{2}$
200	6	$\frac{1}{2}$	1
400	4	$\frac{3}{4}$	1 $\frac{1}{4}$
600	2	$\frac{3}{4}$	1 $\frac{1}{4}$
800	0	1	2
1000	00	1	2
1200	000	1	2

\*Permissible only when part of an approved cable assembly.

grounding portable equipment shall be part of an approved flexible cord assembly. For grounding portable or pendent equipment protected at more than 20 amperes, Table 250-95 shall be followed.

**250-97. Outline Lighting.** Isolated non-current-carrying metal parts of outline lighting systems may be bonded together by a No. 14 conductor protected from physical damage, where a conductor complying with Section 250-95 is used to ground the group.

**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 of adequate current-carrying capacity 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. Equipment may be grounded to a cold water pipe near the equipment.

(b) **To Gas Pipes.** The point of attachment of a grounding conductor to gas piping 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. 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.

**250-115. 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.

**250-116. 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.

**250-117. Clean Surfaces.** Where a non-conductive 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.

## L. Instrument Transformers, Relays, etc.

**250-121. Instrument Transformer Circuits.** The secondary circuits of current and potential instrument transformers shall be grounded where the primary windings are connected to circuits of 300 volts or more to ground, and, where on switchboards, shall be grounded irrespective of voltage, except that such circuits need not be grounded where the primary windings are connected to circuits of 750 volts or less and no live parts or wiring are exposed or accessible to other than qualified persons.

**250-122. Instrument Transformer Cases.** Cases or frames of instrument transformers shall be grounded where accessible to other than qualified persons, except that cases or frames of current transformers, the primaries of which are not over 150 volts to ground and which are used exclusively to supply current to meters, need not be grounded.

**250-123. Cases of Instruments, Meters and Relays — Operating Voltage 750 or Less.** Instruments, meters and relays which operate with windings or working parts at 750 volts or less shall be grounded as follows:

(a) **Not on Switchboards.** Instruments, meters, and relays not located on switchboards, which operate with windings or working parts at 300 volts or more to ground, and accessible to other than qualified persons, shall have the cases and other exposed metal parts grounded;

(b) **On Dead Front Switchboards.** Instruments, meters and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having no live parts on the front of the panels shall have the cases grounded;

(c) **On Live Front Switchboards.** Instruments, meters and relays (whether operated from current and potential transformers, or connected directly in the circuit) on switchboards having exposed live parts on the front of panels shall not have their cases grounded. Mats of insulating rubber or other suitable floor insulation, shall be provided for the operator where the voltage to ground exceeds 150.

**250-124. Cases of Instruments, Meters and Relays—Operating Voltage Over 750.** Where instruments, meters and relays have current-carrying parts over 750 volts to ground, they shall be isolated by elevation or protected by suitable barriers, grounded metal or insulating covers or guards. Their cases shall not be grounded, except as follows:

(a) In electrostatic ground detectors the internal ground segments of the instrument are connected to the instrument case and grounded; the ground detector shall be isolated by elevation.

**250-125. Instrument Grounding Conductor.** The grounding conductor for secondary circuits of instrument transformers and for instrument cases shall not be smaller

than No. 12, where of copper or where of other metal, shall have equal conductance. Cases of instrument transformers, instruments, meters and relays which are mounted directly on grounded metal surfaces of enclosures or grounded metal switchboard panels shall be considered to be grounded and no additional grounding conductor will be required.

### M. Lightning Arresters

**250-131. On Secondary Services, 750 Volts or Less.** Where a lightning arrester is installed on a secondary service, the connections to the service conductors and to grounding conductor shall be as short as practicable. The grounding conductor may be (1) the grounded service conductor, or (2) the common grounding conductor, or (3) the service equipment grounding conductor. The bonding or grounding conductor shall be of copper not smaller than No. 14 or of equivalent corrosion-resistant material.

**250-132. On Primary Circuits.** The grounding conductor of a lightning arrester protecting a transformer which supplies a secondary distribution system may be interconnected as follows:

(a) **Metallic Interconnection.** A metallic interconnection may be made to the secondary neutral provided that, in addition to the direct grounding connection at the arrester:

(1) The grounded conductor of the secondary has elsewhere a grounding connection to a continuous metallic underground water piping system. However, in urban water pipe areas where there are at least four waterpipe connections on the neutral and not less than four such connections in each mile of neutral, the metallic interconnection may be made to the secondary neutral with omission of the direct grounding connection at the arrester.

(2) The grounded conductor of the secondary system is part of a multi-grounded neutral system, of which the primary neutral has at least four ground connections in each mile of line in addition to a ground at each service.

(b) **Through Spark Gap.** Where the secondary is not grounded as in Paragraph 250-132(a), but is otherwise grounded as in Sections 250-82 and 250-83, such interconnection, where made, shall be through a spark gap having a 60-cycle breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kv, and

there shall be at least one other ground on the grounded conductor of the secondary not less than 20 feet distant from the lightning arrester grounding electrode.

**(c) By Special Permission.** Except as above provided, interconnection of the arrester ground and the secondary neutral may be made only by special permission.

## ARTICLE 280 — LIGHTNING ARRESTERS

### A. Industrial Stations

**280-1. Where Required.** Lightning arresters shall be provided in industrial stations in locations where thunderstorms are frequent and adequate protection against lightning is not otherwise provided.

For lightning arresters in hazardous locations, see Articles 500-517.

**280-2. Number Required.** A lightning arrester shall be connected to each ungrounded overhead conductor entering or leaving the station, except that where there is more than one circuit, a single set of arresters may be installed on the station bus where means are provided to protect circuits that may remain disconnected from the bus.

**280-3. Where Connected.** The arrester shall be connected on the line side of all connected station apparatus.

### B. Other Occupancies

**280-11. Utilization Equipment.** Lightning arresters installed for the protection of utilization equipment may be installed either inside or outside the building or enclosure containing the equipment to be protected. Arresters, unless isolated by elevation or made otherwise inaccessible to unqualified persons, shall be enclosed, and where the operating voltage of the circuit exceeds 750 volts between conductors they shall be inaccessible to unqualified persons.

### C. General

**280-21. Location — Indoors.** Arresters installed indoors shall be located well away from other equipment, passageways and combustible parts of buildings, and where containing oil shall be separated from other equipment by walls meeting the requirements of Section 450-42.

**280-22. Location — Outdoors.** Where arresters containing oil are located outdoors, provision shall be made to drain away any accumulation of oil.

Oil may be drained away by ditches and drains or the oil may be absorbed and danger of spreading removed by paving the yard with cinders or other absorbent material to a depth of several inches.

**280-23. Connections — Size and Material.** The connections between the arrester and the line wire or bus, and between arrester and ground shall be of copper wire or cable or the equivalent, and, except as provided on secondary services in Section 250-131, shall not be smaller than No. 6, and shall be made as short and as straight as practicable, avoiding as far as possible all bends and turns, especially sharp bends.

**280-24. Insulation.** Lightning-protection accessories such as gap electrodes, and choke coils where used, shall have an insulation from ground or from other conductors at least equal to the insulation required at other points of the circuit.

**280-25. Switch for Isolating Arrester.** Where isolating switches or disconnecting devices are used, they shall withstand, in full open position, a voltage test between live parts 10 per cent in excess of the maximum voltage test they will withstand to ground.

**280-26. Grounding.** Lightning arresters shall be grounded in the manner prescribed in Article 250.

## **Chapter 3. Wiring Methods and Materials**

### **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 and 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 waterpiping 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.

#### **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.

(b) Conductors of light and power systems of over 600 volts shall not occupy the same enclosure with conductors of light and power systems of 600 volts or less.

(c) Secondary wiring to electric discharge lamps of 1,000 volts or less may occupy the same enclosure as the branch circuit conductors.

(d) Control, relay and ammeter conductors used in connection with any motor or starter may occupy the same enclosure as the motor circuit conductors.

(e) Conductors of signal or radio systems shall not occupy the same enclosure with conductors of light or power systems except as permitted for elevators in Section 620-36; for sound recording in Section 640-5; for remote-control, low-energy power and signal circuits in Sections 725-16 and 725-42; and communication system in Sections 800-3 and 800-21.

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

**300-5. Protection Against Corrosion.** Metal raceways, cable armor, boxes, cabinets and all metallic elbows, couplings, and fittings, unless made of corrosion-resistant material, shall be suitably protected against corrosion inside and outside (except threads at joints) by a coating of approved corrosion-resistant materials such as zinc, cadmium, or enamel. Ferrous raceways, fittings and boxes protected from corrosion solely by enamel may be used only indoors and in occupancies not subject to severe corrosive influences.

Meat-packing plants, tanneries, hide cellars, casing rooms, glue houses, fertilizer rooms, salt storage, some chemical works, metal refineries, pulp mills, sugar mills, round houses, some stables, and similar locations are judged to be occupancies where severe corrosive conditions are likely to be present.

**300-6. Raceways Exposed to Different Temperatures.** Where portions of an interior raceway system are exposed to widely different temperatures, as in refrigerating or cold-storage plants, provision shall be made to prevent circulation of air from a warmer to a colder section through the raceway.

Consideration should be given to expansion and contraction of runs of conduit from temperature changes.

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

**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.

(b) Where there is no objection because of weakening the building structure, armored or non-metallic sheathed cable and Type MI 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 non-metallic boxes in Section 370-7.

**300-11. Secured in Place.** Raceways, cable assemblies, boxes, cabinets and fittings shall, unless otherwise provided, 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, and for wireways in Section 362-6, 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 lamp-holders, receptacles and similar devices.

**300-15. Boxes.** Except as permitted in Sections 336-11 and 410-60, a box shall be installed at each outlet, switch, or junction point of conduit, electrical metallic tubing, surface metal raceway, armored cable, non-metallic sheathed or Type MI cable, and at each outlet and switch point of concealed knob-and-tube work.

**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, non-metallic sheathed cable, armored cable or Type MI cable and surface metal 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; surface metal raceways, 352-4; underfloor raceways, 354-5; cellular metal floor raceways, 356-5; cellular concrete floor raceways, 358-9; wireways, 362-5; auxiliary gutters, 374-5; theatres, 520-5; signs, 600-21(d); elevators, 620-33; and sound recording, 640-3 and 640-4; 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 interior 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) Graphite, talc, or an approved compound may be used as a lubricant in inserting conductors in raceways.

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

**300-19. Supporting Conductors in Vertical Raceways.**

(a) Conductors in vertical raceways shall be supported at intervals not greater than those specified in the following table:

No. 18	to No. 0.....not greater than 100 feet
No. 00	to No. 0000.....not greater than 80 feet
250,000 C. M.	to 350,000 C. M.....not greater than 60 feet
350,001 C. M.	to 500,000 C. M.....not greater than 50 feet
500,001 C. M.	to 750,000 C. M.....not greater than 40 feet
	Above 750,000 C. M.....not greater than 35 feet

(b) One of the following methods of support, or a method of equal effectiveness is recommended:

(1) By clamping devices constructed of or employing insulating wedges inserted in the ends of the conduits. With cables having varnished cambric or thermoplastic insulation it may also be necessary to clamp the conductor.

(2) By inserting boxes at the required intervals in which insulating supports are installed and secured in a satisfactory manner to withstand the weight of the conductors attached thereto, the boxes being provided with covers.

(3) In junction boxes, by deflecting the cables not less than 90 degrees and carrying them horizontally to a distance not less than twice the diameter of the cable, the

cables being carried on two or more insulating supports, and additionally secured thereto by tie wires if desired. When this method is used cables shall be supported at intervals not greater than 20 per cent of those mentioned in the preceding tabulation.

**300-20. Induced Currents in Metal Enclosures.** In metal raceway or cable armor, or where a current of more than 50 amperes enters a metal enclosure, the conductors of circuits operating on alternating-current shall be so arranged as to avoid overheating of the metal by induction. When the capacity of a circuit is such that it is impracticable to run all conductors in one enclosure, the circuit may be divided and two or more enclosures may be used provided each phase conductor of the circuit and the neutral conductor, where one is used, are installed in each enclosure. The conductors of such an installation can conform to the provisions of Section 310-10 for multiple conductors.

Induced currents in an enclosure can be avoided by so grouping the conductors in one enclosure that the current in one direction will be substantially equal to the current in the opposite direction.

In the case of circuits supplying vacuum or electric discharge lighting systems or signs, or X-ray apparatus, and under-plaster extensions permitted by Sections 344-1 to 344-4 inclusive, the currents carried by the conductors are so small that a single conductor may be placed in a metal raceway or cable armor without causing trouble from induction.

Where the conductors of a circuit pass through individual holes in the wall of a metal cabinet, the effect of induction may be minimized by

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

(2) passing all the conductors in the circuit through an insulating block used to cover a hole in the metal cabinet, sufficiently large for all the conductors of the circuit and providing individual holes in the insulating block for the separate conductors.

**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-conditioning ducts is reduced to a minimum.

**300-22. Wiring in Ventilating and Exhaust Ducts.**

(a) Where it is necessary to run a wiring system through air-conditioning ducts or plenum chambers, the wiring method shall be rigid conduit. flexible steel conduit with

lead-covered conductors, or Type ACL armored cable, with fittings suitable for the location. The terminals of circuits of such wiring systems shall be so located that it will not be necessary to install motors or control equipment in the ducts, except for temperature and humidity control. Raceways shall not interfere with the operation of automatic fire dampers in ducts.

The above provisions shall not apply to integral fan systems specifically approved for the purpose.

(b) No wiring system of any type shall be installed in ducts for dust, loose stock or vapor removal.

### **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 current carrying capacity 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.

### 310-2. Application and Construction.

(a) **Conductor Application.** Conductor insulations as specified in the following Table 310-2(a) may be installed for any of the wiring methods recognized in this Chapter, except as otherwise provided for in the Table or in Section 310-3, or as otherwise specified in this Code. They are suitable for 600 volts unless otherwise specified.

(b) **Conductor Construction.** Insulated conductors for use at 600 volts or less shall conform to the provisions of Table 310-2(b).

**Table 310-2(a). Conductor Application**

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions
Rubber-Covered Fixture Wire	*RF-1	60°C 140°F	Fixture wiring. Limited to 300 V.
Solid or 7-Strand	*RF-2	60°C 140°F	Fixture wiring, and as permitted in Section 310-8.
Rubber-Covered Fixture Wire	*FF-1	60°C 140°F	Fixture wiring. Limited to 300 V.
Flexible Stranding	*FF-2	60°C 140°F	Fixture wiring, and as permitted in Section 310-8.

\*Fixture wires are not intended for installation as branch circuit conductors nor for the connection of portable or stationary appliances.

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions
Heat-Resistant Rubber-Covered Fixture Wire	*RFH-1	75°C 167°F	Fixture wiring. Limited to 300 V.
Solid or 7-Strand	*RFH-2	75°C 167°F	Fixture wiring, and as permitted in Section 310-8.
Heat-Resistant Rubber-Covered Fixture Wire	*FFH-1	75°C 167°F	Fixture wiring. Limited to 300 V.
Flexible Stranding	*FFH-2	75°C 167°F	Fixture wiring, and as permitted in Section 310-8.
Thermoplastic-Covered Fixture Wire—Solid or Stranded	*TF	60°C 140°F	Fixture wiring, and as permitted in Section 310-8.
Thermoplastic-Covered Fixture Wire—Flexible Stranding	*TFF	60°C 140°F	Fixture wiring.
Cotton-Covered, Heat-Resistant, Fixture Wire	*CF	90°C 194°F	Fixture wiring. Limited to 300 V.
Asbestos-Covered Heat-Resistant, Fixture Wire	*AF	150°C 302°F	Fixture wiring. Limited to 300 V. and Indoor Dry Location.
Silicone Rubber Insulated Fixture Wire	*SF-1	200°C 392°F	Fixture wiring. Limited to 300 V.
Solid or 7 Strand	*SF-2	200°C 392°F	Fixture wiring and as permitted in Section 310-8.
Silicone Rubber Insulated Fixture Wire	*SFF-1	150°C 302°F	Fixture wiring. Limited to 300 V.
Flexible Stranding	*SFF-2	150°C 302°F	Fixture wiring and as permitted in Section 310-8.
Code Rubber	R	60°C 140°F	Dry locations.
Heat-Resistant Rubber	RH	75°C 167°F	Dry locations.

\*Fixture wires are not intended for installation as branch circuit conductors nor for the connection of portable or stationary appliances.

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions
Heat Resistant Rubber	RHH	90°C 194°F	Dry locations.
Moisture-Resistant Rubber	RW	60°C 140°F	Dry and wet locations. For over 2000 volts, insulation shall be ozone-resistant.
Moisture and Heat Resistant Rubber	RH-RW	60°C 140°F  75°C 167°F	Dry and wet locations. For over 2000 volts, insulation shall be ozone-resistant. Dry locations. For over 2000 volts, insulation shall be ozone-resistant.
Moisture and Heat Resistant Rubber	RHW	75°C 167°F	Dry and wet locations. For over 2000 volts, insulation shall be ozone-resistant.
Latex Rubber	RU	60°C 140°F	Dry locations.
Heat Resistant Latex Rubber	RUH	75°C	Dry locations.
Moisture Resistant Latex Rubber	RUW	60°C 140°F	Dry and wet locations.
Thermoplastic	T	60°C 140°F	Dry locations.
Moisture-Resistant Thermoplastic	TW	60°C 140°F	Dry and wet locations.
Moisture and Heat-Resistant Thermoplastic	THW	75°C 167°F	Dry and wet locations.
Mineral Insulation (Metal Sheathed)	MI	85°C 185°F	Dry and wet locations with Type O termination fittings. Max. operating temperature for special applications 250°C.
Thermoplastic and Asbestos	TA	90°C 194°F	Switchboard wiring only.
Silicone-Asbestos	SA	90°C	Dry locations—max. operating temperature for special application 125°C.

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions
Thermoplastic and Fibrous Outer Braid	TBS	90°C 194°F	Switchboard wiring only.
Varnished Cambric	V	85°C 185°F	Dry locations only. Smaller than No. 6 by special permission.
Asbestos and Varnished Cambric	AVA	110°C 230°F	Dry locations only.
Asbestos and Varnished Cambric	AVL	110°C 230°F	Dry and wet locations.
Asbestos and Varnished Cambric	AVB	90°C 194°F	Dry locations only.
Asbestos	A	200°C 392°F	Dry locations only. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AA	200°C 392°F	Dry locations only. Open wiring. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AI	125°C 257°F	Dry locations only. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AIA	125°C 257°F	Dry locations only. Open wiring. In raceways, only for leads to or within apparatus.
Paper		85°C 185°F	For underground service conductors, or by special permission.
Slow-Burning	SB	90°C 194°F	Dry locations only. Open wiring; and in raceways where temperatures will exceed those permitted for rubber-covered or varnished cambric-covered conductors.

Table 310-2(b). Conductor Insulations

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Heat Resistant Latex Rubber	RUH	90% Unmilled, Grainless Rubber	14-10.....18 Mils 8-2.....25 Mils	Moisture-resistant, flame-retardant, non-metallic covering
Thermoplastic	T	Flame-Retardant, Thermoplastic Compound	14-10.....2/64 Inch 8.....3/64 Inch 6-2.....4/64 Inch 1-4/0.....5/64 Inch 213-500.....6/64 Inch 501-1000.....7/64 Inch 1001-2000.....8/64 Inch	None
Moisture-Resistant Thermoplastic	TW	Flame-Retardant, Moisture-Resistant Thermoplastic	14-10.....2/64 Inch 8.....3/64 Inch 6-2.....4/64 Inch 1-4/0.....5/64 Inch 213-500.....6/64 Inch 501-1000.....7/64 Inch 1001-2000.....8/64 Inch	None
Moisture and Heat-Resistant Thermoplastic	THW	Flame-Retardant, Moisture and Heat-Resistant Thermoplastic	14-10.....3/64 Inch 8-2.....4/64 Inch 1-4/0.....5/64 Inch 213-500.....6/64 Inch	None
Thermoplastic and Asbestos	TA	Thermoplastic and Asbestos	Th'pl'. Asb. 14-8.....20 Mils 20 Mils 6-2.....30 Mils 25 Mils 1-4/0.....40 Mils 30 Mils	Flame-retardant, cotton braid

Silicone-Asbestos	SA	Silicone Rubber	14-10.....3/64 Inch 8-2.....4/64 Inch 1-4/0.....5/64 Inch 213-500.....6/64 Inch 501-1000.....7/64 Inch 1001-2000.....8/64 Inch	Asbestos or glass
Thermoplastic and Fibrous Braid	TBS	Thermoplastic	14-10.....2/64 Inch 8.....3/64 Inch 6-2.....4/64 Inch 1-4/0.....5/64 Inch	Flame-retardant, non-metallic covering
Mineral-Insulated Metal-Sheathed	MI	Magnesium Oxide	16-4.....50 Mils 3-4/0.....55 Mils	Copper
Varnished Cambric	V	Varnished Cambric	14-8.....3/64 Inch 6-2.....4/64 Inch 1-4/0.....5/64 Inch 213-500.....6/64 Inch 501-1000.....7/64 Inch 1001-2000.....8/64 Inch (Dimen. in Mils)      AVA   AVL VC   Asb.   Asb. 14-8 (solid only) 30   20   25	Non-metallic covering or lead sheath
Asbestos and Varnished Cambric	AVA and AVL	Impregnated Asbestos and Varnished Cambric	<div> <div>1st</div> <div>AVA</div> <div>AVL</div> <div>Asb. VC Asb. Asb.</div> </div> 14-8.....10   30   15   25 6-2.....15   30   20   25 1-4/0.....20   30   30   30 213-500.....25   40   40   40 501-1000.....30   40   40   40 1001-2000.....30   50   50   50	AVA-asbestos braid or glass   AVL-lead sheath

Table 310-2(b)—Continued

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Asbestos and Varnished Cambric	AVB	Impregnated Asbestos and Varnished Cambric	VC Asb. 18-8.....30 20 6-2.....40 30 1-4/0.....40 40	Flame-retardant, cotton braid (switchboard wiring)
			Asb. VC 2nd Asb. 14-8.....10 30 15 6-2.....15 30 20 1-4/0.....20 30 30 213-500....25 40 40 501-1000...30 40 40 1001-2000...30 50 50	Flame-retardant, cotton braid
Asbestos	A	Asbestos	14.....30 Mils 12-8.....40 Mils	Without asbestos braid
Asbestos	AA	Asbestos	14.....30 Mils 12-8.....30 Mils 6-2.....40 Mils 1-4/0.....60 Mils	With asbestos braid or glass
Code	R	Code Rubber	14-12.....2/64 Inch 10.....3/64 Inch 8-2.....4/64 Inch 1-4/0.....5/64 Inch 213-500....6/64 Inch 501-1000....7/64 Inch 1001-2000....8/64 Inch	Moisture-resistant, flame-retardant, non-metallic covering

Heat-Resistant	RH RHH	Heat-Resistant Rubber	*14-12.....2/64 Inch 10.....3/64 Inch 8-2.....4/64 Inch 1-4/0.....5/64 Inch 213-500.....6/64 Inch 501-1000.....7/64 Inch 1001-2000.....8/64 Inch	Moisture resistant, flame-retardant, non-metallic covering
Moisture-Resistant	RW	Moisture-Resistant Rubber	14-10.....3/64 Inch 8-2.....4/64 Inch 1-4/0.....5/64 Inch 213-500.....6/64 Inch 501-1000.....7/64 Inch 1001-2000.....8/64 Inch	Moisture-resistant, flame-retardant, non-metallic covering
Moisture and Heat-Resistant	RH-RW	Moisture and Heat Resistant Rubber	14-10.....3/64 Inch 8-2.....4/64 Inch 1-4/0.....5/64 Inch 213-500.....6/64 Inch 501-1000.....7/64 Inch 1001-2000.....8/64 Inch	Moisture-resistant, flame-retardant, non-metallic covering
Moisture and Heat-Resistant	RHW	Moisture and Heat Resistant Rubber	14-10.....3/64 Inch 8-2.....4/64 Inch 1-4/0.....5/64 Inch 213-500.....6/64 Inch 501-1000.....7/64 Inch 1001-2000.....8/64 Inch	Moisture-resistant, flame retardant, non-metallic covering
Latex Rubber	RU	90% Unmilled, Grainless Rubber	14-10.....18 Mils 8-2.....25 Mils	Moisture-resistant, flame-retardant, non-metallic covering
	RUW	90% Unmilled, Grainless Rubber	14-10.....18 Mils 8-2.....25 Mils	Moisture-resistant, flame-retardant, non-metallic covering

\*For 14-12 sizes RHH shall be 3/64 inch thickness insulation.

Table 310-2(b)—Continued

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering																					
Asbestos	AI	Impregnated Asbestos	14.....30 Mils 12-8.....40 Mils	Without asbestos braid																					
Asbestos	AIA	Impregnated Asbestos	<table><tr><td></td><td>Sol.</td><td>Str.</td></tr><tr><td>14.....</td><td>30 Mils</td><td>30 Mils</td></tr><tr><td>12-8.....</td><td>30 Mils</td><td>40 Mils</td></tr><tr><td>6-2.....</td><td>40 Mils</td><td>60 Mils</td></tr><tr><td>1-4 /0.....</td><td>60 Mils</td><td>75 Mils</td></tr><tr><td>213-500.....</td><td></td><td>90 Mils</td></tr><tr><td>501-1000.....</td><td></td><td>105 Mils</td></tr></table>		Sol.	Str.	14.....	30 Mils	30 Mils	12-8.....	30 Mils	40 Mils	6-2.....	40 Mils	60 Mils	1-4 /0.....	60 Mils	75 Mils	213-500.....		90 Mils	501-1000.....		105 Mils	With asbestos braid or glass
	Sol.	Str.																							
14.....	30 Mils	30 Mils																							
12-8.....	30 Mils	40 Mils																							
6-2.....	40 Mils	60 Mils																							
1-4 /0.....	60 Mils	75 Mils																							
213-500.....		90 Mils																							
501-1000.....		105 Mils																							
Paper		Paper		Lead sheath																					
Slow Burning	SB	3 Braids Impregnated Fire Retardant, Cotton Thread	14-10.....3 /64 Inch 8-2.....4 /64 Inch 1-4 /0.....5 /64 Inch 213-500.....6 /64 Inch 501-1000.....7 /64 Inch 1001-2000.....8 /64 Inch	Outer cover finished smooth and hard																					

The fibrous covering over individual rubber-covered conductors of lead-sheathed or multiple-conductor cable is not required to be flame retardant. For armored cable, see Section 334-2. For non-metallic-sheathed cable, see Section 336-2. For Type UF cable, see Section 339-1.

(c) **Marking.** Insulated wires, cables and cords of all kinds except paper-insulated wire 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. This may be omitted for slow-burning and asbestos-covered switchboard wires.

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

(3) Name of the manufacturing company and, if desired, trade name of the wire.

(4) Month and year when manufactured. This may be omitted for slow-burning wires.

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

(d) **Classification.** In addition to the type letters specified in Table 310-2(b), the following letters shall apply:

(1) A type letter or letters used alone indicates a single insulated conductor.

(2) The letter "D" used as a suffix indicates a twin wire with two insulated conductors laid parallel under an outer fibrous covering.

(3) The letter "M" used as a suffix indicates an assembly of two or more insulated conductors twisted together under an outer fibrous covering.

(4) The letter "L" used as a suffix indicates an outer covering of lead.

(5) **Voltage.** Type letters, when used alone, indicate conductors for use at not more than 600 volts. Conductors for use at higher voltages shall be indicated by adding numerical suffixes to the type letters as follows:

- 10—for use at not more than 1000 volts.
- 20—for use at not more than 2000 volts.
- 30—for use at not more than 3000 volts.
- 40—for use at not more than 4000 volts.
- 50—for use at not more than 5000 volts.

The working voltages referred to in the Table are the operating voltages between phases of single and two-phase systems, and three-phase systems with grounded or ungrounded neutral.

(6) All NEC standard conductors shall be examined and tested at the factory and, if approved, shall be labeled before shipment.

(e) **Identification of Insulation.** All rubber-insulated conductors and all thermoplastic-insulated conductors, No. 14 and larger, shall have a readily recognizable durable marking to indicate the grade of insulation; except that single-conductor, code-rubber insulated conductors having a lead sheath; and multi-conductor cables, armored cable, and non-metallic-sheathed cable having code-rubber or non-moisture-resistant thermoplastic-insulated conductors, need not be so marked.

(f) **Identified Conductors.** Single insulated conductors of No. 6 or smaller, intended for use as identified conductors of circuits, except (1) for fixture wires as outlined below, and (2) for mineral insulated-metal sheathed cable, shall have an outer identification of a white or natural gray color. Twin and twisted-pair conductors and three-conductor cables shall have one conductor, and four-conductor cables shall have at least one conductor identified in this manner.

For fixture wires the identification shall be as above, or by means of (1) ridges, or (2) grooves, or (3) stripes colored white or natural gray so located on the exterior of the wires as to identify it.

Wires having their outer covering finished to show a white or natural gray color but having colored tracer threads in the braid, identifying the source of manufacture, are considered as meeting the provisions of this Paragraph.

(g) Single conductors, intended for use as unidentified conductors, and conductors other than the identified conductor in multi-conductor cables, shall be finished to show a color or combination of colors other than, and contrasting with, white or natural gray. The colors contrasting with white or natural gray, may be provided by means of an approved stripe or stripes on black conductors. For identification requirements for conductors larger than No. 6 see Section 200-6(b).

(h) **Insulation Thickness—Over 600 volts.** The thickness of insulation for conductors for use at over 600 volts shall conform to Tables 310-2(h-1 thru h-4):

Table 310-2(h-1)

**Thickness of Rubber Insulation for Rubber-Covered Wire and Cable, in 64ths of an Inch**

Conductor Size AWG. or MCM	Classification					
	R 10	R 20				
	RH 10	RH 20	RW 30†	RW 40†	RW 50†	
	RW 10	RW 20	RH-RW 30†	RH-RW 40†	RH-RW 50†	
	RHW 10	RHW 20	RHW 30†	RHW 40†	RHW 50†	
14-12	4	5	..	..	..	
10- 8*	4	5	7	9	10*	
6- 2	5	6	8	9	10	
1-4/0	6	7	8	9	10	
213-500	7	8	9	10	11	
501-1000	8	9	9	10	11	
1001-2000	9	9	10	11	12	

\* No. 8 AWG. is the minimum conductor size for 5000 volts operation.

† Shall be of approved ozone-resistant type for operation at voltages over 2000.

Table 310-2(h-2)

**Thickness of Varnished-Cambrie Insulation for Single-Conductor Cable, in 64ths of an Inch**

Conductor Size AWG or MCM	For Voltages Not Exceeding				
	1000	2000	3000	4000	5000
14	4	..	..	..	..
12	4	5	..	..	..
10	4	5	6	..	..
8-2	4	5	6	7	9
1-4/0	5	6	6	7	9
213-500	6	6	7	8	10
501-1000	7	7	7	8	10
1001-2000	8	8	8	9	10

Table 310-2(h-3)

**Thickness of Varnished-Cambric Insulation for  
Multiple-Conductor Cable, in 64ths of an Inch**

Conductor Size AWG or MCM	For Voltages Not Exceeding									
	1000		2000		3000		4000		5000	
	C	B	C	B	C	B	C	B	C	B
14	4	0	..	..	..	..	..	..	..	..
12	4	0	5	0	..	..	..	..	..	..
10	4	0	5	0	5	2	..	..	..	..
8-2	4	0	5	0	5	2	6	3	6	4
1-4/0	5	0	6	0	6	2	6	3	6	4
213-500	6	0	6	0	6	2	6	3	7	4
501-1000	6	2	6	2	6	3	6	4	7	4
1001-2000	7	2	7	2	7	3	7	4	7	5

The thickness given in columns headed "C" are for the insulation on the individual conductors. Those given in the columns headed "B" are for the thickness of the overall belt of insulation.

Table 310-2(h-4)

**Thickness of Asbestos and Varnished-Cambric  
Insulation for Single-Conductor Cable,  
Types AVA, AVB and AVL, in Mils**

Conductor AWG or MCM	1st Wall Asbestos	Varnished Cambric					Asbestos 2nd Wall
	For Voltages Not Exceeding						
	1000-5000	1000	2000	3000	4000	5000	1000-5000
14-2	15	45	60	80	100	120	25
1-4/0	20	45	60	80	100	120	30
213-500	25	45	60	80	100	120	40
501-1000	30	45	60	80	100	120	40
1001-2000	30	55	75	95	115	140	50

**310-3. Insulating Materials.**

(a) The rubber insulations include those made from natural and synthetic rubber, neoprene and other vulcanizable materials.

(b) Thermoplastic insulation may stiffen at temperatures below minus 10°C (14°F) and care should be used in its installation at such temperatures. It may be deformed when subject to pressure; care should be taken in its installation, as for example, at bushings, or points of support. See Section 373-6(b).

**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.

**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-resistant, rubber-covered (Type RW); moisture and heat-resistant, rubber-covered (Type RHW); moisture-resistant, thermoplastic-covered (Type TW); moisture and heat-resistant, thermoplastic-covered (Type THW); lead covered; mineral insulated-metal sheathed (Type MI); 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 Type USE, except that branch circuit and feeder cable may be Type 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 enforcing the Code.

**310-7. Corrosive Conditions.** Conductors exposed to oils, greases, vapors, gases, fumes, liquids or other substances having a deleterious effect upon the conductor or insulation shall be of a type approved for the purpose.

**310-8. Minimum Size of Conductors.** Conductors, whether solid or stranded, shall not be smaller than No. 14, except

for printing press control circuits; as provided for flexible cords in Section 400-7; for fixture wire in Section 410-18; for fractional horsepower motors in Section 430-22; for cranes and hoists in Section 610-14; for elevator control and signal circuits in Section 620-12; for machine tools in Section 670-21; and for remote-control, low-energy power, low-voltage power and signal circuits in Section 725-13.

**310-9. Stranded Conductors.** Except when used as bus bars or in Type MI Cable, 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 they are of the same length and have the same circular-mil area and type of insulation. Where conductors are run in multiple, they shall be arranged and terminate at both ends in such a manner as to insure equal division of the total current between all conductors that are involved.

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

**310-11. Current-Carrying Capacity.** The maximum, continuous, current-carrying capacities of copper conductors are given in Tables 310-12 and 310-13. The current-carrying capacities of aluminum conductors are given in Tables 310-14 and 310-15.

### Notes To Tables 310-12 through 310-15.

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.

2. **Application of Tables.** For open wiring on insulators and for concealed knob-and-tube work, the allowable current-carrying capacities of Tables 310-13 and 310-15 shall be used. For all other recognized wiring methods, the allowable current-carrying capacities of Tables 310-12 and 310-14 shall be used,

unless otherwise provided in this Code.

3. **Aluminum Conductors.** For aluminum conductors, the allowable current-carrying capacities shall be in accordance with Tables 310-14 and 310-15.

4. **Bare Conductors.** Where bare conductors are used with insulated conductors, their allowable current-carrying capacity shall be limited to that permitted for the insulated conductors of the same size.

5. **Type MI Cable.** The temperature limitation on which the current carrying capacities of Type MI cable are based, is

determined by the insulating materials used in the end seal. Termination fittings incorporating unimpregnated organic insulating materials are limited to 85°C. operation.

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.

7. Use of Conductors With Higher Operating Temperatures. Where the room temperature is within 10 degrees C of the maximum allowable operating temperature of the insulation, it is desirable to use an insulation with a higher maximum allowable operating temperature; although insulation can be used in a room temperature approaching its maximum allowable operating temperature limit if the current is reduced in accordance with the Correction Factors for different room temperatures.

8. More Than Three Conductors in a Raceway or Cable. Tables 310-12 and 310-14 give the allowable current-carrying capacities for not more than three conductors in a raceway or cable. Where the number of conductors in a raceway or cable exceeds three, the allowable current-carrying capacity of each conductor shall be reduced as shown in the following Table:

Number of Conductors	Per Cent of Values in Tables 310-12 and 310-14
4 to 6	80
7 to 24	70
25 to 42	60
43 and above	50

*Exception — When conductors of different systems, as provided*

*in Section 300-3, are installed in a common raceway the derating factors shown above apply to the number of Power and Lighting (Articles 210, 215, 220 and 230) conductors only.*

9. Where Type RH-RW rubber insulated wire is used in wet locations the allowable current carrying capacities shall be that of Column 2 in Tables 310-12 through 310-15. Where used in dry locations the allowable current carrying capacities shall be that of Column 3 in Tables 310-12 through 310-15.

10. Overcurrent Protection. Where the standard ratings and settings of overcurrent devices do not correspond with the ratings and settings allowed for conductors, the next higher standard rating and setting may be used.

11. Neutral Conductor. A neutral conductor which carries only the unbalanced current from other conductors, as in the case of normally balanced circuits of three or more conductors, shall not be counted in determining current-carrying capacities as provided for in Note 8.

In a 3-wire circuit consisting of two phase wires and the neutral of a 4-wire, 3-phase system, a common conductor carries approximately the same current as the other conductors and is not therefore considered as a neutral conductor.

12. Voltage Drop. The allowable current-carrying capacities in Tables 310-12 through 310-15 are based on temperature alone and do not take voltage drop into consideration.

13. Deterioration of Insulation. It should be noted that even the best grades of rubber insulation will deteriorate in time, so eventually will need to be replaced.

**Table 310-12. Allowable Current-Carrying Capacities of Insulated Copper Conductors in Amperes**

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

Size AWG MCM	Rubber Type R Type RW	Rubber Type RH	Paper	Asbestos Var-Cam Type AVA Type AVL	Impreg- nated Asbestos Type AI (14-8) Type AIA	Asbestos Type A (14-8) Type AA
	Type RU Type RUW (14-2)	RUH (14-2)	Thermo- plastic Asbestos Type TA SA			
	Type RH-RW See Note 9	Type RH-RW See Note 9	Var-Cam Type V			
	Thermo- plastic Type T Type TW	Type RHW Thermo- plastic Type THW	Asbestos Var-Cam Type AVB			
			MI Cable			
			RHH†			
14	15	15	25	30	30	30
12	20	20	30	35	40	40
10	30	30	40	45	50	55
8	40	45	50	60	65	70
6	55	65	70	80	85	95
4	70	85	90	105	115	120
3	80	100	105	120	130	145
2	95	115	120	135	145	165
1	110	130	140	160	170	190
0	125	150	155	190	200	225
00	145	175	185	215	230	250
000	165	200	210	245	265	285
0000	195	230	235	275	310	340
250	215	255	270	315	335	....
300	240	285	300	345	380	....
350	260	310	325	390	420	....
400	280	335	360	420	450	....
500	320	380	405	470	500	....
600	355	420	455	525	545	....
700	385	460	490	560	600	....
750	400	475	500	580	620	....
800	410	490	515	600	640	....
900	435	520	555	....	....	....
1000	455	545	585	680	730	....
1250	495	590	645	....	....	....
1500	520	625	700	785	....	....
1750	545	650	735	....	....	....
2000	560	665	775	840	....	....

**CORRECTION FACTORS, ROOM TEMPS. OVER 30° C. 86° F.**

C.	F.					
40	104	.82	.88	.90	.94	.95
45	113	.71	.82	.85	.90	.92
50	122	.58	.75	.80	.87	.89
55	131	.41	.67	.74	.83	.86
60	140	....	.58	.67	.79	.83
70	158	....	.35	.52	.71	.76
75	167	....	....	.43	.66	.72
80	176	....	....	.30	.61	.69
90	194	....	....	....	.50	.61
100	212	....	....	....	....	.51
120	248	....	....	....	....	....
140	284	....	....	....	....	....

†The current-carrying capacities for Type RHH conductors for sizes AWG 14, 12 and 10 shall be the same as designated for Type RII conductors in this Table.

**Table 310-13. Allowable Current-Carrying Capacities of Insulated Copper Conductors in Amperes**Single Conductor in Free Air  
(Based on Room Temperature of 30° C. 86° F.)

Size AWG MCM	Rubber Type R Type RW	Rubber Type RH	Thermo- plastic Asbestos Type TA SA	Asbestos Var-Cam Type AVA Type AVL	Impreg- nated Asbestos Type AI (14-8) Type AIA	Asbestos Type A (14-8) Type AA	Slow- Burning Type SB
	Type RU Type RUW (14-2)	RUH (14-2)	Var-Cam Type V				
	Type RH-RW See Note 9	Type RH-RW See Note 9	Asbestos Var-Cam Type AVB				
	Thermo- plastic Type T Type TW	Type RHW Thermo- plastic Type THW	MI Cable				
			RHH†				
14	20	20	30	40	40	45	30
12	25	25	40	50	50	55	40
10	40	40	55	65	70	75	55
8	55	65	70	85	90	100	70
6	80	95	100	120	125	135	100
4	105	125	135	160	170	180	130
3	120	145	155	180	195	210	150
2	140	170	180	210	225	240	175
1	165	195	210	245	265	280	205
0	195	230	245	285	305	325	235
00	225	265	285	330	355	370	275
000	260	310	330	385	410	430	320
0000	300	360	385	445	475	510	370
250	340	405	425	495	530	....	410
300	375	445	480	555	590	....	460
350	420	505	530	610	655	....	510
400	455	545	575	665	710	....	555
500	515	620	660	765	815	....	630
600	575	690	740	855	910	....	710
700	630	755	815	940	1005	....	780
750	655	785	845	980	1045	....	810
800	680	815	880	1020	1085	....	845
900	730	870	940	....	....	....	905
1000	780	935	1000	1165	1240	....	965
1250	890	1065	1130	....	....	....	....
1500	980	1175	1260	1450	....	....	1215
1750	1070	1280	1370	....	....	....	....
2000	1155	1385	1470	1715	....	....	1405

**CORRECTION FACTORS, ROOM TEMPS. OVER 30° C. 86° F.**

C. F.							
40 104	.82	.88	.90	.94	.95	....	....
45 113	.71	.82	.85	.90	.92	....	....
50 122	.58	.75	.80	.87	.89	....	....
55 131	.41	.67	.74	.83	.86	....	....
60 140	....	.58	.67	.79	.83	.91	....
70 158	....	.35	.52	.71	.76	.87	....
75 167	....	....	.43	.66	.72	.86	....
80 176	....	....	.30	.61	.69	.84	....
90 194	....	....	....	.50	.61	.80	....
100 212	....	....	....	....	.51	.77	....
120 248	....	....	....	....	....	.69	....
140 284	....	....	....	....	....	.59	....

†The current-carrying capacities for Type RHH conductors for sizes AWG 14, 12 and 10 shall be the same as designated for Type RH conductors in this Table.

Weatherproof-covered conductors used for service drops have the same current-carrying capacity as Type SB.

**Table 310-14. Allowable Current-Carrying Capacities of Insulated Aluminum Conductors in Amperes**

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

Size AWG MCM	Rubber Type R, RW, RU, RUW (12-2)	Rubber Type RHH (14-2)	Thermo- plastic Asbestos Type TA SA	Asbestos Var-Cam Type AVA Type AVB Type AVL	Impreg- nated Asbestos Type AI (14-8) Type AIA	Asbestos Type A (14-8) Type AA
	Type RH-RW Note 9	Type RH-RW Note 9†	Var-Cam Type V			
	Thermo- plastic Type T, TW	Type RHH Thermo- plastic Type THW	Asbestos Var-Cam Type AVB			
			MI Cable			
			RHH†			
12	15	15	25	25	80	80
10	25	25	30	35	40	45
8	30	40	40	45	50	55
6	40	50	55	60	65	75
4	55	65	70	80	90	95
3	65	75	80	95	100	115
*2	75	90	95	105	115	130
*1	85	100	110	125	135	150
*0	100	120	125	150	160	180
*00	115	135	145	170	180	200
*000	130	155	165	195	210	225
*0000	155	180	185	215	245	270
250	170	205	215	250	270	....
300	190	230	240	275	305	....
350	210	250	260	310	335	....
400	225	270	290	335	360	....
500	260	310	330	380	405	....
600	285	340	370	425	440	....
700	310	375	395	455	485	....
750	320	385	405	470	500	....
800	330	395	415	485	520	....
900	355	425	455	....	....	....
1000	375	445	480	560	600	....
1250	405	485	530	....	....	....
1500	435	520	580	650	....	....
1750	455	545	615	....	....	....
2000	470	560	650	705	....	....

**CORRECTION FACTORS, ROOM TEMPS. OVER 30° C. 86° F.**

C.	F.						
40	104	.82	.88	.90	.94	.95	....
45	113	.71	.82	.85	.90	.92	....
50	122	.58	.75	.80	.87	.89	....
55	131	.41	.67	.74	.83	.86	....
60	140	....	.58	.67	.79	.83	.91
70	158	....	.35	.52	.71	.76	.87
75	167	....	....	.43	.66	.72	.86
80	176	....	....	.30	.61	.69	.84
90	194	....	....	....	.50	.61	.80
100	212	....	....	....	....	.51	.77
120	248	....	....	....	....	....	.69
140	284	....	....	....	....	....	.59

\*For three wire, single phase service and sub-service circuits, the allowable current-carrying capacity of RH, RH-RW, 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 current-carrying capacities for Type RHH conductors for sizes AWG 12, 10 and 8 shall be the same as designated for Type RH conductors in this Table.

**Table 310-15. Allowable Current-Carrying Capacities of Insulated Aluminum Conductors in Amperes**

Single Conductor in Free Air  
(Based on Room Temperature of 30° C. 86° F.)

Size AWG MCM	Rubber Type R, RW, RU, RUW (12-2)	Rubber Type RH	Thermo- plastic Asbestos Type TA SA	Asbestos Var-Cam Type AVA Type AVL	Impreg- nated Asbestos Type AI (14-8) Type AIA	Asbestos Type A (14-8) Type AA	Slow- Burning Type SB
	Type RH-RW Note 9	RUH (14-2)	Var-Cam Type V				
		Type RH-RW Note 9	Asbestos Var-Cam Type AVB				
		Type RHW	MI Cable				
	Thermo- plastic Type T, TW	Thermo- plastic Type THW	RHH†				
12	20	20	30	40	40	45	30
10	30	30	45	50	55	60	45
8	45	55	55	65	70	80	55
6	60	75	80	95	100	105	80
4	80	100	105	125	135	140	100
3	95	115	120	140	150	165	115
2	110	135	140	165	175	185	135
1	130	155	165	190	205	220	160
0	150	180	190	220	240	255	185
00	175	210	220	255	275	290	215
000	200	240	255	300	320	335	250
0000	230	280	300	345	370	400	290
250	265	315	330	385	415	....	320
300	290	350	375	435	460	....	360
350	330	395	415	475	510	....	400
400	355	425	450	520	555	....	435
500	405	485	515	595	635	....	490
600	455	545	585	675	720	....	560
700	500	595	645	745	795	....	615
750	515	620	670	775	825	....	640
800	535	645	695	805	855	....	670
900	580	700	750	....	....	....	725
1000	625	750	800	930	990	....	770
1250	710	855	905	1175	....	....	985
1500	795	950	1020	....	....	....	....
1750	875	1050	1125	....	....	....	....
2000	960	1150	1220	1425	....	....	1165

**CORRECTION FACTORS, ROOM TEMPS. OVER 30° C. 86° F.**

C. F.							
40 104	.82	.88	.90	.94	.95	....	....
45 113	.71	.82	.85	.90	.92	....	....
50 122	.58	.75	.80	.87	.89	....	....
55 131	.41	.67	.74	.83	.86	....	....
60 140	....	.58	.67	.79	.83	.91	....
70 158	....	.35	.52	.71	.76	.87	....
75 167	....	....	.43	.66	.72	.86	....
80 176	....	....	.30	.61	.69	.84	....
90 194	....	....	....	.50	.61	.80	....
100 212	....	....	....	....	.51	.77	....
120 248	....	....	....	....	....	.69	....
140 284	....	....	....	....	....	.59	....

†The current-carrying capacities for Type RHH conductors for sizes AWG 12, 10 and 8 shall be the same as designated for Type RH conductors in this Table.

Weatherproof-covered conductors used for service drops have the same current-carrying capacity as Type SB.

## ARTICLE 320 — OPEN WIRING ON INSULATORS

**320-1. Definition.** Open wiring is a wiring method using cleats, knobs, tubes and flexible tubing for the protection and support of insulated conductors run in or on buildings, and not concealed by the building structure.

**320-2. Use.** Open wiring on insulators may be used for exposed work, either inside or outside building; in dry or wet locations; where subject to corrosive vapors such as covered by Article 480; for services as covered by Article 230, provided the requirements of this Article are satisfied.

Open wiring on insulators shall not be used (1) in commercial garages, (2) in theaters, (3) in motion-picture studios, (4) in hoistways, and (5) in hazardous locations, except in storage compartments of Class III locations as provided in Paragraph 503-3(b).

**320-3. Other Articles.** In addition to the provisions of this Article, open wiring shall conform to the other applicable provisions of this Code. See especially Articles 300 and 730.

**320-4. Conductors.** The type of conductors shall conform to Article 310. Only single conductors shall be used.

(a) The allowable current-carrying capacities of insulated conductors as shown in Tables 310-13 and 310-15 shall apply to open wiring on insulators.

**320-5. Supports.**

(a) Conductors shall not be in contact with any object other than their insulating supports. They shall be rigidly supported on noncombustible, non-absorptive insulating material as follows:

(1) Under ordinary circumstances, supports for wiring over flat surfaces shall be not more than  $4\frac{1}{2}$  feet apart. Where the conductors are likely to be disturbed, the distance between supports shall be shortened sufficiently to provide adequate support for conductors;

(2) Conductors shall be supported within 6 inches of a tap;

(3) Conductors shall not be dead ended at a rosette, lampholder, or receptacle unless the last support is within 12 inches of the device.

(b) The following exceptions to the provisions of Paragraph 320-5(a) may be permitted:

*Exception No. 1. For use of non-metallic flexible tubing, see Section 320-7.*

*Exception No. 2. Conductors of No. 8 or larger installed in the open across open spaces where not likely to be disturbed, may be supported at distances not greater than 15 feet provided that approved noncombustible, non-absorptive insulating separators assuring not less than  $2\frac{1}{2}$ -inch separation between conductors, are installed at intervals of not over  $4\frac{1}{2}$  feet.*

*Exception No. 3. In buildings of mill construction where not likely to be disturbed, feeders in the open, not smaller than No. 8, may be separated about six inches and installed direct from timber to timber, being supported from each timber only.*

(c) When nails are used to mount knobs they shall not be smaller than 10 penny. When screws are used to mount knobs, or when nails or screws are used to mount cleats, they shall be of a length sufficient to penetrate the wood to a depth equal to at least one-half the height of the knob and fully the thickness of the cleat. Cushion washers shall be used with nails.

**320-6. Conductor Separation.** Open conductors shall be separated as follows:

(a) For voltage not exceeding 300 volts between conductors,  $2\frac{1}{2}$  inches from each other and shall be separated from the surface wired over at least  $\frac{1}{2}$  inch in dry locations.

(b) For voltages of 301 to 600 volts between conductors, 4 inches from each other and shall be separated from surface wired over at least 1 inch.

(c) In damp or wet locations, a separation of at least 1 inch from the surface wired over shall be maintained for all voltages.

**320-7. Flexible Non-metallic Tubing.** In dry locations, when not exposed to severe physical damage, conductors

may be separately encased in flexible tubing. Tubing shall be in continuous length not exceeding 15 feet, and secured to the surface wired over by straps spaced not exceeding 4½ feet apart.

**320-8. Tie Wires.** No. 8 or larger conductors supported on solid knobs shall be securely tied thereto. Tie wires shall have a covering equivalent to conductors which they confine.

**320-9. Passing Through Walls and Floors.** Open conductors shall be separated from contact with walls, floors, timbers or partitions through which they pass by tubes or bushings of noncombustible, non-absorptive insulating material. Where the bushing is shorter than the hole, a waterproof sleeve of non-inductive material shall be inserted in the hole and an insulating bushing slipped into the sleeve at either end in such a manner as to keep the conductors absolutely out of contact with the sleeve. Each conductor must be carried through a separate tube or sleeve.

**320-10. Separation from Metal Work.** Open conductors shall be separated at least 2 inches from metallic conduit, piping, or other conducting material, and from any exposed lighting, power or signal conductor, or shall be separated therefrom by a continuous and firmly fixed non-conductor additional to the insulation of the conductor. Where any insulating tube is used, it shall be secured at the ends. Deviation from this requirement may, when necessary, be allowed by the authority enforcing this Code.

**320-11. Separation from Piping in Damp Locations.** Open conductors located close to water pipes or tanks, or in other damp locations, shall be so placed that an air space will be permanently maintained between them and pipes which they cross. Where practicable, conductors shall be installed over, rather than under, pipes upon which moisture is likely to gather or which may leak.

**320-12. Protection from Physical Damage.** Where open conductors cross ceiling joists and wall studs, and are exposed to physical damage, they shall be protected by one of the following methods. Conductors within 7 feet from the floor shall be considered exposed to physical damage.

(a) By guard strips not less than 7/8 inch in thickness and at least as high as the insulating supports, placed on each side of and close to the wiring.

(b) By a substantial running board at least  $\frac{1}{2}$  inch thick back of the conductors with side protections. Running boards shall extend at least 1 inch outside the conductors, but not more than 2 inches and the protecting sides shall be at least 2 inches high and at least  $\frac{7}{8}$  inch thick.

(c) By boxing made as above and furnished with cover kept at least 1 inch away from the conductors within. Where protecting vertical conductors on side walls the boxing shall be closed at the top and the holes through which the conductors pass shall be bushed.

(d) By rigid metal conduit or electrical metallic tubing, in which case the rules of Articles 346 or 348 shall apply; or by metal piping, in which case the conductors shall be encased in continuous lengths of approved flexible tubing. The conductors passing through metal enclosures shall be so grouped that current in both directions is approximately equal.

**320-13. In Accessible Attics.** Conductors in unfinished attics or roof spaces shall be installed in accordance with the provisions of Section 324-8.

**320-14. Entering Spaces Subject to Dampness, Wetness or Corrosive Vapors.** Conductors entering or leaving locations subject to dampness, wetness or corrosive vapors shall have drip loops formed on them and shall then pass upward and inward from the outside of buildings, or from the damp, wet, or corrosive location, through noncombustible, non-absorptive insulating tubes. See also Sections 230-49 and 730-21.

**320-15. Switches.**

(a) Surface-type snap switches shall be mounted in accordance with the provisions of Section 380-10. Metal boxes are not required. See Section 380-3.

(b) Other types of switches shall be installed in accordance with the provisions of Section 380-3.

## ARTICLE 324—CONCEALED KNOB-AND-TUBE WORK

**324-1. Definition.** Concealed knob-and-tube wiring is a wiring method using knobs, tubes and flexible non-metallic tubing for the protection and support of insulated conductors concealed in hollow spaces of walls and ceilings of buildings.

**324-2. Use.** Concealed knob-and-tube work may be used in the hollow spaces of walls and ceilings. It shall not be used (1) in commercial garages, (2) in theaters, except as provided in Section 520-4, (3) in motion-picture studios, nor (4) in hazardous locations.

**324-3. Other Articles.** In addition to the provisions of this Article, concealed knob-and-tube wiring shall conform to the other applicable provisions of this Code. See especially Article 300.

**324-4. Conductors.** Only single conductors shall be used. The type of conductors shall conform to Article 310.

**324-5. Supports.** Conductors shall be supported at intervals not exceeding  $4\frac{1}{2}$  feet by knobs or tubes of non-combustible, non-absorptive, insulating material. There shall be a knob within 6 inches from each tap. Tie wires shall comply with Section 320-8. Where such support is impracticable and the conductors are in a dry location, they may be fished when separately enclosed in flexible non-metallic tubing extending in continuous lengths from one support to the next or to a box, or from one box to another.

**324-6. Conductor Separation.**

(a) Conductors shall be separated at least 3 inches and maintained at least 1 inch from the surface wired over.

(b) At distributing centers, meters, outlets, switches or other places where space is limited and the 3-inch separation cannot be maintained, each conductor shall be encased in a continuous length of flexible tubing.

(c) Where practicable, conductors shall be run singly on separate timbers or studding.

**324-7. Separation from Other Objects and Protection.** Conductors shall be separated from other conductors and objects as follows:

(a) The provisions as to rigid supporting and clearance from foreign wires and other objects, as specified for open wiring in Sections 320-9, 320-10, 320-11, and 320-15, shall be complied with.

(b) Conductors passing through cross timbers in plastered partitions shall be protected by an additional non-combustible, non-absorptive insulating tube extending at least 3 inches above the timber.

**324-8. In Unfinished Attics and Roof Spaces.** Conductors in unfinished attics or roof spaces shall comply with the following:

(a) Conductors in unfinished attics and roof spaces shall be run through or on the sides of joists, studs and rafters, except in attics and roof spaces having head room at all points of less than 3 feet in buildings completed before the wiring is installed.

(b) Where conductors in accessible unfinished attics or roof spaces reached by stairway or permanent ladder are run through bored holes in floor joists or through bored holes in studs or rafters within 7 feet of the floor or floor joists, such conductors shall be protected by substantial running boards extending at least 1 inch on each side of the conductors and securely fastened in place.

(c) Where carried along the sides of rafters, studs or floor joists, neither running boards nor guard strips will be required.

**324-9. Boxes of Insulating Material.** Non-metallic outlet boxes may be used as provided in Sections 370-3 and 370-7.

**324-10. Switches.** See Sections 380-3 and 380-10.

## ARTICLE 328—BARE-CONDUCTOR FEEDERS

**328-1. Use.** By special permission, bare conductors installed in accordance with the provisions of Sections 300-1 to 300-22 inclusive and in accordance with the provisions of the following Sections 328-2 to 328-7 inclusive may be used for feeders only. Such bare conductors may be installed only in a chase, channel or shaft of noncombustible material in a building of fire-resistive construction; and only where the voltage between conductors does not exceed 600 volts. Bare conductors shall not be used in damp or wet locations, nor in any hazardous location, nor where subject to corrosive vapor, except in storage-battery rooms as provided in Section 480-7.

**328-2. Size and Capacity of Copper Conductors.** The maximum permissible current shall be 1000 amperes per square inch of cross-sectional area of conductor in unventilated enclosures, and 1200 amperes per square inch in ventilated enclosures. These provisions are not intended to apply to equipment such as controls and switchgear.

**328-3. Branch Taps.** Branch taps from bare-conductor feeders may be installed as specified in Section 240-15; provided that the mechanical protection specified by Exceptions No. 5 and 6 of Section 240-15 shall not be required for that portion of the conductor located in the chase, channel or shaft.

**328-4. Accessibility.** The conductors shall not be accessible to other than qualified persons.

**328-5. Supports.** Conductors shall be supported as follows:

(a) Conductors shall be supported on noncombustible, non-absorptive insulating supports of adequate mechanical strength.

(b) Conductors shall be so supported that a separation between conductors, and between conductors and ground, of not less than that specified in Section 384-26 will be maintained under all conditions of operation.

**328-6. Fire Cutoffs.** Where floors are pierced, suitable cutoffs against vertical travel of fire shall be provided. See also Section 300-21.

**328-7. Special Safeguards.** In addition to the provisions of the preceding sections, the authority enforcing this Code may require other safeguards in view of special conditions that may be met in a particular installation.

## ARTICLE 330—MINERAL INSULATED-METAL SHEATHED CABLE

### Type MI

#### A. General

**330-1. Definition and Construction.** For the purpose of this Article, mineral insulated-metal sheathed Type MI cable is a cable in which one or more electrical conductors are insulated with a highly compressed refractory mineral insulation and enclosed in a liquidtight and gastight metallic tube sheathing. It shall be used with approved fittings for terminating and connecting to boxes, outlets and other equipment.

**330-2. Use.** Mineral insulated-metal sheathed cable may be used for services, feeders and branch circuits in both exposed and concealed work, in dry or wet locations; in Class I, Class II, and Class III hazardous locations as noted in the appropriate Articles; for under plaster extensions as provided in Article 344; and embedded in plaster finish on brick or other masonry. It may be used where exposed to weather or continuous moisture, for underground runs and embedded in masonry, concrete or fill, in buildings in course of construction or where exposed to oil, gasoline, or other conditions not having a deteriorating effect on the metal sheath. The sheath of mineral insulated-metal sheathed cable exposed to destructive corrosive conditions, such as some types of cinder fill, shall be protected by materials suitable for those conditions.

**330-3. Other Articles.** In addition to the provisions of this Article, the installation of mineral insulated-metal sheathed cable shall comply with the other applicable provisions of this Code. See especially Article 300.

#### B. Installation

**330-4. Supports.** Mineral insulated-metal sheathed cable shall be securely supported by approved staples, straps, hangers or similar fittings, so designed and installed as not to injure the cable. Cable shall be secured at intervals not exceeding 6 feet except where cable is fished.

**330-5. Through Studs, Joists and Rafters.** See Section 300-8.

**330-6. Wet Locations.** In portions of dairies, laundries, canneries, and other wet locations, and in locations where walls are frequently washed, the entire wiring system, including all boxes and fittings used therewith, shall be made watertight and the cable shall be mounted so that there is at least one-quarter inch air space between it and the wall or other supporting surface.

**330-7. Bends.** All bends shall be so made that the cable will not be damaged and the radius of the curve of the inner edge of any bend shall be not less than 5 times the diameter of the cable.

**330-8. Terminating Seal.** At all points where mineral insulated-metal sheathed cable terminates an approved seal shall be provided immediately after stripping to prevent entrance of moisture into the mineral insulation. The conductors extending beyond the sheath shall be insulated with an approved insulating material.

**330-9. Fittings.** When Type MI cable is connected to boxes or equipment, the fittings shall be approved for the conditions of service. When single conductor Type MI cables enter metal boxes through separate openings, refer to Section 300-20.

**330-10. Insulation Resistance.** The completed wiring system shall be tested for insulation resistance in accordance with Section 110-19.

### C. Construction Specifications

**330-11. General.** Type MI Cable for 600 volts shall conform to the following:

(a) **Conductors.** The conductors are solid copper and have cross sectional areas corresponding to the standard American Wire Gauge sizes.

(b) **Insulation.** The insulation is a highly compressed refractory mineral which provides proper spacing for the conductors.

(c) **Outer Sheath.** The outer sheath shall be of a continuous copper construction to provide mechanical protection and a moisture seal, and an adequate path for grounding purposes.

## ARTICLE 334—ARMORED CABLE

### Types AC, ACT, ACV and ACL

**334-1. Definition.** An armored cable is a fabricated assembly of insulated conductors and a flexible metallic covering.

**334-2. General.** Armored cable for 600 volts or less shall conform to the following:

(a) **Armor.** All types of armored cables except Types ACL and ACV, in all sizes, shall have an internal bonding strip of either copper or aluminum in intimate contact with the armor for its entire length.

(b) **Marking.** The provisions of Section 310-2 shall apply, except ready identification of the maker shall be by distinctive external markers in the cable armor throughout its entire length.

**334-3. Use.** Armored cable (Type AC or ACT) may be used for both exposed work and concealed work in dry locations; for underplaster extensions as provided in Article 344; and imbedded in plaster finish on brick or other masonry, except in damp or wet locations. Armored cable (ACV) may be used only for exposed work in dry locations in buildings used for industrial or commercial purposes, and shall not be smaller than No. 4, except where approved for over 600 volts under Sections 710-3 and 710-32. Armored 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, or where exposed to oil, gasoline or other conditions having a deteriorating effect on the insulation. Armored cable may be run or fished in the air voids of masonry block or tile walls where such walls are not exposed or subject to excessive moisture or dampness but not below grade line. Armored cable shall not be used (1) in theaters, except as provided in Section 520-4; (2) in motion-picture studios; (3) in any hazardous locations; (4) where exposed to corrosive fumes or vapors; (5) on cranes or hoists, except as provided in Section 610-11 Exception No. 3; (6) in storage battery rooms; nor (7) in hoistways or on elevators, except as provided in Section 620-21.

**334-4. Other Articles.** In addition to the provisions of this Article, armored cable shall conform to other applicable provisions of this Code. See especially Article 300.

**334-5. Supports.** Armored 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 at intervals not exceeding  $4\frac{1}{2}$  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.

**334-6. 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.

(b) In accessible attics and roof spaces, for which see Section 334-8.

(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.

**334-7. Through Studs, Joists and Rafters.** See Section 300-8.

**334-8. In Accessible Attics.** Cable 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 joist across the face of rafters or studing, 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.

**334-9. Protection at Cable Ends.** At all points where the armor 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 armored 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 armored cable to other cable or raceway wiring methods, an outlet box shall be installed at junction point as required in Section 300-15.

**334-10. Bends.** All bends shall be so made that the armor of the cable will not be injured, and the radius of the curve of the inner edge of any bend shall be not less than 5 times the diameter of the cable.

**334-11. Boxes and Fittings.** See appropriate Sections in Article 370.

**334-12. Switches.** See Section 380-3.

**334-13. Conductors.** Conductors used in armored cable for 600 volts or less shall conform to the following:

(a) Conductors shall comply with the requirements for the type of conductors used. Additional protection for the conductors shall be provided as follows: In Type AC, the conductors shall have an over-all moisture-resistant and flame-retardant fibrous covering; in Type ACT, the individual conductors only shall have a moisture-resistant fibrous covering.

**ARTICLE 336—NON-METALLIC SHEATHED CABLE****Types NM and NMC**

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

**336-2. Construction.** Non-metallic sheathed cable shall be an approved Type NM or NMC in sizes No. 14 to 4 AWG inclusive. 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. Overall 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 Article 310, the cable shall carry distinctive marker on exterior for its entire length, specifying cable type, and the name of the manufacturing company.

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

(a) **Type NM.** This type of non-metallic 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 non-metallic 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 Non-Metallic Sheathed Cable.** These types shall not be used as: (1) Service-entrance cable, (2) in commercial garages, (3) in theatres except as provided in Section 520-4, (4) in motion picture studios, (5) in storage battery rooms, (6) in hoistways, (7) in any hazardous location, (8) embedded in poured cement, concrete or aggregate.

**336-4. Other Articles.** In addition to the provisions of this Article, installations of non-metallic sheathed cable shall conform to the other applicable provisions of this Code. See especially Article 300.

**336-5. Supports.** Non-metallic 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 334-8.

**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.** Non-metallic outlet boxes approved for the purpose may be used as provided in Section 370-3.

**ARTICLE 338—SERVICE-ENTRANCE CABLE****Types ASE, SE and USE**

**338-1. Definition.** Service-entrance cable is an assembly of two or more conductors, one of which may be uninsulated, provided with a suitable over-all covering, primarily used for services and conforming with one of the following types:

(a) Type ASE, having inherent protection against mechanical abuse and a flame-retardant, moisture-resistant covering.

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

(c) 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.

**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) 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) Service-entrance cables without individual insulation on the grounded conductor may be used only for range, wall-mounted oven and counter-mounted cooking unit, and clothes dryer circuits, or as feeders from a service cabinet to supply other buildings, or as service-entrance conductors for such other buildings, when the following conditions are met:

(1) The cable has a final non-metallic outer covering.

(2) The supply is alternating current not exceeding 150 volts to ground.

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) 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, service-entrance cable used for interior wiring shall comply with the applicable provisions of Article 300.

(b) Cable with metal interlocking armor shall be installed in accordance with the applicable provisions of Article 334.

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

(d) 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 RW, TW, RUW, 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 carry distinctive markers on exterior for its entire length, specifying cable type, and the name of manufacturing company.

**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 Paragraph 310-2(b).

#### 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 over-current protection not in excess of the rated current carrying capacity of the individual conductors.

(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) Where buried directly in the earth, supplementary mechanical protection, such as a covering board, concrete pad, raceway, etc. when considered necessary, may be required by the authority enforcing the Code.

(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 non-metallic sheathed cable it shall conform with the provisions of Article 336 and shall be of the multiple conductor type.

(e) This type of cable shall not be used: (1) as service-entrance cable, (2) in commercial garages, (3) in theatres except as provided in Section 520-4; (4) in motion picture studios, (5) in storage battery rooms, (6) in hoistways, (7) in any hazardous location, (8) embedded in poured cement, concrete or aggregate.

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

**339-5. Rated Current-Carrying Capacity.** The current-carrying capacity of conductors in Type UF cable shall be according to Tables 310-12 and 310-14.

## ARTICLE 342—NON-METALLIC SURFACE EXTENSIONS

**342-1. Description.** Non-metallic surface extension is an assembly of two insulated conductors within a non-metallic jacket and intended for mounting directly on the surface of walls or ceilings.

**342-2. Other Articles.** In addition to the provisions of this Article, non-metallic surface extensions shall conform to other applicable provisions of this Code.

**342-3. Use Permitted.** A non-metallic surface extension may be used only where all of the following conditions are met:

(a) The extension is from existing outlets on branch circuits.

(b) The extension is run exposed.

(c) The extension is in a dry location.

(d) The building is occupied for residential or office purposes.

**342-4. Use Prohibited.** An extension shall not be installed:

(a) In unfinished basements, attics, or roof spaces.

(b) Where voltage exceeds 150 volts between conductors.

(c) Where subject to corrosive vapors.

**342-5. Location in Room.** One or more extensions may be run in any direction from an existing outlet, but not on the floor or within 2 inches from the floor.

**342-6. Outlets Per Circuit.** The total number of outlets supplied by one branch circuit, including those previously installed and those of the extension, shall be in conformity with the requirements of Article 210.

**342-7. Not to Run Outside Room.** An extension shall not be run through a floor or partition, nor outside the room in which it originates.

**342-8. Supports.** Non-metallic surface extensions shall be secured in place by approved means at intervals not exceed-

ing 8 inches, except that where connection to the supplying outlet is made by means of an attachment plug the first fastening may be placed 12 inches or less from the plug. There shall be at least one fastening between each two adjacent outlets supplied. An extension shall be attached only to woodwork or plaster finish, and shall not be in contact with any metal work or other conductive material except the metal plates on receptacles.

**342-9. Splices and Taps.** Extensions shall consist of a continuous unbroken length of the assembly, without splices, and without exposed conductors between fittings. Taps may be made where fittings completely covering the tap connections are used.

**342-10. Bends.** A bend which reduces the normal spacing between the conductors shall be covered with a cap to protect the assembly from physical damage.

**342-11. Fittings.** Each run shall terminate in a fitting which covers the end of the assembly. All fittings and devices shall be of a type approved for the purpose.

## ARTICLE 344—UNDERPLASTER EXTENSIONS

**344-1. Use.** An underplaster extension installed as permitted by this Article, may be used only for extending an existing branch circuit in a building of fire-resistive construction.

**344-2. Materials.** Such extensions shall be run in rigid or flexible conduit, armored cable, electrical metallic tubing, Type MI cable or metal raceways approved for the purpose. Standard sizes of conduit, cable, tubing and raceways shall be used except that for a single conductor only conduit or tubing having not less than 5/16 inch inside diameter, single-conductor armored cable or single conductor Type MI cable may be used.

**344-3. Box and Fittings.** See Article 370.

**344-4. Installation.** An underplaster extension shall be laid on the face of masonry or other material and buried in the plaster finish of ceilings or walls. The methods of installation of the raceway or cable for such extension shall be as specified elsewhere in this Code for the particular type of material used, except that where alternating current is to be employed, all of the conductors of a circuit need not be contained in a single raceway or cable.

**344-5. Extension to Another Floor.** No such extension shall extend beyond the floor on which it originates unless installed in a standard size of rigid metal conduit, electrical metallic tubing, armored cable, or MI cable.

## ARTICLE 346—RIGID METAL CONDUIT

**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. Conduits and fittings exposed to severe corrosive influences shall be of corrosion-resistant material suitable for the conditions. Where practicable, the use of dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.

Meat-packing plants, tanneries, hide cellars, casing rooms, glue houses, fertilizer rooms, salt storage, some chemical works, metal refineries, pulp and paper mills, sugar mills, round houses, textile bleacheries, plants producing synthetic staples, some stables, and similar locations are judged to be occupancies where severe corrosive conditions are likely to be present.

**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 non-cinder concrete at least 2 inches thick or unless the conduit is at least 18 inches under the fill.

**346-4. Wet Locations.** In portions of dairies, laundries, canneries, and other wet locations, and in locations where walls are frequently washed, the entire conduit system, including all boxes and fittings used therewith, shall be so installed and equipped as to prevent water from entering the conduit and the conduit shall be mounted so that there is at least one-quarter inch air space between the conduit and the wall or other supporting surface.

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

**346-5. Minimum Size.** No conduit smaller than  $\frac{1}{2}$  inch, electrical trade size, shall be used, except as provided for underplaster extensions in Article 344, and for enclosing the leads of motors as permitted in Paragraph 430-145(b).

**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 Tables 1 and 2 of Chapter 9.

(2) Where conductors are of various sizes to be used in combination, use Tables 3 and 4 of Chapter 9 and the dimensions of rubber-covered conductors from Table 5 of Chapter 9.

**(b) Rewiring Existing Conduits:** For rewiring existing conduits, the allowable fill may be determined from Tables 3 and 4 of Chapter 9 using the dimensions from Table 5 of Chapter 9.

**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 Paragraph 373-6(b) for the protection of conductors at bushings.

**346-9. Couplings.**

(a) Threadless couplings and connectors used with conduit shall be made tight. Where installed in wet places or where buried in masonry, concrete or fill shall be of a type to prevent water from entering the conduit.

(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.

**Table 346-10**  
**Radius of Conduit Bends**

Size of Conduit	Conductors Without Lead Sheath	Conductors With Lead Sheath
½ in.	4 in.	6 in.
¾ in.	5 in.	8 in.
1 in.	6 in.	11 in.
1¼ in.	8 in.	14 in.
1½ in.	10 in.	16 in.
2 in.	12 in.	21 in.
2½ in.	15 in.	25 in.
3 in.	18 in.	31 in.
3½ in.	21 in.	36 in.
4 in.	24 in.	40 in.
5 in.	30 in.	50 in.
6 in.	36 in.	61 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. Boxes and Fittings.** See Article 370.

## **B. Construction Specifications**

**346-13. General.** Rigid metal conduit shall conform to the following:

(a) Rigid conduit as shipped shall be in standard lengths of 10 feet including coupling, one coupling to be furnished with each length. Each length shall be reamed and threaded on each end.

(b) Steel conduit shall have an interior coating of a character and appearance so as to readily distinguish it from ordinary pipe commonly used for other than electrical purposes.

(c) Non-ferrous conduit of corrosion-resistant material shall have suitable markings.

## 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 afterwards, 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 non-cinder concrete at least 2 inches thick or unless the tubing is at least 18 inches under the fill.

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

### A. Installation

**348-3. Corrosive Fumes.** Where tubing is exposed to corrosive fumes or vapors such as may exist in meat-packing plants, tanneries, hide cellars, casing rooms, glue houses, fertilizer rooms, salt storage, some chemical works, metal refineries, pulp mills, sugar mills, round houses, some stables, and similar locations, tubing and fittings of corrosion-resistant material suitable for the conditions shall be used. Where practicable, the use of dissimilar metals throughout the system shall be avoided to eliminate the possibility of galvanic action.

**348-4. Wet Locations.** In portions of dairies, laundries, canneries, and other wet locations, and in locations where walls are frequently washed, the entire tubing system, including all boxes and fittings used therewith, shall be so installed and equipped as to prevent water from entering the tubing, and the tubing shall be mounted so that there is at least one-quarter inch air space between the tubing and the wall or other supporting surface.

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

**348-5. Minimum and Maximum Sizes.** No tubing smaller than  $\frac{1}{2}$  inch, electrical trade size, shall be used except as provided for underplaster extensions in Article 344 and for enclosing the leads of motors as permitted in Paragraph 430-145(b). The maximum size of tubing shall be the 2-inch electrical trade size.

**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, and where buried in masonry, concrete, or fill, or where installed in wet places shall be of a type to prevent water from entering the raceway.

**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.

**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. Boxes and Fittings.** See Article 370.

## **B. Construction Specifications**

**348-13. General.** Electrical metallic tubing shall conform to the following:

(a) **Cross Section.** The tubing, and elbows and bends for use with the tubing, shall have a circular cross-section.

(b) **Finish.** Tubing shall have such a finish or treatment of outer surfaces as will provide an approved permanent means of readily distinguishing it, after installation, from rigid conduit.

(c) **Connectors.** Where the tubing is coupled together by threads, the connector shall be so designed as to prevent bending of the tubing at any part of the thread.

## ARTICLE 350—FLEXIBLE METAL CONDUIT

**350-1. Other Articles.** Installations of flexible metal conduit shall comply with the provisions of appropriate (or applicable) provisions of Article 300 and with Sections 334-5, 334-6, 334-10, and 346-5 to 346-8 inclusive.

**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; (2) in hoistways, except as provided in Section 620-21; (3) in storage-battery rooms; (4) in any hazardous location except as permitted by Sections 502-4 and 503-3; nor (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 Paragraph 430-145(b); and (3) for connection not over 48 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.

**Table 350-3**

Size AWG	Maximum Number of Conductors in $\frac{3}{8}$ " Flexible Metal Conduit		
	Types RF-32, R, RH	Type RW-RHW	Types TF, T, TW, RU, RUF, RUW
18	4	—	8
16	3	—	6
14	3	2	5
12	2	2	4
10	—	—	3

## ARTICLE 351—LIQUID-TIGHT FLEXIBLE METAL CONDUIT

**351-1. Purpose.** Liquid-tight flexible metal conduit is not intended as a general purpose raceway material. The provisions of this Article shall apply to a type of flexible conduit having an outer liquid-tight jacket and employed with suitable terminal fittings approved for the purpose.

**351-2. Use.** The use of this wiring material shall be restricted as follows:

(a) For the connection of motors or portable equipment where flexibility of connection is required.

(b) Liquid-tight flexible metal conduit shall not be used under the following conditions: (1) where subject to physical damage; (2) where in contact with rapidly moving parts; (3) under conditions such that its temperature, with or without enclosed conductors carrying current, is above 60°C (140°F); (4) in any hazardous location, except as described in Paragraph 501-4(b) and Sections 502-4 and 503-3, unless it is specially approved for such use.

**351-3. Maximum Size.** The maximum size of liquid-tight flexible metal conduit shall not exceed 1¼ inch electrical trade size.

**351-4. Conductor Size.** The maximum size of conductor installed in liquid-tight flexible metal conduit shall not exceed the following values:

Trade Size of Conduit	Size of Conductor
⅜ inch	16 Awg
½ inch	12 Awg
¾ inch	8 Awg
1 inch	6 Awg
1¼ inch	2 Awg

## ARTICLE 352—SURFACE METAL RACEWAYS

**352-1. Use.** Surface metal raceway may be installed in dry locations. It shall not be used (1) where concealed, except that metal raceways approved for the purpose may be used for underplaster extensions; (2) where subject to severe physical damage unless approved for the purpose; (3) where the voltage is 300 volts or more between conductors unless the metal has a thickness of not less than .040 inches; (4) where subject to corrosive vapors; (5) in hoistways; nor (6) in any hazardous location.

**352-2. Other Articles.** Installations of surface metal raceways shall comply with the applicable provisions of Article 300.

### A. Installation

**352-3. Size of Conductors.** No conductor larger than No. 6 shall be installed in surface metal raceway.

**352-4. Number of Conductors in Raceways.** The number of conductors installed in any raceway shall be no greater than the number for which the raceway is designed.

**352-5. Extension Through Walls and Floors.** Except in multi-outlet assemblies, raceways may be extended through dry walls, dry partitions and dry floors, if in unbroken lengths where passing through.

**352-6. Combination Raceways.** Where combination metal raceways are used both for signal and for lighting and power circuits, the different systems shall be run in separate compartments, identified by sharply contrasting colors of the interior finish, and the same relative position of compartments shall be maintained throughout the premises.

### B. Construction Specifications

**352-7. General.** Surface metal raceways shall be of such construction as will distinguish them from other raceways. Surface metal raceways and their elbows, couplings, and similar fittings shall be so designed that the sections can be electrically and mechanically coupled together, while protecting the wires from abrasion. Holes for screws or bolts inside the raceway shall be so designed that when screws or bolts are in place their heads will be flush with the metal surface.

## **ARTICLE 353—MULTI-OUTLET ASSEMBLY**

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

**353-2. Use.** Multi-outlet assembly may be installed in dry locations. It shall not be installed (1) where concealed, except that the back and sides of metal multi-outlet assembly may be surrounded by the building finish and non-metallic multi-outlet assembly may be recessed in the baseboard; (2) where subject to severe physical damage unless approved for the purpose; (3) where the voltage is 300 volts or more between conductors unless assembly is of metal having a thickness of not less than .040 inches; (4) where subject to corrosive vapors; (5) in hoistways; nor (6) in any hazardous locations.

**353-3. Metal Multi-Outlet Assembly Through Dry Partitions.** Metal multi-outlet 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 falls within the partitions.

## ARTICLE 354—UNDERFLOOR RACEWAYS

**354-1. Other Articles.** Installations of underfloor raceways shall comply with the applicable provisions of Article 300.

**354-2. Use.** Underfloor raceways may be installed beneath the surface of concrete or other flooring material, or in office occupancies, where laid flush with the concrete floor and covered with linoleum or equivalent floor covering. Open-bottom type of raceways may be installed in concrete fill between the rough and the finished floor only. Underfloor raceways shall not be installed (1) where subject to corrosive vapors nor (2) in any hazardous location.

**354-3. Covering.** Raceway coverings shall conform to the following:

(a) **Raceways Not Over 4 Inches Wide.** Half-round raceways not over 4 inches in width, and, except as permitted in paragraph (c) of this section, flat-top raceways not over 4 inches in width, shall have not less than  $\frac{3}{4}$  inches of concrete or wood above the raceway.

(b) **Raceways Over 4 Inches in Width or With Less Than  $\frac{1}{2}$  Inch Separation.** Flat-top raceways over 4 inches in width or raceways of any width placed less than  $\frac{1}{2}$  inch apart, shall be covered with concrete to a depth of not less than  $1\frac{1}{2}$  inches.

(c) **Raceways Flush With Concrete.** In office occupancies, approved metal flat-top raceways if not over 4 inches in width may be laid flush with the concrete floor surface provided they are covered with substantial linoleum not less than  $\frac{1}{8}$  inch in thickness or with equivalent floor covering. Where more than one and not more than three single raceways are each installed flush with the concrete, they must be (1) contiguous with each other and joined to form a rigid assembly, or (2) spaced not less than  $\frac{1}{2}$  inch apart.

**354-4. Size of Conductors.** No conductor larger than that for which the raceway is approved shall be installed in underfloor raceways and the largest size conductor allowed shall be 500,000 cm.

**354-5. Number of Conductors in Raceway.** The combined cross-sectional area of all conductors shall not exceed 40 per cent of the interior area of the raceway; except that where the raceway contains only armored cable or non-metallic sheathed cable, these requirements shall not apply.

**354-6. Splices and Taps.** Splices or taps shall be made only in junction boxes.

**354-7. Discontinued Outlets.** When an outlet is discontinued, the conductors supplying the outlet shall be removed from the raceway.

**354-8. Open-Bottom Raceway—How Laid.** Open-bottom raceways shall be mechanically secured to the concrete pad. Open-bottom raceways shall be laid on a smooth pad of concrete extending at least 1 inch on each side of the raceway and at least 1 inch thick.

*Exception No. 1. This thickness may be reduced to  $\frac{1}{4}$  inch where the raceway crosses a run of conduit.*

*Exception No. 2. That in lieu of a concrete pad, fittings which will protect the conductors from contact with piping, structural steel and other obstructions may be used.*

**354-9. Laid in Straight Lines.** Underfloor raceways shall be laid so that a straight line from the center of one junction box to the center of the next junction box will coincide with the center line of the raceway system. Raceways shall be firmly held in place to prevent disturbing this alignment during construction.

**354-10. Markers at Ends.** At every end of line of raceway, a fitting shall be installed extending through the surface of the floor to mark the line of the duct. Where a duct line is interrupted by another duct line, but continues in a straight line beyond, and has junction boxes or outlets on either side of the crossing line, no markers are necessary at the interrupting point.

**354-11. Dead Ends.** Dead ends of raceways shall be closed.

**354-12. Low Points.** Where practicable, raceways and their fittings shall be so arranged as to avoid low points that may form traps for water.

**354-13. Fittings at Angles.** Where raceways are run at other than right angles, special fittings shall be provided,

when in the judgment of the authority enforcing this Code, these are necessary.

**354-14. Junction Boxes.** Junction boxes shall be leveled to the floor grade and sealed against the entrance of water. Junction boxes used with metal raceways shall be metal and shall be electrically continuous with the raceways.

**354-15. Inserts.** Inserts shall be leveled to the floor grade and sealed against the entrance of water. Inserts used with metal raceways shall be metal and shall be electrically continuous with the raceway. Inserts set in or on fiber raceways before the floor is laid shall be mechanically secured to the raceway. Inserts set in fiber raceways after the floor is laid shall be screwed into the raceway. In cutting through the raceway wall and setting inserts, chips and other dirt shall not be allowed to fall into the raceway, and tools shall be used which are so designed as to prevent the tool from entering the raceway and injuring conductors that may be in place.

**354-16. Connections to Cabinets and Wall Outlets.** Connections between raceways and distribution centers and wall outlets shall be made by means of rigid or flexible metal conduit or by means of fittings specially approved for the purpose.

**354-17. Boxes and Fittings.** See Article 370.

## ARTICLE 356—CELLULAR METAL FLOOR RACEWAYS

**356-1. Definitions.** For the purposes of this Article, a "cellular metal floor raceway" shall be defined as the hollow spaces of cellular metal floors, together with suitable fittings, which may be approved as enclosures for electrical conductors; a "cell" shall be defined as a single, enclosed tubular space in a cellular metal floor member, the axis of the cell being parallel to the axis of the metal floor member; a "header" shall be defined as a transverse raceway for electrical conductors, providing access to predetermined cells of a cellular metal floor, thereby permitting the installation of electrical conductors from a distribution center to the cells.

**356-2. Use.** Conductors shall not be installed in cellular metal floor raceways (1) where subject to corrosive vapor; (2) in any hazardous location; nor (3) in commercial garages, except for supplying ceiling outlets or extensions to the area below the floor but not above. No electric conductors shall be installed in any cell or header which contains a pipe for steam, water, air, gas, drainage, or other service than electrical.

**356-3. Other Articles.** Installations of conductors in the raceways of cellular metal floor shall comply with the applicable provisions of Article 300.

### A. Installation

**356-4. Size of Conductors.** No conductor larger than No. 0 shall be installed, except by special permission.

**356-5. Number of Conductors In Raceway.** The combined cross-sectional area of all conductors shall not exceed 40 per cent of the interior area of the header feeding the individual cells; except that where the raceway contains only armored cable or non-metallic sheathed cable, these requirements shall not apply.

**356-6. Splices and Taps.** Splices and taps shall be made only in header access units or junction boxes.

**356-7. Discontinued Outlets.** When an outlet is discontinued, the conductors supplying the outlet shall be removed from the raceway.

**356-8. Markers.** A suitable number of markers shall be installed extending through the floor for the future locating of cells and for system identification.

**356-9. Junction Boxes.** Junction boxes shall be levelled to the floor grade and sealed against the entrance of water. Junction boxes used with these raceways shall be of metal and shall be electrically continuous with the raceway.

**356-10. Inserts.** Inserts shall be levelled to the floor grade and sealed against the entrance of water. Inserts shall be of metal and shall be electrically continuous with the raceway. In cutting through the cell wall and setting inserts, chips and other dirt shall not be allowed to fall into the raceway, and tools shall be used which are designed to prevent the tool from entering the cell and injuring the conductors.

**356-11. Connection to Cabinets and Extensions from Cells.** Connections to cabinets and extensions from cells to outlets shall be made by means of rigid or flexible conduit or by means of fittings approved for the purpose.

## **B. Construction Specifications**

**356-12. General.** Cellular metal floor raceways shall be so constructed that adequate electrical and mechanical continuity of the complete system will be secured. They shall provide a complete enclosure for the conductors. The interior surfaces shall be free from burrs and sharp edges, and surfaces over which conductors are drawn shall be smooth. Suitable bushings or fittings having smooth rounded edges shall be provided where conductors pass.

## ARTICLE 358—CELLULAR CONCRETE FLOOR RACEWAYS

**358-1. Scope.** Precast cellular concrete floor raceways shall comply with the applicable requirements of Article 300, and shall also comply with the provisions of Sections 358-2 to 358-11 inclusive. For the purpose of this Article, "precast cellular concrete floor raceways" shall be defined as the hollow spaces in floors constructed of precast cellular concrete slabs, together with suitable metal fittings designed to provide access to the floor cells in an approved manner. A "cell" shall be defined as a single, enclosed tubular space in a floor made of precast cellular concrete slabs, the direction of the cell being parallel to the direction of the floor member. "Header ducts" shall be defined as transverse metal raceways for electrical conductors, furnishing access to predetermined cells of a precast cellular concrete floor, thus providing for the installation of electrical conductors from a distribution center to the floor cells.

**358-2. Use.** Conductors shall not be installed in precast cellular concrete floor raceways (1) where subject to corrosive vapor; (2) in hazardous locations; nor (3) in commercial garages, except for supplying ceiling outlets or extensions to the area below the floor but not above. No electrical conductors shall be installed in any cell or header which contains a pipe for steam, water, air, gas, drainage, or any service other than electrical.

**358-3. Header Duct.** The header duct shall be installed in a straight line, at right angles to the cells. The header duct shall be mechanically secured to the top of the precast cellular concrete floor. The end joints shall be closed by metallic closure fittings and sealed against the penetration of water. The header duct shall be electrically continuous throughout its entire length and shall be electrically bonded to the enclosure of the distribution center.

**358-4. Connection to Cabinets and Other Enclosures.** Connection from header duct to cabinets and other enclosures shall be made by means of metallic duct and fittings approved for the purpose.

**358-5. Junction Boxes.** Junction boxes shall be levelled to the floor grade and sealed against the entrance of water. Junction boxes shall be of metal and shall be mechanically and electrically continuous with the header ducts.

**358-6. Markers.** Each hidden access point between a header and a cell intended for future use shall be provided with a marker extending through the floor covering. A suitable number of markers shall be installed, extending through the floor covering, to locate the cells and to provide system identification.

**358-7. Inserts.** Inserts shall be levelled to the floor grade and sealed against the entrance of water. Inserts shall be of metal and shall be fitted with receptacles of the grounded type. A ground conductor shall connect the insert receptacles to a positive ground connection provided on the header duct. In cutting through the cell wall for setting inserts or other purposes (such as providing access openings between header duct and cells) chips and other dirt shall not be allowed to fall into the raceway, and the tool used shall be so designed as to prevent the tool from entering the cell and injuring the conductors.

**358-8. Size of Conductors.** No conductor larger than No. 0 shall be installed, except by special permission.

**358-9. Number of Conductors in Raceway.** The combined cross-sectional area of all conductors in any header shall not exceed 40 per cent of the interior cross-sectional area of such header; except that where the header contains only armored cable or non-metallic sheathed cable, or both, this limitation shall not apply.

**358-10. Splices and Taps.** Splices and taps shall be made only in header duct access units or junction boxes.

**358-11. Discontinued Outlets.** When an outlet is discontinued, the conductors supplying the outlet shall be removed from the header and cell.

## ARTICLE 362—WIREWAYS

**362-1. Definition.** Wireways are sheet-metal troughs with hinged or removable covers for housing and protecting electrical wires and cable and in which conductors are laid in place after the wireway has been installed as a complete system.

**362-2. Use.** Wireways may be installed only for exposed work. Wireways intended for outdoor use shall be of approved raintight construction. Wireways shall not be installed: (1) where subject to severe physical damage or corrosive vapor; nor (2) in any hazardous location.

**362-3. Other Articles.** Installations of wireways shall comply with the applicable provisions of Article 300.

**362-4. Size of Conductors.** No conductor larger than 500,000 c.m. shall be installed in any wireway.

**362-5. Number of Conductors.** Wireways shall not contain more than 30 conductors at any cross section, unless the conductors are for signaling circuits or are control conductors between a motor and its starter and used only for starting duty. The sum of the cross-sectional areas of all contained conductors at any cross-section of a wireway shall not exceed 20 per cent of the interior cross-sectional area of the wireway.

The correction factors specified in Note 8 of Tables 310-12 and 310-14 are not applicable to the foregoing.

**362-6. Splices and Taps.** Splices or taps, made and insulated by approved methods, may be located within the wireway provided they are accessible. The conductors, including splices and taps, shall not fill the wireway to more than 75 per cent of its area at that point.

**362-7. Supports.** Wireways shall be securely supported at intervals not exceeding 5 feet, unless specially approved for supports at greater intervals, but in no case shall the distance between supports exceed 10 feet.

**362-8. Extension Through Walls.** Wireways may extend transversely through dry walls if in unbroken lengths where passing through.

**362-9. Dead-Ends.** Dead-ends of wireways shall be closed.

**362-10. Extensions From Wireways.** Extensions from wireways shall be made with rigid or flexible metal conduit, electrical metallic tubing, surface metal raceway or armored cable.

**362-11. Marking.** Wireways shall be marked so that their manufacturer's name or trade mark will be visible after installation.

## ARTICLE 364—BUSWAYS

**364-1. Other Articles.** Installations of busways shall comply with the applicable provisions of Article 300.

**364-2. Use.** Busways may be installed only for exposed work. Busways shall not be installed (1) where subject to severe physical damage or corrosive vapors; (2) in hoistways; (3) in any hazardous location; nor (4) outdoors or in wet or damp locations unless specially approved for the purpose.

Busways may be used for service-entrance conductors. See Section 230-44.

It is recommended that where secondary systems are operated ungrounded, a combination ground detector and potentializer plug be used as an auxiliary fitting for busway systems to establish a definite potential difference between the bus-bars and the grounded casing of the busways. This will serve to drain off any static or other charge from the entire busway system including its connected apparatus, supply and branch circuit conductors.

**364-3. Support.** Busways shall be securely supported at intervals not exceeding 5 feet, unless specially approved for supports at greater intervals, but in no case shall the distance between supports exceed 10 feet. Where a busway is installed in a vertical position, the supports for the bus-bars shall be designed for vertical installation.

**364-4. Extension Through Walls.** Busways may extend transversely through dry walls if in unbroken lengths where passing through. Busways may extend vertically through dry floors when totally enclosed (unventilated) where passing through and for a minimum distance of six feet above the floor to provide adequate protection from physical damage.

**364-5. Dead-Ends.** A dead-end of a busway shall be closed.

**364-7. Branches from Busways.** Branches from busways shall be made with busways or with rigid or flexible metal conduit, electrical metallic tubing, surface metal raceway, armored cable or with suitable cord assemblies approved for hard usage for portable equipment or for the connection of stationary equipment to facilitate their interchange.

**364-8. Overcurrent Protection.** Overcurrent protection shall be provided in accordance with Sections 364-9 to 364-13 inclusive.

**364-9. Rating of Overcurrent Protection—Feeders and Sub-Feeders.** Where the allowable current rating of the busway does not correspond to a standard rating of the overcurrent device, the next higher rating may be used.

**364-10. Reduction in Size of Busway.** Overcurrent protection may be omitted at points where busways are reduced in size, provided that the smaller busway does not extend more than 50 feet and has a current rating at least equal to one-third the rating or setting of the overcurrent device next back on the line, and provided further that such busway is free from contact with combustible material.

**364-11. Branch Circuits.** Where a busway is used as a feeder, devices or plug-in connections for tapping off branch-circuits from the busway shall contain the overcurrent devices required for the protection of the branch circuits.

*Exception No. 1. For overcurrent protection of taps, see Section 240-15.*

*Exception No. 2. For fixed or semi-fixed lighting fixtures, the branch circuit overcurrent device may be part of the fixture cord plug on cord-connected fixtures.*

*Exception No. 3. Where fixtures without cords are plugged directly into the busway, the overcurrent device may be mounted on the fixture.*

**364-12. Rating of Overcurrent Protection—Branch Circuits.** A busway may be used as a branch circuit of any one of the types described in Article 210. When so used, the rating or setting of the overcurrent device protecting the busway shall determine the ampere rating of the branch circuit, and the circuit shall in all respects conform with the requirements of Article 210 that apply to branch circuits of that rating.

**364-13. Length of Busways Used as Branch Circuits.** Busways which are used as branch circuits and which are so designed that loads can be connected at any point shall be

limited to such lengths as will provide that in normal use the circuits will not be overloaded.

In general, the length of such run in feet should not exceed three times the ampere rating of the branch circuit.

**364-14. Marking.** Busways shall be marked with the voltage and current rating for which they are designed, and with the manufacturer's name or trademark in such manner as to be visible after installation.

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

### A. Scope and General

**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. Installations in hazardous locations shall conform to Articles 500 to 517 inclusive.

**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. Non-Metallic Boxes.** Non-metallic boxes may be used only with open wiring on insulators, concealed knob-and-tube work, non-metallic sheathed cable, and with non-metallic waterproof wiring.

**370-4. Metallic Boxes.** Where used with knob-and-tube work or 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

**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 boxes of non-conductive material be used with non-metallic sheathed cable when such cable is used in locations where there is likely to be occasional moisture present such as in dairy barns.

**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 limitations in Paragraphs 370-6(a and b) shall not apply to terminal housings supplied with motors, nor to

types of boxes or fittings without knockout and having hubs or recessed parts for terminal bushings and locknuts.

Paragraphs 370-6(a and b) do not apply to conductors used for rewiring existing raceways as referred to in Table 3, Chapter 9.

(a) The maximum number of conductors, 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.

**Table 370-6(a-1)—Deep Boxes**

Box Dimensions, Inches Trade Size	Maximum Number of Conductors			
	No. 14	No. 12	No. 10	No. 8
1½ x 3¼ octagonal .....	5	5	4	0
1½ x 4 octagonal .....	8	7	6	5
1¼ x 4 square .....	9	7	6	4
1½ x 4 square .....	11	9	7	5
1½ x 4 11/16 square .....	16	12	10	8
2⅛ x 4 11/16 square .....	20	16	12	10
2 x 1¾ x 2¾ .....	5	4	4	
2½ x 1¾ x 2¾ .....	6	6	5	
3 x 1¾ x 2¾ .....	7	7	6	

Where there is not sufficient space for a deeper box, four No. 14 Awg conductors may enter a box provided with cable clamps and containing one or more devices on a single mounting strap.

**Table 370-6(a-2)—Shallow Boxes  
of Less than 1½ Inches Depth**

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

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

ductors 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.

(b) For combinations not shown in above Tables the following Table shall apply.

**Table 370-6(b)**

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

**370-7. Conductors Entering Boxes or Fittings.** Conductors entering boxes or fitting 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 metal outlet boxes or fittings are installed with open wiring or concealed knob-and-tube work, conductors shall enter through insulating bushings or, in dry places, through flexible tubing extending from the last insulating support and firmly secured to the box or fitting. 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) **Non-Metallic Boxes.** Where non-metallic boxes are used with open wiring or concealed knob-and-tube work, the conductors shall enter through individual holes. Where flexible tubing is used to encase the conductor, the tubing shall extend from the last insulating support and may be run into the box or terminate at the wall of the box. If non-metallic 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.

**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.**

(a) **General.** Boxes, fittings and cabinets shall be securely fastened in place. Boxes and fittings, not over 100 cubic inches in size, which are attached to firmly secured exposed raceway by threading or other connection designed for the purpose, are considered as so fastened.

(b) **Concealed Work.** In concealed work, except as prescribed in Paragraph 370-13(c), boxes and fittings, unless securely held in place by concrete, masonry or other building material in which they are embedded, shall be secured to a stud, joist or similar fixed structural unit, or to a metal or wooden support which is secured to such a structural unit. Wooden supports shall be not less than  $\frac{7}{8}$  inch in thickness. Lath of wood, metal or composition shall not be

considered a structural unit. See Sections 410-15 and 410-16 for support of fixtures.

(c) **Exposed Work.** In exposed work, and in concealed work in existing buildings where conductors or cables are fished and boxes cannot be secured as provided in Paragraph 370-13(b) without disturbing the building finish, the boxes may be mounted directly upon the plaster surface when securely fastened in place.

**370-14. Depth of Outlet Boxes for Concealed Work.** Outlet boxes for concealed work shall have an internal depth of at least  $1\frac{1}{2}$  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  $\frac{1}{2}$  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) Non-metallic covers and plates may be used with non-metallic outlet boxes. When metal covers or plates are used, they are subject to the grounding requirements of Section 250-42.

(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 non-combustible 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.

**370-16. Fastened to Gas Pipes.** Outlet boxes used where gas outlets are present shall be so fastened to the gas pipes as to be mechanically secure.

**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 1¼-inch trade size and larger, containing conductors of No. 6 or larger, the minimum dimensions of a pull box or a junction box installed in a raceway 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 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.

*Exception. The limitations of Paragraphs 370-18(a-1 and a-2) are not intended to apply to terminal housings supplied with motors, nor to types of boxes or fittings without knockouts and having hubs or recessed parts for terminal bushings and locknuts.*

(b) **Conductors in Pull or Junction Boxes.** In pull boxes or junction boxes having any dimension over 6 feet, all conductors shall be cabled or racked up in an approved manner.

See Paragraph 373-6(b) for insulation of conductors at bushings.

**370-19. Junction Boxes Be Accessible.** Junction 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.

### C. Construction Specifications

**370-20. Metallic Outlet, Switch and Junction Boxes and Fittings.** Outlet, switch and junction boxes and fittings, when of metal, shall conform to the following.

(a) **Corrosion-Resistant.** Metallic boxes and fittings, unless of corrosion-resistant metal, shall be well galvanized, enameled, or otherwise properly coated, inside and out, to prevent corrosion.

See Section 300-5 for limitation in the use of boxes and fittings protected from corrosion solely by enamel.

It is recommended that the protective coating be of conductive material, such as cadmium, tin or zinc, in order to secure better electrical contact.

(b) **Thickness of Metal.** For sheet steel boxes and fittings not over 100 cubic inches in size, the metal shall not be less than No. 14 USS gauge (0.0747 inches in thickness). Cast metal boxes shall have a wall thickness of not less than  $\frac{1}{8}$  inch, except that boxes of malleable iron shall have a wall thickness of not less than  $\frac{3}{32}$  inch.

(c) **Boxes Over 100 Cubic Inches.** Boxes of over 100 cubic inches in size shall be composed of metal and shall conform to the requirements for cabinets and cutout boxes, except that the covers may consist of single flat sheets secured to the box proper by screws, or bolts instead of hinges. Boxes having covers of this form are for use only for enclosing joints in conductors or to facilitate the drawing in of wires and cables. They are not intended to enclose switches, cutouts or other control devices.

**370-21. Covers.** Metal covers shall be of a thickness not less than that specified for the walls of the box or fitting of the same material and with which they are designed to be used, or shall be lined with firmly attached insulating material not less than  $\frac{1}{32}$  inch in thickness. Covers of porcelain or other approved insulating material may be used when of such form and thickness as to afford the requisite protection and strength.

**370-22. Bushings.** Covers of outlet boxes and outlet fittings having holes through which flexible cord pendants may pass, shall be provided with approved bushings or shall have smooth, well-rounded surfaces, upon which the cord may bear. Where conductors other than flexible cord may pass through a metal cover, there shall be provided a separate hole for each wire, said hole being equipped with a bushing of suitable insulating material.

**370-23. Non-Metallic Boxes.** Provisions for supports, or other mounting means, for non-metallic boxes, shall be outside of the box, or the box shall be so constructed as to prevent contact between the conductors in the box and the supporting screws.

## ARTICLE 373—CABINETS AND CUTOUT BOXES

**373-1. Scope.** The provisions of this Article shall apply to the installation of cabinets and cutout boxes. Installations in hazardous locations shall conform to the provisions of Articles 500 to 517 inclusive.

### A. Installation

**373-2. Damp or Wet Locations.** In damp or wet locations, cabinets and cutout boxes of the surface type shall be so placed or equipped as to prevent moisture or water from entering and accumulating within the cabinet or cutout box, and shall be mounted so there is at least one-quarter inch air space between the enclosure and the wall or other supporting surface. Cabinets or cutout boxes installed in wet locations shall be weatherproof.

It is recommended that boxes of non-conductive material be used with non-metallic 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.

**373-4. Unused Openings.** Unused openings in cabinet or cutout boxes shall be effectively closed to afford protection substantially equivalent to that of the wall of the cabinet or cutout box. Where metal plugs or plates are used with non-metallic cabinets or cutout boxes, they shall be recessed at least  $\frac{1}{4}$  inch from the outer surface.

**373-5. Conductors Entering Cabinets or Cutout Boxes.** Conductors entering cabinets or cutout boxes 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 Cabinets and Cutout Boxes.** Where metal cabinets or cutout boxes are installed with open wiring or concealed knob-and-tube work, conductors shall enter

through insulating bushings or, in dry places, through flexible tubing extending from the last insulating support and firmly secured to the cabinet or cutout box.

**373-6. Deflection of Conductors.** Conductors entering or leaving cabinets or cutout boxes and the like shall conform to the following:

(a) **Width of Gutters.** Vertical conductors No. 1 or larger shall not be deflected where they enter or leave a cabinet unless a gutter having a width in accordance with the following Table is provided:

**Table 373-6(a)—Width of Gutters**

Conductor Size	Minimum Width of Gutter in Inches
No. 1 .....	3
0 to 00 .....	3½
000 to 0000 .....	4
250,000 c.m. ....	4½
300,000 to 350,000 c.m. ....	5
400,000 to 500,000 c.m. ....	6
600,000 to 900,000 c.m. ....	8
1,000,000 to 1,250,000 c.m. ....	10
1,500,000 to 2,000,000 c.m. ....	12

(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.

**373-7. Space in Enclosures.** Cabinets and cutout boxes shall conform to the following:

(a) **To Accommodate Conductors.** Cabinets and cutout boxes shall be selected which have sufficient space to accommodate all conductors installed in them without crowding.

**373-8. Switch Enclosures.** Switch enclosures shall not be used as junction boxes, troughs or raceways for conductors feeding through or tapping off to other switches, unless

designs suitable for the purpose are employed to provide adequate space for this purpose.

**373-9. Side or Back Wiring Spaces or Gutters.** Cabinets and cutout boxes shall be provided with back wiring spaces, gutters, or wiring compartments as required by Paragraphs 373-11(c and d).

## **B. Construction Specifications**

**373-10. Material.** Cabinets and cutout boxes shall conform to the following:

(a) **Metal Cabinets and Boxes.** Metal cabinets and cutout boxes shall be well galvanized, plated with cadmium or other approved metallic finish, enameled, or otherwise properly coated, inside and out, to prevent corrosion.

It is recommended that the protective coating be of conductive material, such as cadmium, tin or zinc, in order to secure better electrical contact.

(b) **Strength.** The design and construction of cabinets and cutout boxes shall be such as to secure ample strength and rigidity. If constructed of sheet steel, the metal shall be of not less than No. 16 USS gauge (.0598) in thickness.

(c) **Composition Cabinets.** Composition cabinets shall be submitted for approval prior to installation.

**373-11. Spacing.** The spacing within cabinets and cutout boxes shall conform to the following:

(a) **General.** The spacing within cabinets and cutout boxes shall be sufficient to provide ample room for the distribution of wires and cables placed in them, and for a separation between metal parts of devices and apparatus mounted within them as follows:

(1) **Base.** There shall be an air space of at least 1/16 inch, except at points of support, between the base of the device and the wall of any metal cabinet or cutout box in which the device is mounted.

(2) **Doors.** There shall be an air space of at least 1 inch between any live metal part (including live metal parts of enclosed fuses) and the door, unless the door is lined with an approved insulating material or is of a thickness of metal not less than No. 12 USS gauge (.1046 inch), when the air space shall be not less than 1/2 inch.

(3) **Doors and Walls—Link Fuses.** There shall be a space of at least 2 inches between open link fuses and metal-lined walls or metal, metal-lined or glass-paneled doors.

(4) **Live Parts.** Except as noted above, there shall be an air space of at least  $\frac{1}{2}$  inch between the walls, back, gutter partition, if of metal, or door of any cabinet or cutout box and the nearest exposed current-carrying part of devices mounted within the cabinet where the potentials do not exceed 250 volts. This spacing shall be increased to at least one inch where the potentials exceed 250 volts.

(b) **Switch Clearance.** Cabinets and cutout boxes shall be deep enough to allow the closing of the doors when 30-ampere branch-circuit panelboard switches are in any position, or when combination cutout switches are in any position, or when other single-throw switches are opened as far as their construction will permit.

(c) **Wiring Space.** Cabinets and cutout boxes which contain devices or apparatus connected within the cabinet or box to more than 8 conductors, including those of branch circuits, meter loops, sub-feeder circuits, power circuits and similar circuits, but not including the supply circuit or a continuation thereof, shall have back wiring spaces or one or more side wiring spaces, side gutters or wiring compartments.

(d) **Wiring Space—Enclosure.** Side wiring spaces, side gutters or side wiring compartments of cabinets and cutout boxes shall be rendered tight enclosures by means of covers, barriers or partitions extending from the bases of the devices, contained in the cabinet, to the door, frame, or sides of the cabinet; provided, however, that where the enclosure contains only those conductors which are led from the cabinet at points directly opposite their terminal connections to devices within the cabinet, such covers, barriers or partitions may be omitted. Partially enclosed back wiring spaces shall be provided with covers to complete enclosure. Wiring spaces that are required by Paragraph 373-11(c) and which are exposed when doors are open, shall be provided with covers to complete the enclosure.

## ARTICLE 374 — AUXILIARY GUTTERS

**374-1. Purpose.** Auxiliary gutters, used to supplement wiring spaces at meter centers, distribution centers, switchboards and similar points of wiring systems, may enclose conductors or bus-bars, but shall not be used to enclose switches, overcurrent devices or other appliances or apparatus.

**374-2. Extension Beyond Equipment.** An auxiliary gutter shall not extend a greater distance than 30 feet beyond the equipment which it supplements except in elevator work. Any extension beyond this distance shall comply with the provisions for wireways in Article 362 or with the provisions for busways in Article 364.

**374-3. Supports.** Gutters shall be supported throughout their entire length at intervals not exceeding 5 feet.

**374-4. Covers.** Covers shall be securely fastened to the gutter.

**374-5. Number of Conductors.** Auxiliary gutters shall not contain more than 30 conductors at any cross section unless the conductors are for signalling circuits or are control conductors between a motor and its starter and used only for starting duty. The sum of the cross-sectional areas of all contained conductors at any cross section of an auxiliary gutter shall not exceed 20 per cent of the interior cross-sectional area of the gutter.

The correction factors specified in Note 8 of Tables 310-12 and 310-14 are not applicable to the foregoing.

For elevators see Section 620-35.

**374-6. Carrying Capacity of Copper Bars.** The current carried continuously in bare conductors in auxiliary gutters shall not exceed 1000 amperes per square inch of cross-section of the conductor.

**374-7. Clearance of Bare Live Parts.** Bare conductors shall be securely and rigidly supported so that the minimum clearance between bare current-carrying metal parts of

opposite polarities mounted on the same surface shall be not less than 2 inches, nor less than 1 inch for parts that are held free in the air. A clearance not less than 1 inch shall be secured between bare current-carrying metal parts and any metal surface. Adequate provision shall be made for expansion and contraction of copper bars.

**374-8. Splices and Taps.** Splices and taps shall conform to the following:

(a) Splices or taps, made and insulated by approved methods, may be located within gutters when they are accessible by means of removable covers or doors. The conductors, including splices and taps, shall not fill the gutter to more than 75 per cent of its area.

(b) Taps from bare conductors shall leave the gutter opposite their terminal connections and conductors shall not be brought in contact with uninsulated current-carrying parts of opposite polarity.

(c) All taps shall be suitably identified at the gutter as to the circuit or equipment which they supply.

(d) Tap connections from conductors in auxiliary gutters shall be provided with overcurrent protection in conformity with the provisions of Section 240-15.

**374-9. Construction and Installation.** Auxiliary gutters shall be constructed in accordance with the following:

(a) Gutters shall be so constructed and installed that adequate electrical and mechanical continuity of the complete system will be secured.

(b) Gutters shall be of substantial construction and shall provide a complete enclosure for the contained conductors. All surfaces, both interior and exterior, shall be suitably protected from corrosion. Corner joints shall be made tight and where the assembly is held together by rivets or bolts, these shall be spaced not more than 12 inches apart.

(c) Suitable bushings, shields or fittings having smooth rounded edges shall be provided where conductors pass between gutters, through partitions, around bends, between gutters and cabinets or junction boxes and at other locations where necessary to prevent abrasion of the insulation of the conductors.

(d) Gutters shall be constructed of sheet metal of thicknesses not less than in the following table:

Table 374-9(d)

Maximum Width of the Widest Surface of Gutters  
Thickness (USS Sheet Steel Gauge)

Up to and including 6 inches .....	No. 16; 0.0598 inch
Over 6 in. and not over 18 in. ....	No. 14; 0.0747 inch
Over 18 in. and not over 30 in. ....	No. 12; 0.1046 inch
Over 30 inches .....	No. 10; 0.1345 inch

(e) Where insulated conductors are deflected within the auxiliary gutter, either at the ends or where conduits, fittings or other raceways enter or leave the gutter, or where the direction of the gutter is deflected greater than 30 degrees, dimensions corresponding to Section 373-6 shall apply.

(f) Auxiliary gutters intended for outdoor use shall be of approved raintight construction.

## 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.

**380-3. Enclosures.** Switches and circuit-breakers shall be of the externally operable type enclosed in metal boxes or cabinets, except pendent and surface type snap switches and knife switches mounted on an open face switchboard or panelboard.

**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.

**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. 1. Where mounted on switchboards or control panels.*

*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.

**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 non-conducting, non-combustible material. Face plates of non-ferrous metal shall be not less than 0.040 inch in thickness, of ferrous metal, not less than 0.030; and plates of non-conducting, non-combustible material shall be not less than 0.10 inch in thickness.

**380-10. Mounting of Surface-Type Snap Switches.** Snap switches used with open wiring on insulators shall be mounted on sub-bases of insulating material which will separate the conductors at least  $\frac{1}{2}$  inch from the surface wired over.

**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.

**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, except where accessible to qualified operators only.

**380-13. Knife Switches.**

(a) Knife switches rated for more than 1200 amperes at 250 volts or less, and for more than 600 amperes at 251 to 600 volts, shall be used only as isolating switches and shall not be opened under load.

(b) To interrupt currents greater than 1200 amperes at 250 volts or less, or 600 amperes at 251 to 600 volts, a circuit-breaker or a switch of special design approved for such purpose shall be used.

(c) Knife switches of lower rating may be used as general-use switches and may be opened under load.

(d) Motor-circuit switches (see Definition) may be of the knife-switch type.

**380-14. Rating of Snap Switches.** Snap switches installed for the following types of loads shall be rated as follows:

(a) **Non-Inductive Loads.** For non-inductive loads other than tungsten-filament lamps, switches shall have an ampere rating not less than the ampere rating of the load.

(b) **Tungsten Filament Loads.** For tungsten-filament lamp load and for combined tungsten-filament and non-inductive loads, switches shall be "T" rated or, where on alternating-current circuits, may be a general use alternating-current snap switch.

*Exception. A switch that is not "T" rated may be installed to control such loads provided all three of the following qualifications are satisfied.*

*(1) Where switches are used in branch circuit wiring systems in private homes; in rooms in multiple-occupancy dwellings used only as living quarters by tenants; in private hospital or hotel rooms; or in similar locations but not in public rooms or places of assembly; and*

*(2) Only where such a switch controls permanently connected fixtures or lighting outlets in one room only, or in one continuous hallway where the lighting fixtures may be located at different levels, or on porches or in attics or basements not used for assembly purposes; and*

*(3) The switch is rated at not less than 10A, 125V; 5A, 250V; or for the 4-way types, 5A, 125V; 2A, 250V.*

(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 on signs and outline lighting, see Section 600-2.

For switches controlling motors, see Sections 430-83 and 430-110.

## **B. Construction Specifications**

**380-15. Marking.** Switches shall be marked with the current and voltage and, if horsepower rated, the maximum rating for which they are designed.

**380-16. 600-Volt Knife Switches.** Auxiliary contacts of a renewable or quick-break type or the equivalent, shall be provided on all 600-volt knife switches designed for use in breaking currents over 200 amperes.

It is recommended that such auxiliary contacts be provided on all direct-current switches rated at over 250 volts.

**380-17. Multiple Fuses.** Switches rated above 600 amperes may be arranged for fuses in multiple provided as few fuses as possible are used and the fuses are of the same type and rating and are so mounted as to eliminate a potential difference between the terminals of the fuses.

## ARTICLE 384 — SWITCHBOARDS AND PANELBOARDS

**384-1. Scope.** The requirements of this Article shall apply to all switchboards, panelboards, and distribution boards installed for the control of light and power circuits.

*Exception No. 1. Switchboards in utility company operated central stations or substations, which directly control energy derived from generators or transforming devices.*

*Exception No. 2. Switchboards or portions thereof used exclusively to control signal circuits operated by batteries.*

The requirements of this Article shall apply to battery-charging panels where current is taken from light or power circuits.

**384-2. Application of Other Articles.** Switches, circuit-breakers and overcurrent devices used on switchboards, 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. Switchboards and panelboards in hazardous locations shall conform to the requirements of Articles 500 to 517 inclusive.

**384-3. Support and Arrangement of Bus-bars and Conductors.**

(a) Conductors and bus-bars on a switchboard, panelboard or control board shall be so located as to be free from physical damage and shall be held firmly in place.

(b) The arrangement of bus-bars and conductors shall be such as to avoid overheating due to inductive effects.

### A. Switchboards

**384-4. Location of Switchboards.** Switchboards which have any exposed live parts shall be located in permanently dry locations and then only where under competent supervision and accessible only to qualified persons.

**384-5. Wet Locations.** Where a switchboard is in a wet location or outside of a building, it shall be enclosed in a

weather-proof enclosure or cabinet installed to conform to Section 373-2.

**384-6. Location Relative to Easily Ignitable Material.** Switchboards shall be so placed as to reduce to a minimum the probability of communicating fire to adjacent easily ignitable material.

**384-7. Clearance from Ceiling.** Switchboards shall not be built up to a non-fireproof ceiling, a space of three feet being left between the ceiling and the board, unless an adequate fireproof shield is provided between the board and the ceiling.

**384-8. Clearance Back of Switchboard.** Where the equipment or wiring on the back of the switchboard is accessible only from the space behind the board, there shall be a clear space of at least 18 inches between such equipment or wiring and the wall for a single panel switchboard not exceeding 42 inches in width, and at least 24 inches when the board consists of a wider panel or more than one panel. Where the space behind the board is accessible only from one end, these spaces shall be increased by at least 6 inches. The space back of the board shall be kept clear of foreign material and shall not be used for storage purposes, nor as passageways.

Reduction of clearances for short intervals by building columns behind the switchboard, or by equipment on a single panel in the switchboard, is permitted provided the clearances are not reduced below those required for a single panel board.

Some of the above dimensions are exceptions to Section 110-16.

**384-9. Conductor Covering.** Insulated conductors where closely grouped, as on the rear of switchboards, shall each have a flame-retardant outer covering. The conductor covering shall be stripped back a sufficient distance from the terminals so as to not make contact with them. Insulated conductors used for instrument and control wiring on the back of switchboards shall be flame-retardant, either inherently or by means of an outer covering, such as one of the following types: R, RH, RW, RHH, RHW, V, AVA, AVB, T, TA, TBS, TW, THW, MI, or other types specifically approved for the purpose.

**384-11. Grounding Switchboard Frames.** Switchboard frames and structures supporting switching equipment shall

be grounded, except that frames of direct-current single-polarity switchboards need not be grounded if effectively insulated.

**384-12. Grounding of Instruments, Relays, Meters and Instrument Transformers on Switchboards.** Instruments, relays, meters and instrument transformers located on switchboards shall be grounded as specified in Sections 250-121 to 250-125.

## **B. Panelboards**

**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.

**384-14. Lighting and Appliance Branch Circuit Panelboard.** For the purposes of this Section, 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 of a lighting and appliance branch circuit panelboard shall be installed in any one cabinet or cutout box.

**384-16. Overcurrent Protection.**

(a) A lighting and appliance branch circuit panelboard supplied by conductors having overcurrent protection greater than 200 amperes shall be protected on the supply side by overcurrent devices having a rating not greater than that of the panelboard.

*Exception. Except as installed for service as in Paragraph 230-90(a).*

(b) Panelboards equipped with snap switches rated at 30 amperes or less, shall have overcurrent protection not in excess of 200 amperes.

(c) The overcurrent protective devices of all panelboards installed in industrial or commercial buildings where loads continue for long periods of time, shall have a rating not less than 125 per cent of the circuit loading, as determined by Articles 210 and 220.

**384-17. Panelboards in Damp or Wet Locations.** Panelboards in damp or wet locations shall be installed in conformity to Section 373-2.

**384-18. Enclosure.** Panelboards shall be mounted in cabinets or cutout boxes.

**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.

### C. Construction Specifications

**384-20. Panels.** The panels of switchboards shall be made of moisture-resistant, noncombustible material.

**384-21. Bus-bars.** Bus-bars may be of bare metal provided they are rigidly mounted.

**384-22. Protection of Instrument Circuits.** Instruments, pilot lights, potential transformers, and other switchboard devices with potential coils, except where the operation of the overcurrent device might introduce a hazard in the operation of devices, shall be supplied by a circuit that is protected by standard overcurrent devices of a rating not greater than 15 amperes, except that for ratings of 2 amperes or less special types of enclosed fuses may be used.

**384-23. Component Parts.** Switches, fuses, and fuseholders used on panelboards shall conform to the requirements of Articles 240 and 380 so far as they apply.

**384-24. Knife Switches.** Knife switches shall be so arranged that the blades, when exposed during operation, will be dead when the switches are open.

**384-25. Color-Coding.** On switchboards or panelboards that are provided with color markings to indicate the main bus-bars to which branch circuit bus-bars are connected, the colors shall conform to the color coding of Section 210-5.

**384-26. Spacings.** Except at switches and circuit-breakers, the distance between bare metal parts, bus-bars, etc., shall be not less than specified in the following Table:

**Table 384-26—Spacings Between Bare Metal Parts**

	Opposite Polarity When Mounted on the Same Surface	Opposite Polarity When Held Free in Air	*Live Parts to Ground
Not over 125 volts .....	$\frac{3}{4}$ inch	$\frac{1}{2}$ inch	$\frac{1}{2}$ inch
Not over 250 volts .....	1 $\frac{1}{4}$ inch	$\frac{3}{4}$ inch	$\frac{1}{2}$ inch
Not over 600 volts .....	2 inches	1 inch	1 inch

\*For spacing between live parts and doors of cabinets, see subparagraph a of Section 373-11.

It should be noted that the above distances are the minimum allowable, and it is recommended that greater distances be provided whenever the conditions will permit.

At switches, enclosed fuses, etc., parts of the same polarity may be placed as close together as convenience in handling will allow, unless close proximity causes excessive heating.

## 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.

## **Chapter 4. Equipment for General Use**

### **ARTICLE 400—FLEXIBLE CORDS**

#### **A. General and Types**

**400-1. General.** Flexible cords shall be suitable for the conditions of use and location.

**400-2. Types.** Cords of the several types shall conform to the descriptions of Table 400-11. Types of flexible cords other than those listed in Table 400-11 and other uses for types listed in the Table, shall be the subject of special investigations and shall not be used before being approved.

#### **B. Use and Installation**

**400-3. Use.** Flexible cord may be used only for (1) pendants; (2) wiring of fixtures; (3) connection of portable lamps or appliances; (4) elevator cables; (5) wiring of cranes and hoists; (6) for the connection of stationary equipment to facilitate their interchange; or (7) to prevent the transmission of noise or vibration.

**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.

**400-6. Cords in Show-Windows and Show-Cases.** Flexible cord used in show-windows and show-cases shall be of types S, SO, SJ, SJO, ST, SJT, or AFS, except for the wiring of chain supported fixtures, and for supplying current to portable lamps and other merchandise for exhibition purposes.

**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.

**400-8 Insulation—Over 300 Volts.** Where the voltage between any two conductors exceeds 300, but does not exceed 600, flexible cord of No. 10 and smaller shall have rubber or thermoplastic insulation on the individual conductors at least 3/64 inch in thickness, unless type S, SO or ST cord is used.

**400-9. Overcurrent Protection and Current-Carrying Capacities of Flexible Cords.**

(a) **Overcurrent Protection.** Flexible cords not smaller than No. 18, and tinsel cords, or cords having equivalent characteristics, of smaller size approved for use with specific appliances, shall be considered as protected against overcurrent by the overcurrent devices described in Section 240-5. Cords shall be not smaller than required in Table 400-9(b) for the rated current of the appliance.

**Table 400-9(b). Current-Carrying Capacity of Flexible Cord in Amperes**

Table 400-9(b) gives the allowable current-carrying capacities for not more than three current-carrying conductors in a cord. If the number of current-carrying conductors in a cord is from four to six the allowable current-carrying capacity of each conductor shall be reduced to 80 per cent of the values in the Table.

(Based on Room Temperature of 30°C (86°F.). See Section 400-9 and Table 400-11.)

Size AWG	Rubber Types TP, TS	Rubber Types PO, C, PD, P, PW, K, E, EO	Rubber Types S, SO, SR, SJ, SJO, SV, SP	Types AFS, AFSJ, HC, HPD, HSI, HS, HPN	Types AVPO, AVPD	Cotton Types CFC* CFPO* CFPD*
	Thermo- plastic Types TPT, TSP	Thermo- plastic Type ET	Thermo- plastic Types ST, SRT, SJT, SVP, SPT			Asbestos Types AFC* AFPO* AFPD*
27**	0.5	..	..	..	..	..
18	...	5	7	10	17	6
17	...	..	..	12	..	..
16	...	7	10	15	22	8
15	...	..	..	17	..	..
14	...	15	15	20	28	17
12	...	20	20	30	36	23
10	...	25	25	35	47	28
8	...	35	35	..	..	..
6	...	45	45	..	..	..
4	...	60	60	..	..	..
2	...	80	..	..	..	..

\*These types are used almost exclusively in fixtures where they are exposed to high temperatures and ampere ratings are assigned accordingly.

\*\*Tinsel cord.

**Note to Table 400-9(b)**

**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.

**400-10. Pull at Joints and Terminals.** Flexible cords shall be so connected to devices and to fittings that tension will not be transmitted to joints or terminal screws. This shall be accomplished by a knot in the cord, winding with tape, by a special fitting designed for that purpose, or by other approved means which will prevent a pull on the cord from being directly transmitted to joints or terminal screws.

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**Notes to Table 400-11**

1. Except for Types AFPO, CFPO, PO-1, PO-2, PO, SP-1, SP-2, SPT-1, SPT-2, TP, TPT, and AVPO, individual conductors are twisted together.

2. Type PO-1 is for use only with portable lamps, portable radio receiving appliances, portable clocks and similar appliances which are not liable to be moved frequently and where appearance is a consideration.

3. Types TP, TPT, TS, and TST are suitable for use in lengths not exceeding eight feet when attached directly, or by means of a special type of plug, to a portable appliance rated at 50 watts or less and of such nature that extreme flexibility of the cord is essential.

4. Type K is suitable for use on theatre stages.

5. Rubber-filled or varnished cambric tapes may be substituted for the inner braids.

6. Types S, SO, and ST are suitable for use on theatre stages, in garages and elsewhere, where flexible cords are permitted by this Code.

7. Traveling cables for operating, control and signal circuits may have one or more non-metallic fillers or may have a supporting filler of stranded steel wires having its own protective braid or cover. Cables exceeding 100 feet in length shall have steel supporting fillers, except in locations subject to excessive moisture or corrosive vapors or gases. Where steel supporting fillers are used, they shall run straight through the center of the cable assembly and shall not be cabled with the copper strands of any conductor.

8. A third conductor in these cables is for grounding purposes only.

9. The individual conductors of all cords except those of heat-resistant cords (Types AFC, AFPO, AFD, AFS, AFSJ, AVPO, AVPD, CFC, CFPO and CFPD) shall have a rubber or thermoplastic insulation, except that the grounding conductor where used, shall be in accordance with Paragraph 400-14(b). A rubber compound shall be vulcanized except for heater cords (Types HC, HPD and HSJ) and for belt fillers in Types P-1, P-2, P, PW-1, PW-2 and PW.

# Table 400-11. Flexible Cord

(See Section 400-2)

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid on Each Conductor	Outer Covering	Use		
Parallel Tinsel Cord	TP See Note 3	27	2	Rubber	None	Rubber	Attached to an Appliance	Damp Places	Not Hard Usage
	TPT See Note 3	27	2	Thermo-plastic	None	Thermo-plastic	Attached to an Appliance	Damp Places	Not Hard Usage
Jacketed Tinsel Cord	TS See . Note 3	27	2 or 3	Rubber	None	Rubber	Attached to an Appliance	Damp Places	Not Hard Usage
	TST See Note 3	27	2 or 3	Thermo-plastic	None	Thermo-plastic	Attached to an Appliance	Damp Places	Not Hard Usage
Asbestos-Covered Heat-Resistant Cord	AFC	18, 16 14	2 or 3	Impreg-nated Asbestos	Cotton or Rayon	None	Pendant	Dry Places	Not Hard Usage
	AFPO		2		None	Cotton, Rayon or Saturated Asbestos			
	AFPD		2 or 3						
Cotton-Cov-ered Heat Resistant Cord	CFC	18, 16 14	2 or 3	Impreg-nated Cotton	Cotton or Rayon	None	Pendant	Dry Places	Not Hard Usage
	CFPO		2		None	Cotton or Rayon			
	CFPD		2 or 3						

See Notes

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid on Each Conductor	Outer Covering	Use		
Parallel Cord	PO-1	18	2	Rubber	Cotton	Cotton or Rayon	See Note 2	Dry Places	Not Hard Usage
	PO-2	18, 16					Pendant or Port.		
	PO	18-10							
All Rubber Parallel Cord	SP-1	18	2	Rubber	None	Rubber	Pendant or Portable	Damp Places	Not Hard Usage
	SP-2	18, 16		Thermo-plastic	None	Thermoplastic	Refrigerators or Room Air Conditioners	Damp Places	Not Hard Usage
	SP-3 Note 8	18-12							
All Plastic Parallel Cord	SPT-1		2	Thermo-plastic	None	Thermoplastic	Pendant or Portable	Damp Places	Not Hard Usage
	SPT-2	18, 16							
All Plastic Parallel Cord	SPT-3 Note 8	18-12	2	Thermo-plastic	None	Thermoplastic	Refrigerators or Room Air Conditioners	Damp Places	Not Hard Usage

See Notes

Lamp Cord	C	18-10	2 or more	Rubber	Cotton	None	Pendant or Port.	Dry Places	Not Hard Use
Twisted Portable Cord	PD	18-10	2 or more	Rubber	Cotton	Cotton or Rayon	Pendant or Port.	Dry Places	Not Hard Usage
Reinforced Cord	P-1	18	2 or more	Rubber	Cotton	Cotton over Rubber Filler	Pendant or Portable	Dry Places	Not Hard Use
	P-2	18, 16							Hard Usage
	P	18-10							
Moisture-Proof Reinforced Cord	PW-1	18	2 or more	Rubber	Cotton	Cotton, Moisture-Resistant Finish over Rubber Filler	Pendant or Port.	Damp Places	Not Hard Use
	PW-2	18, 16							Hard Usage
	PW	18-10							
Braided Heavy Duty Cord	K See Note 4	18-10	2 or more	Rubber	Cotton	Two Cotton, Moisture-Resistant Finish See Note 5	Pendant or Portable	Damp Places	Hard Usage
Vacuum Cleaner Cord	SV	18	2	Rubber	None	Rubber	Pendant or Portable	Damp Places	Not Hard Use
	SVT			Thermopl'		Thermoplastic			
Junior Hard Service Cord	SJ	18, 16	2, 3 or 4	Rubber	None	Rubber	Pendant or Portable	Damp Places	Hard Usage
	SJO					Oil Resist. Compound			
	SJT			Thermopl' or Rubber		Thermoplastic			

See Notes

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid on Each Conductor	Outer Covering	Use		
Hard Service Cord	S See Note 6	18-10	2 or more	Rubber	None	Rubber	Pendant or Portable	Damp Places	Extra Hard Usage
	SO					Oil Resist. Compound			
	ST			Thermopl' or Rubber		Thermoplastic			
Rubber-Jacketed Heat-Resistant Cord	AFSJ	18, 16	2 or 3	Impreg-nated Asbestos	None	Rubber	Portable	Damp Places	Portable Heaters
	AFS	18, 16, 14							
Heater Cord	HC	18-12	2, 3 or 4	Rubber & Asbestos	Cotton	None	Portable	Dry Places	Portable Heaters
	HPD				None	Cotton or Rayon			
Rubber Jacketed Heater Cord	HSJ	18-16		Rubber & Asbestos	None	Cotton and Rubber	Portable	Damp Places	Portable Heaters
Jacketed Heater Cord	HS	14-12	2, 3, or 4	Rubber and Asbestos	None	Cotton, and Rubber or Neoprene	Portable	Damp Places	Portable Heaters
All-Neoprene Heater Cord	HPN	18-16	2	Neoprene	None	Neoprene	Portable	Damp Places	Portable Heaters

See Notes

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Braid On Each Conductor	Outer Covering	Use		
							Pendant or Portable	Damp Places	Not Hard Usage
Heat & Moisture Resistant Cord	AVPO	18-10	2	Asbestos & Var. Comb.	None	Asbestos, Flame-Ret. Moisture Resist.	Pendant or Portable	Damp Places	Not Hard Usage
	AVPD		2 or 3						
Range Cable	SR	8-4	3 or 4	Rubber	None	Rubber or Neoprene	Portable	Damp Places	Ranges
	SRT	8-4	3 or 4	Thermoplastic	None	Thermoplastic	Portable	Damp Places	Ranges
Elevator Cable	E See Note 7	18-14	2 or more	Rubber	Cotton	Three Cotton, Outer one Flame-Retardant & Moisture Resist. See Note 5 One Cotton and a Neoprene Jacket See Note 5	Elevator Lighting and Control	Non-Hazardous Locations	
	EO See Note 7							Hazardous Locations	
	ET See Note 7	18-14		Thermoplastic	Rayon	Three cotton, Outer one Flame-Retardant & Moisture Resistant. See Note 5		Non-Hazardous Locations	

See Notes

### C. Construction Specifications

**400-12. Labels.** Flexible cords shall be examined and tested at the factory and shall be labeled before shipment.

**400-13. Grounded Conductor Identification.** One conductor of flexible cords shall have a continuous marker readily distinguishing it from the other conductor or conductors. The identification shall consist of one of the following:

(a) **Colored Braid.** A braid finished to show a white or natural gray color and the braid on the other conductor or conductors finished to show a readily distinguishable solid color or colors.

(b) **Tracer in Braid.** A tracer in a braid of any color contrasting with that of the braid and no tracer in the braid of the other conductor or conductors. No tracer shall be used in the braid of any conductor of a flexible cord which contains a conductor having a braid finished to show white or natural gray, except, in the case of Types C, PD and PO cords having the braids on the individual conductors finished to show white or natural gray. In such C, PD and PO cords the identifying marker may consist of the solid white or natural gray finish on one conductor provided there is a colored tracer in the braid of each other conductor.

(c) **Colored Insulation.** A white or natural gray insulation on one conductor and insulation of a readily distinguishable color or colors on the other conductor or conductors for cords having no braids on the individual conductors (except cords which have insulation on the individual conductors integral with the jacket).

(d) **Colored Separator.** A white or natural gray separator on one conductor and a separator of a readily distinguishable solid color on the other conductor or conductors of cords having insulation on the individual conductors integral with the jacket.

(e) **Tinned Conductors.** One conductor having the individual strands tinned and the other conductor or conductors having the individual strands untinned for cords having insulation on the individual conductors integral with the jacket.

(f) **Surface Marking.** A stripe, ridge or groove so located on the exterior of the cord as to identify one conductor

for cords having insulation on the individual conductors integral with the jacket.

**400-14. Grounding Conductor Identification.** A conductor intended to be used as a grounding conductor shall have a continuous identifying marker readily distinguishing it from the other conductor or conductors. The identifying marker shall consist of one of the following:

(a) **Colored Braid.** A braid finished to show a green color.

(b) **Colored Insulation or Covering.** For cords having no braids on the individual conductors a green insulation or a green covering on one conductor.

**400-15. Insulation Thickness.** The nominal thickness of rubber or thermoplastic conductor insulation in Types TS, TST, PO-1, P-1, PW-1, SV, and SVT shall be not less than 1/64 inch. The nominal thickness of rubber insulation in Types HC, HPD, HSJ, and HS shall be not less than 1/64 inch for the Nos. 18-16 AWG sizes, and not less than 2/64 inch for the Nos. 14-12 AWG sizes. The nominal thickness of the thermoplastic insulation in Type ET elevator cable shall be not less than 20 mils for the No. 16 AWG size and not less than 1/32 inch for the No. 14 AWG size. The nominal thickness of the rubber insulation in Types E and EO elevator cables shall be not less than 20 mils for the No. 18 and 16 AWG sizes. The nominal thickness of latex-rubber insulation, when employed, in Types SJ, SJO, S and SO shall be not less than 15 mils for the Nos. 18-16 AWG sizes and not less than 18 mils for the No. 14 AWG and larger sizes. The nominal thickness of conductor insulation in Types PO, P, PW, SP-2, SPT-2, HPN, SR, and SRT shall be not less than 3/64 inch. The nominal thickness of thermoplastic insulation in Type SPT-3 shall be not less than 4/64 inch for sizes 18-16 and 5/64 inch for No. 14 and 6/64 inch for No. 12 AWG. For other types, the minimum nominal thickness of rubber or thermoplastic conductor insulation shall be as follows: size AWG 27, and 18 to 26—2/64 inch; 14 to 10—3/64 inch; 8—4/64 inch.

**400-16. Attached to Receptacle Plugs.** Where a flexible cord is provided with a grounding conductor and equipped with an attachment plug, the plug shall comply with Paragraphs 250-59(a and b).

## ARTICLE 402—FIXTURE WIRES

**402-1. Use.** Fixture wires are designed for installation in lighting fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use. Also, they are used for connecting lighting fixtures to the conductors of the circuit that supplies the fixtures.

For application in lighting fixtures, see Article 410.

Fixture wires are not intended for installation as branch circuit conductors or for the connection of portable or stationary appliances.

**402-2. Minimum Size.** Fixture wires shall not be smaller than No. 18.

### 402-3. Insulation.

(a) The rubber insulations include those made from natural and synthetic rubber, neoprene and other vulcanized materials.

Thermoplastic insulation may stiffen at temperatures below minus 10°C. (14°F.) and care should be used in its installation at such temperatures. It may be deformed when subject to pressure; care should be taken in its installation, as for example, at bushings, or points of support. See Section 373-6(b).

(b) 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.

**Table 402-4. Allowable Current-Carrying Capacity of  
Fixture Wire**

(Based on Room Temperature of 30°C., 86°F.)

Size AWG	Fixture Wire	
	Thermoplastic Types TF, TFF	
	Rubber Types	Cotton Type CF*
	RF-1, RF-2, FF-1,	Asbestos Type AF*
	FF-2, RFH-1, RFH-2,	Silicone Rubber Types
	FFH-1, FFH-2	SF-1*, SF-2*, SFF-1*, SFF-2*
18	5	6
16	7	8
14	..	17

\*These types are used almost exclusively in fixtures where they are exposed to high temperatures and ampere ratings are assigned accordingly.

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.

**402-5. Overcurrent Protection.** See Section 240-5(d).

Table 402-6. Fixture Wire

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Rubber-Covered Fixture Wire Solid or 7-Strand	RF-1	Code Rubber	18.....1/64 Inch	Non-metallic covering
	RF-2	Code Rubber	18-16.....2/64 Inch	Non-metallic covering
		Latex Rubber	18-16.....18 Mils	
Rubber-Covered Fixture Wire Flexible Stranding	FF-1	Code Rubber	18.....1/64 Inch	Non-metallic covering
	FF-2	Code Rubber	18-16.....2/64 Inch	Non-metallic covering
		Latex Rubber	18-16.....18 Mils	
Heat Resistant Rubber-Covered Fixture Wire Solid or 7-Strand	RFH-1	Heat-Resistant Rubber	18.....1/64 Inch	Non-metallic covering
	RFH-2	Heat-Resistant Rubber	18-16.....2/64 Inch	Non-metallic covering
		Heat-Resistant Latex Rubber	18-16.....18 Mils	
Heat Resistant Rubber-Covered Fixture Wire Flexible Stranding	FFH-1	Heat-Resistant Rubber	18.....1/64 Inch	Non-metallic covering
	FFH-2	Heat-Resistant Rubber	18-16.....2/64 Inch	Non-metallic covering
		Heat-Resistant Latex Rubber	18-16.....18 Mils	
Thermoplastic-Cov- ered Fixture Wire— Solid or Stranded	TF	Thermoplastic	18-16.....2/64 Inch	None

Continued on next page

Table 402-6 (Continued)

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
Thermoplastic-Covered Fixture Wire—Flexible Stranding	TFF	Thermoplastic	18-16.....2/64 Inch	None
Cotton-Covered, Heat-Resistant, Fixture Wire	CF	Impregnated Cotton	18-14.....2/64 Inch	None
Asbestos-Covered, Heat-Resistant, Fixture Wire	AF	Impregnated Asbestos	18-14.....2/64 Inch	None
Silicone Insulated Fixture Wire	SF-1	Silicone Rubber	18.....1/64 Inch	Non Metallic Covering
Solid or 7-Strand	SF-2	Silicone Rubber	18-14.....1/32 Inch	Non Metallic Covering
Silicone Insulated Fixture Wire	SFF-1	Silicone Rubber	18.....1/64 Inch	Non Metallic Covering
Flexible Stranding	SFF-2	Silicone Rubber	18-14.....1/32 Inch	Non Metallic Covering

## **ARTICLE 410—LIGHTING FIXTURES, LAMPHOLDERS, LAMPS, RECEPTACLES AND ROSETTES**

### **A. General**

**410-1. Scope.** Lighting fixtures, lampholders, pendants, receptacles, and rosettes, 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.

**410-2. Application to Other Articles.** Equipment for use in hazardous locations shall conform to Articles 500 to 517.

**410-3. Live Parts.** Fixtures, lampholders, lamps, rosettes and receptacles shall have no live parts normally exposed to contact, except in the case of cleat-type lampholders, receptacles and rosettes which are located at least 8 feet above the floor. 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**

**410-4. Fixtures in Damp, Wet or Corrosive 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.

(b) Fixtures installed in corrosive locations shall be of a type approved for such locations.

**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 pro-

vided 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.

**410-7. Fixtures in Show-Windows.** Externally wired fixtures shall not be used in a show-window.

*Exception: Fixtures of the chain-supported type may be externally wired.*

**410-8. Fixtures in Clothes Closets.**

(a) Fixtures in clothes closets shall be installed on the ceiling or on the wall above the door.

(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.

**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, rosette, 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 non-combustible material.

**410-14. Connection of Fixtures.** In general, fluorescent fixtures when supported independently of the outlet box shall be connected through metal raceways or armored conductors. 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.

## D. Fixture Supports

**410-15. Supports — General.** Fixtures, lampholders, rosettes 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.

**410-18. Conductor Size.** Fixture conductors shall not be smaller than No. 18.

**410-19. Conductor Insulation.**

(a) Fixtures shall be wired with conductors having insulation suitable for the current, voltage, and temperature to which the conductors will be subjected.

(b) Where fixtures are installed in damp, wet, or corrosive locations, conductors shall be of a type approved for such locations.

(c) For current-carrying capacity of fixture wire, see Table 402-4.

(d) For maximum operating temperature and voltage limitation of fixture wires, see Section 310-2.

**410-20. Conductors for Certain Conditions.**

(a) Fixtures provided with Mogul base screw-shell lampholders and operating at not more than 300 volts between conductors shall be wired with Type AF, SF-1, SF-2, SFF-1 or SFF-2 fixture wire.

(b) Fixtures provided with other than Mogul base screw shell lampholders and operating at not more than 300 volts between conductors shall be wired with Type AF, SF-1, SF-2, SFF-1, SFF-2 fixture wire or Type AFC, AFPO, or AFPD flexible cord.

*Exception No. 1. Where temperatures do not exceed 90°C (194°F), Type CF fixture wire or Type CFC, CFPD, or CFPO flexible cord may be used.*

*Exception No. 2. Where temperatures exceed 60°C but are not higher than 75°C, Type RH rubber-covered wire, Type RFH-1, RFH-2, FFH-1, and FFH-2 fixture wires may be used.*

See Sections 402-6 and 310-2 for fixture wires and conductors; also, Table 400-9(b) for flexible cords.

#### **410-21. Conductors for Movable Parts.**

(a) Stranded conductors shall be used on chain fixtures and other movable parts.

(b) Conductors shall be so arranged that the weight of the fixture or movable parts will not put a tension on the conductors.

#### **410-22. Pendent Conductors for Incandescent Filament Lamps.**

(a) Pendent lampholders with permanently attached leads, where used in other than festoon wiring, shall be hung from separate stranded rubber-covered conductors which are soldered directly to the circuit conductors but supported independently thereof.

(b) Such pendent conductors shall be not smaller than No. 14 for heavy-duty or medium-base screw-shell lampholders, nor, except for approved Christmas tree and decorative lighting outfits, smaller than No. 18 for intermediate or candelabra-base lampholders.

(c) Pendent conductors longer than 3 feet shall be twisted together where not cabled in an approved assembly.

#### **410-23. Protection of Conductors.**

(a) Conductors shall be secured in a manner that will not tend to cut or abrade the insulation.

(b) Conductors shall be protected from abrasion where they pass through metal.

(c) Exposed flexible cord or fixture wire shall not be used to supply permanently installed fixtures in show cases or wall cases.

**410-24. Conductor Protection at Lampholders.** Where a metal lampholder is attached to a flexible cord, the inlet shall be equipped with an insulating bushing which, if threaded, shall not be smaller than nominal  $\frac{3}{8}$  inch pipe size. The edges of the bushing shall be rounded and all inside fins removed in order to provide a smooth bearing surface for the conductors.

Bushings having holes  $\frac{9}{32}$  inch in diameter are suitable for use with plain pendent cord and holes  $\frac{13}{32}$  inch in diameter with reinforced cord.

**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 110-13 and 110-14.

**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.*

**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.

## F. Construction of Fixtures

**410-28. Combustible Shades and Enclosures.** Adequate air space shall be provided between lamps and shades or other enclosures of combustible material.

### 410-29. Fixture Rating.

(a) All fixtures requiring ballasts or transformers shall be plainly marked with their electrical rating and the manufacturer's name, trade-mark or other suitable means of identification.

(b) The electrical rating shall include the voltage and frequency, and shall indicate the current rating of the unit including the ballast, transformer or auto-transformer.

**410-30. Design and Material.** Fixtures shall be constructed of metal, wood, or other approved material and shall be so designed and assembled as to secure requisite mechanical strength and rigidity. Wireways, including the entrances thereto, shall be such that conductors may be drawn in and withdrawn without injury.

**410-31. Non-Metallic Fixtures.** In all fixtures not made entirely of metal, wireways shall be lined with metal unless approved armored or lead-covered conductors with suitable fittings are used.

### 410-32. Mechanical Strength.

(a) Tubing used for arms and stems where provided with cut threads shall be not less than 0.040 inch in thickness and when provided with rolled (pressed) threads shall be not less than 0.025 inch in thickness. Arms and other parts shall be fastened to prevent turning.

(b) Metal canopies supporting lampholders, shades, etc., exceeding 8 lbs., or incorporating attachment plug receptacles, shall be not less than 0.020 inch in thickness. Other canopies shall be not less than 0.016 inch when made of steel and not less than 0.020 inch when of other metals.

(c) Pull type canopy switches shall not be inserted in the rims of metal canopies which are less than 0.025 inch in thickness unless the rims are reinforced by the turning of a bead or the equivalent. Pull type canopy switches, whether mounted in the rims or elsewhere in sheet metal canopies, shall be located not more than 3½ inches from the center of

the canopy. Double set screws, double canopy rings, a screw ring, or equal method shall be used where the canopy supports a pull type switch or pendent receptacle.

The above thickness requirements apply to measurements made on finished (formed) canopies.

**410-33. Wiring Space.** Bodies of fixtures, including portable lamps, shall provide ample space for splices and taps and for the installation of devices, if any. Splice compartments shall be of non-absorptive, non-combustible material.

**410-34. Fixture Studs.** Fixture studs which are not parts of outlet boxes, hickey, tripods, and crowfeet shall be made of steel, malleable iron, or other approved material.

**410-35. Insulating Joints.** Insulating joints shall be composed of materials especially approved for the purpose. Those which are not designed to be mounted with screws or bolts shall have a substantial exterior metal casing, insulated from both screw connections.

**410-36. Portable Lamps.** Portable table and floor lamps and fan motors on ceiling fixtures may be wired with approved rubber-covered conductors, provided the wiring is not located so as to be subject to undue heating from lamps.

**410-37. Portable Handlamps.** Handlamps of the portable type supplied through flexible cords shall be of the molded composition or other type approved for the purpose. Metal-shell paper-lined lampholders shall not be used. Handlamps shall be equipped with a handle. Where subject to physical damage or where lamps may come in contact with combustible material, handlamps shall be equipped with a substantial guard attached to the lampholder or the handle.

For garages, see Section 511-6.

**410-38. Cord Bushings.** Bushing or the equivalent shall be provided where flexible cord enters the base or stem of a portable lamp. The bushing shall be of insulating material unless a jacketed type of cord is used.

**410-39. Tests.** All wiring shall be free from short-circuits and grounds, and shall be tested for these defects prior to being connected to the circuit.

**410-40. Live Parts.** Exposed live parts within porcelain fixtures shall be suitably recessed and so located as to make it improbable that wires will come in contact with them.

There shall be a spacing of at least  $\frac{1}{2}$  inch between live parts and the mounting plane of the fixture.

### 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.

### H. Construction of Lampholders

**410-44. Insulation.** The outer metal shell and the cap shall be lined with insulating material which shall prevent the shell and cap from becoming a part of the circuit. The lining shall not extend beyond the metal shell more than  $\frac{1}{8}$  inch, but shall prevent any current-carrying part of the lamp base from being exposed when a lamp is in the lampholding device.

**410-45. Lead Wires.** Lead wires, furnished as a part of weatherproof lampholders and intended to be exposed after installation, shall be of approved, stranded, rubber-covered conductors, not less than No. 14 gauge (No. 18 gauge for candelabra sockets), and shall be sealed in place or otherwise made raintight.

**410-46. Switched Lampholders.** Switched lampholders shall be of such construction that the switching mechanism interrupts the electrical connection to the center contact. The switching mechanism may also interrupt the electrical connection to the screw shell when connection to the center contact is simultaneously interrupted.

### J. Lamps

**410-49. Bases, Incandescent Lamps.** An incandescent lamp for general use on lighting branch circuits shall not be

equipped with a Medium base when rated over 300 watts, nor with a Mogul base when rated over 1,500 watts. Above 1,500 watts, special approved bases or other devices shall be used.

**410-50. Enclosures, Mercury-Vapor Lamp Auxiliary Equipment.** Resistors or regulators for mercury-vapor lamps shall be enclosed in noncombustible cases and treated as sources of heat.

**410-51. Arc Lamps.** Arc lamps used in theatres shall conform to Section 520-61, and arc lamps used in projection machines shall conform to Section 540-20. Arc lamps used on constant-current systems shall conform to the general requirements of Article 710.

## K. Receptacles

### 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) Faceplates of non-ferrous metal shall be not less than 0.040 inch in thickness, and of ferrous metal, not less than 0.030, and plates of non-conducting, non-combustible material shall be not less than 0.10 inch in thickness.

**410-53. Receptacles in Floors.** Receptacles located in floors shall be enclosed in floor boxes especially approved for the purpose.

*Exception: Where such receptacles are located in elevated floors of show-windows or other locations and when the authority enforcing this Code judges them to be free from physical damage, moisture and dirt, the standard approved type of flush receptacle box may be used.*

**410-54. Receptacles in Damp or Wet Locations.** Receptacles installed in damp or wet locations shall be of the weatherproof type.

**410-55. Receptacles—Grounding Type.** Receptacles (1) installed for the attachment of flexible cords that have a grounding conductor, (2) having a maximum rating of 15 amperes at a potential between 151 and 300 volts; or having a maximum rating of either 15 or 20 amperes at a maximum potential of 150 volts, (3) having two current-carrying con-

tacts and one fixed grounding member, and (4) having a terminal for the connection of a grounding conductor, shall have this grounding terminal of a distinctly different appearance from the other two terminals.

**410-56. Attachment Plugs.** Attachment plugs for use with grounding type receptacles, Section 410-55, and having two current-carrying contacts and one fixed grounding member shall have this grounding member so designed as to prevent it making contact with either of the current-carrying contacts of the receptacle. Any terminal for the connection of a grounding conductor shall be of distinctly different appearance from the other two terminals.

### **L. Rosettes**

**410-57. Approved Types.**

(a) Fusible rosettes shall not be installed.

(b) Separable rosettes which make possible a change in polarity shall not be used.

**410-58. Rosettes in Damp and Wet Locations.** Rosettes installed in damp or wet locations shall be of the weatherproof type.

**410-59. Rating.** Rosettes shall be rated at 660 watts, 250 volts, with a maximum current rating of 6 amperes.

**410-60. Rosettes for Exposed Wiring.** When designed for use with exposed wiring, rosettes shall be provided with bases which shall have at least two holes for supporting screws, shall be high enough to keep the wires and terminals at least  $\frac{1}{2}$  inch from the surface wired over, and shall have a porcelain lug under each terminal to prevent the rosette being placed over projections which would reduce the separation to less than  $\frac{1}{2}$  inch.

**410-61. Rosettes for Use With Boxes or Raceways.** When designed for use with conduit boxes or wire raceways, rosette bases shall be high enough to keep wires and terminals at least  $\frac{3}{8}$  inch from the surface wired over.

### **M. Special Provisions for Flush and Recessed Fixtures**

**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 410-70 inclusive.

#### 410-63. Temperature.

(a) Fixtures shall be so constructed or installed that adjacent combustible 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 (320°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  $\frac{1}{2}$  inch from combustible material.

#### 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 Paragraphs 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.

### N. Construction; Flush and Recessed Fixtures

410-66. Temperature. Fixtures shall be so constructed that adjacent combustible material will not be subject to temperatures in excess of 90°C (194°F).

410-67. Enclosure. Sheet metal enclosures shall be protected against corrosion by galvanizing, plating, or other

equivalent heat-resisting coating, and shall not be less than No. 22 USS gauge (.0299 in.).

**410-68. Lamp Wattage Marking.** Incandescent lamp fixtures shall be marked to indicate the maximum allowable wattage of lamps. The markings shall be permanently installed, in letters at least  $\frac{1}{4}$  inch high, and located where visible during relamping.

**410-69. Solder Prohibited.** No solder shall be used in the construction of the fixture box.

**410-70. Lampholders.** Lampholders of the screw-shell type shall be of porcelain unless specially approved for the purpose. Cements, where used, shall be of the high-heat type.

### **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.

**410-72. Direct-Current Equipment.** Fixtures installed on direct current circuits shall be equipped with auxiliary equipment and resistors especially designed and approved for direct current operation and the fixtures shall be so marked.

#### **410-73. Voltages—Dwelling Occupancies.**

(a) Equipment having an open-circuit voltage of more than 1000 volts shall not be installed in dwelling occupancies.

(b) Equipment having an open-circuit voltage of more than 300 volts shall not be installed in dwelling occupancies 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  $1\frac{1}{2}$  inches from the surface of the fiberboard.

(3) Where such fixtures are partially or wholly recessed, the provisions of Section 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.

**410-75. Auxiliary Equipment Not Integral with Fixture.**

(a) Auxiliary equipment, including reactors, capacitors, resistors, and similar equipment, where not installed as part of a lighting fixture assembly shall be enclosed in accessible, permanently-installed metal cabinets.

(b) Such separate equipment should be installed close to the lamps to keep the conductors between lamps and auxiliaries as short as possible. Where display cases are not permanently installed, no portion of a secondary circuit may be included in more than a single case.

(c) Ballasts approved for separate mounting and for direct connection to an approved wiring system need not be separately enclosed.

**410-76. Auto-Transformers.** An auto-transformer which is used as part of a ballast for supplying lighting units and which raises the voltage to more than 300 volts shall be supplied only by a grounded system.

**410-77. Switches.** Snap switches shall conform to Section 380-14.

## **Q. Special Provisions for Electric Discharge Lighting Systems of More Than 1,000 Volts**

### **410-78. General.**

(a) Equipment for use with electric discharge lighting systems and designed for an open-circuit voltage of more than 1,000 volts shall be of a type approved for such service.

(b) The terminal of an electric discharge lamp shall be considered as alive when any lamp terminal is connected to a potential of more than 300 volts.

(c) In addition to complying with the general requirements for lighting fixtures, such equipment shall conform to Sections 410-78 to 410-90 inclusive.

For signs and outline lighting, see Article 600.

### **410-79. Control.**

(a) Fixtures or lamp installations shall be controlled either singly or in groups by an externally-operable switch or circuit-breaker which shall open all ungrounded primary conductors.

(b) The switch or circuit-breaker shall be located within sight of the fixtures or lamps, or it may be located elsewhere if it is provided with means for locking in the open position.

**410-80. Lamp Terminals and Lampholders.** Parts which must be removed for lamp replacement shall be hinged or fastened by an approved means. Lamps or lampholders or both shall be so designed that there shall be no exposed live parts when lamps are being inserted or are being removed.

**410-81. Transformer Ratings.** Transformers and ballasts shall have a secondary open-circuit voltage of not more than 15,000 volts with an allowance on test of 1,000 volts additional. The secondary current rating shall be not more than 120 milli-amperes when the open circuit voltage is more than 7500 volts, and not more than 240 milli-amperes when the open circuit voltage is 7500 volts or less.

**410-82. Transformer Type.** Transformers shall be of an approved enclosed type. Transformers of other than the askarel insulated or dry type shall not be used.

**410-83. Transformer Secondary Connections.**

(a) The high-voltage windings of transformers shall not be connected in series or in parallel, except that for two transformers, each having one end of its high-voltage winding grounded and connected to the enclosure, the high-voltage windings may be connected in series to form the equivalent of a mid-point grounded transformer.

(b) The grounded ends shall be connected by an insulated conductor not smaller than No. 14 AWG.

**410-84. Transformer Locations.**

(a) Transformers shall be accessible after installation.

(b) The transformers should be installed as near to the lamps as practicable to keep the secondary conductors as short as possible.

(c) Transformers shall be so located that adjacent combustible materials will not be subjected to temperatures in excess of 90°C (194°F).

**410-85. Transformer Loading.** The lamps connected to any transformer shall be of such length and characteristics as not to cause a condition of continuous over-voltage on the transformer.

**410-86. Wiring Method. Secondary Conductors.** Approved gas-tube sign cable suitable for the voltage of the circuit shall be used. For installation of conductors, see Section 600-31.

**410-87. Lamp Supports.** Lamps shall be adequately supported as required in Section 600-33.

**410-88. Exposure to Damage.** Lamps shall not be located where normally exposed to physical damage.

**410-89. Marking.** Each fixture or each secondary circuit of tubing having an open-circuit voltage of more than 1,000 volts shall have a clearly legible marking in letters not less than 1/4 inch high reading "Caution.....volts." The voltage indicated shall be the rated open-circuit voltage.

**410-90. Switches.** Snap switches shall conform to Section 380-14.

## R. Grounding

**410-91. General.** Fixtures and lighting equipment shall be grounded as provided in Sections 410-92 to 410-96 inclusive.

**410-92. Metallic Wiring Systems.** Metal fixtures installed on outlets wired with grounded metal raceway or grounded armored cable shall be grounded.

**410-93. Non-Metallic Wiring Systems.** Metal fixtures installed on outlets wired with knob-and-tube work, or non-metallic 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 non-current-carrying parts of fixtures and lampholders.

**410-94. Equipment of More Than 150 Volts to Ground.**

(a) Metal fixtures, transformers and transformer enclosures on circuits operating at more than 150 volts to ground shall be grounded.

(b) Other exposed metal parts shall be grounded unless they are insulated from ground and other conducting surfaces and are inaccessible to unqualified persons, except that lamp tie wires, mounting screws, clips and decorative bands on glass lamps spaced not less than 1½ inches from lamp terminals need not be grounded.

**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.

**410-96. Methods of Grounding.** Equipment shall be considered as grounded where mechanically connected in a permanent and effective manner to metal raceway, the armor of armored cable, the grounding conductor in non-metallic sheathed cable, or to a separate grounding conductor not smaller than No. 14, provided that the raceway, armor, or grounding conductor is grounded in a manner specified in Article 250.

## ARTICLE 422—APPLIANCES

### A. General

**422-1. Scope.** This Article shall apply to electric appliances used in any occupancy.

**422-2. Branch Circuit Requirements.** Every appliance shall be supplied by a branch circuit of one of the types specified in Article 210. Motor-operated appliances shall also conform to the requirements of Article 430.

See Table 220-5 for the conductors of a household range branch circuit.

### B. Installation of Appliances

**422-3. Flexible Cords.** Flexible cords used to connect heating appliances shall comply with the following:

(a) **Heater Cords Required.** All smoothing irons and portable electrically-heated appliances rated at more than 50 watts and which produce temperatures in excess of 121°C (250°F) on surfaces with which the cord is liable to be in contact shall be provided with one of the types of approved heater cords listed in Table 400-11.

(b) **Other Heating Appliances.** All other portable electrically-heated appliances shall be connected with one of the approved types of cord listed in Table 400-11, selected in accordance with the usage specified in that Table.

**422-4. Insulation of Appliances.** Portable appliances shall be provided with an adequate dielectric interposed between current-carrying parts and those external surfaces which persons can touch, except for toasters, grills or other heating appliances in which the current-carrying parts at high temperature are necessarily exposed. In locations where the dielectric is exposed to physical damage, it shall be suitably protected.

**422-5. Portable Immersion Heaters.** Electric heaters of the portable immersion type shall be so constructed and installed that current-carrying parts are effectively insulated from electrical contact with the substance in which immersed. The authority enforcing this Code may make exception of special applications of apparatus where suitable precautionary measures are followed.

**422-6. 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.

**422-7. Stands for Portable Appliances.** Each smoothing iron and other portable electrically-heated appliance which is intended to be applied to combustible material shall be equipped with an approved stand, which may be a separate piece of equipment or may be a part of the appliance.

**422-8. Signals for Heated Appliances.** In other than residence occupancies, each electrically-heated appliance, or group of electrically-heated appliances, intended to be applied to combustible material, shall be installed in connection with a signal unless the appliance is provided with an integral temperature-limiting device.

**422-9. Flatirons.** Electrically heated smoothing irons intended for use in residences shall be equipped with approved temperature-limiting means.

**422-10. Water Heaters.** It is recommended that permanently-installed electrically-heated water heaters be equipped with temperature-limiting means.

**422-11. Infra-Red Lamp Industrial Heating Appliances.**

(a) Infra-red heating lamps rated at 300 watts or less may be used with lampholders of the medium-base unswitched porcelain type, or other types approved for the purpose.

(b) Screw-shell lampholders shall not be used with infra-red lamps over 300 watts rating unless the lampholders are especially approved for the purpose.

(c) Lampholders may be connected to any of the branch circuits of Article 210 and, in industrial occupancies, may be operated in series on circuits of more than 150 volts to ground provided the voltage rating of the lampholders is not less than the circuit voltage.

Each section, panel or strip carrying a number of infra-red lampholders (including the internal wiring of such section, panel or strip) is considered an appliance. The terminal connection block of each such assembly is deemed an individual outlet.

**422-12. Grounding.** Metal frames of portable and stationary 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.

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.

#### **422-13. 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 422-14.;

(2) Be approved for the temperature of the space in which it is located.

### **C. Control and Protection of Appliances**

**422-14. Disconnecting Means.** Each appliance shall be provided with a means for disconnection from all ungrounded conductors.

#### **422-15. Disconnection of Portable Appliances.**

(a) For portable appliances (including household ranges and clothes dryers) a separable connector or an attachment plug and receptacle may serve as the disconnecting means.

(b) The rating of a receptacle or of a separable connector shall not be less than the rating of any appliance connected thereto, except that demand factors authorized elsewhere in this Code may be applied.

(c) Attachment plugs and connectors shall conform to the following:

(1) **Live Parts.** They shall be so constructed and installed as to guard against inadvertent contact with live parts.

(2) **Interrupting Capacity.** They shall be capable of interrupting their rated current without hazard to the operator.

**(3) Interchangeability.** They shall be so designed that they will not fit into receptacles of lesser rating.

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.

#### **422-16. 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.

**422-17. Unit Switches as Disconnecting Means.** Switches which are a part of an appliance shall not be considered as taking the place of the single disconnecting means required by Part C of this Article, unless there are other means for disconnection as follows:

(a) **Multi-Family Dwellings.** In multi-family (more than two) dwellings, the disconnecting means shall be within the apartment, or on the same floor as the apartment in which the appliance is installed, and may control lamps and other appliances.

(b) **Two-Family Dwellings.** In two-family dwellings, the disconnecting means may be outside of 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.

(d) **Other Occupancies.** In other occupancies, the branch-circuit switch or circuit-breaker, where readily accessible to the user of the appliance, may be used for this purpose.

**422-18. Switch and Circuit-Breaker to Be Indicating.** Switches and circuit-breakers used as disconnecting means shall be of the indicating type.

**422-19. Motor-Driven Appliances.** A switch or circuit-breaker which serves as the disconnecting means for a stationary motor-driven appliance of 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.

**422-20. Overcurrent Protection.**

(a) Appliances, other than such motor-operated appliances as are 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.

(b) A range, hot plate or similar appliance with surface heating elements, having a maximum demand of more than 70 amperes, as calculated in accordance with Table 220-5, shall have the main circuit subdivided into two or more circuits, each provided with overcurrent protection rated at not more than 50 amperes.

(c) Infra-red lamp heating appliances shall have overcurrent protection not exceeding 50 amperes.

**D. Marking of Appliances**

**422-21. Nameplate.** Each electric appliance shall be provided with a nameplate, giving the maker's name and the normal rating in volts and amperes, or in volts and watts.

**422-22. Marking of Heating Elements.** Individual heating elements which are a part of an electric appliance containing more than one heating element shall each be legibly marked with normal rating in volts and amperes, or in volts and watts.

**E. Special Provisions For Fixed Electrical Space Heating****422-23. General.**

(a) Equipment for use with electrical space heating systems shall be of a type approved for such service.

(b) In addition to complying with the general requirements for appliances, such equipment shall comply with Part E of this Article.

(c) The special provisions of this Article shall apply to electrically energized units, panels and cables for space heating. They shall also include central heating systems employing electrical heating units.

(d) Electrical space heating systems employing methods of installation other than covered by Part E of this Article may be used only by special permission.

**422-24. Use.** Space heating systems shall not be used:

(a) Where exposed to severe physical damage unless adequately protected.

(b) In wet or damp locations unless specially approved for the purpose.

See also rules on Corrosive Conditions, Section 310-7.

**422-25. Temperature Limitations.** The operating temperature of room surfaces where embedded elements and panels are used shall not exceed 66°C. (150°F.). (Based on room temperature of 30°C., 86°F.)

**422-26. Appliances to Be Complete Units.**

(a) Panels and cables shall be installed in their complete sizes or lengths as supplied by the manufacturer.

(b) Units which are shortened or from which the marking labels or nameplates are missing shall not be installed.

(c) Units shall be suitable for use with approved wiring systems.

**422-27. Heating Cable Construction.** Heating cables shall be furnished complete with factory-assembled non-heating leads at least 7 feet in length, and the leads shall consist of conductors and wiring approved for general use or other wiring approved for the purpose.

**422-28. Marking of Heating Cables.** Each unit length of heating cable shall have a permanent marking located within 3 inches of the terminal end of the non-heating leads, and shall be legibly marked with the manufacturer's name or identification symbol, catalog number, and rating in volts and watts or amperes.

The lead wires shall have the following color identifications: 230 volts nominal—red, 115 volts nominal—yellow.

**422-29. Controllers and Disconnecting Means.**

(a) Thermostats and thermostatically controlled switching devices which indicate an "off" position and which interrupt line current shall open simultaneously all ungrounded conductors in the "off" position.

(b) Thermostats and thermostatically controlled switching devices which do not have "on" or "off" positions are not required to open all ungrounded conductors.

See Sections 422-14, 422-16 and 422-18 for disconnecting means for stationary appliances.

(c) Switching devices consisting of combined thermostats and manually controlled switches which serve both as controllers and disconnecting means shall:

(1) Open regardless of temperature 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.

#### 422-30. Clearances of Wiring in Ceilings.

(a) Wiring located above heated ceilings and within thermal insulation 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 current carrying capacities of conductors shall be computed on the basis of the correction factors given in Tables 310-12 and 310-14.

(b) Wiring located above heated ceilings and over thermal insulation having a minimum thickness of 2 inches requires no correction for temperature.

(c) Wiring located above heated ceilings and within a joist space having no thermal insulation shall be spaced not less than two inches above the ceiling and shall be considered as operating at an ambient of 50°C. The current carrying capacities of conductors shall be computed on the basis of the correction factors given in Tables 310-12 and 310-14.

#### 422-31. Clearances of 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 located away from the heated surfaces, and the wiring shall be considered as operating at an ambient of 40°C. (104°F.); and the current carrying capacities of conductors shall be computed on the basis of the correction factors given in Tables 310-12 and 310-14.

#### 422-32. Area Restrictions.

(a) Heating panels shall not extend beyond the room in which they originate.

(b) Cables shall not be installed in closets, over cabinets which extend to the ceiling, under walls or partitions or over walls or partitions which extend to the ceiling.

*Exception: Single runs of cable may pass over partitions where they are embedded.*

(c) This requirement shall not prohibit low-temperature heat sources in closets to control relative humidity.

**422-33. Clearance from Other Objects and Openings.** Panels and cables shall be separated at least 8 inches from lighting fixtures, outlet and junction boxes, and 2 inches from ventilating openings and other such openings in room surfaces, or sufficient area shall be provided to assure that no heating cables or panels will be covered by surface mounted lighting units.

**422-34. 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.

**422-35 Installation of Heating Cables in Dry Board and Plaster.**

(a) Cables shall not be installed in walls.

(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 and similar fire-resistant materials. With metal lath or other conducting surfaces, a coat of plaster (brown or scratch coat) shall be applied to completely cover the metal lath or conducting surface before the cable is attached.

(d) The entire ceiling surface shall have a finish of thermally non-insulating sand plaster or other approved non-insulating material having a nominal thickness of  $\frac{1}{2}$ -inch.

(e) Cables shall be secured at intervals not exceeding 16 inches by means of approved stapling, tape, plaster or other approved means. Staples or metal fasteners which straddle the cable shall not be used with metal lath or other conducting surface.

(f) In dry board installations, the entire ceiling shall be covered with gypsum board not exceeding  $\frac{1}{2}$  inch thickness. The void between the upper layer of gypsum board and the surface layer of gypsum board shall be filled with thermally conducting plaster or other approved material.

(g) Cables shall be kept free from contact with metal or conducting surfaces.

(h) Caution should be used in attaching a surface layer of gypsum so that the nails or other fastenings do not pierce the heating cable.

**422-36. Installation of Non-Heating Leads.**

(a) Non-heating leads of cables shall be installed in accordance with approved wiring methods from the junction box to a location on the underside of the ceiling.

(b) 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.

(c) The marking of the leads shall be visible in the junction box.

**422-37. Installation of Cables in Concrete or Poured Masonry Floors.**

(a) Adjacent runs of cable not exceeding  $2\frac{3}{4}$  watts per foot shall be installed not less than 1 inch on centers.

(b) Cables shall be secured in place by non-metallic frames or spreaders while the concrete or other finish is applied.

(c) A spacing of at least 1 inch shall be maintained between the heating cable and other metallic bodies embedded in the floor.

(d) Leads shall be protected where they leave the floor by rigid metal conduit, electrical metallic tubing, or by other approved raceways extending to the junction box.

(e) Bushings shall be used where the leads emerge in the floor slab.

**422-38. 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) Cable shall be tested for insulation resistance after plastering or the pouring of floors. See Section 110-19, Insulation Resistance.

**F. Provisions for Room Air-Conditioning Units**

**422-39. General.** The provisions of Sections 422-40 and 422-41 shall apply to electrically energized units and equipment which control temperature and humidity.

**422-40. Grounding.** Exposed non-current-carrying metal parts which are liable to become energized shall be grounded under one or more of the following conditions:

- (a) Where permanently connected to metal-clad wiring;
- (b) When in a wet location and not isolated;
- (c) When within reach of a person standing on the ground outside of a building;
- (d) When in a hazardous location, see Article 500;
- (e) Where in electrical contact with metal or metal lath;
- (f) Where more than 150 volts to ground.

**422-41. Branch Circuit Requirements.**

(a) The total load 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 load 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.

## ARTICLE 430—MOTORS, MOTOR CIRCUITS AND CONTROLLERS

NOTE: See Diagram Next Page for Section 430-1

### A. General

**430-2. General.** The following general requirements cover provisions for motors, motor circuits, and controllers which do not properly fall into the other parts of this Article.

**430-3. Sealed (Hermetic Type) Refrigeration Compressor.** For the purposes of this Article, a sealed (hermetic-type) refrigeration compressor is a mechanical compressor consisting of a compressor and a motor, both of which are enclosed in the same housing, with no external shaft nor shaft seals, the motor operating in the refrigerant atmosphere.

**430-4. In Sight From.** Where in this Article it is specified that some equipment shall be "in sight from" another equipment, it means that the equipment must be visible and not more than 50 feet distant.

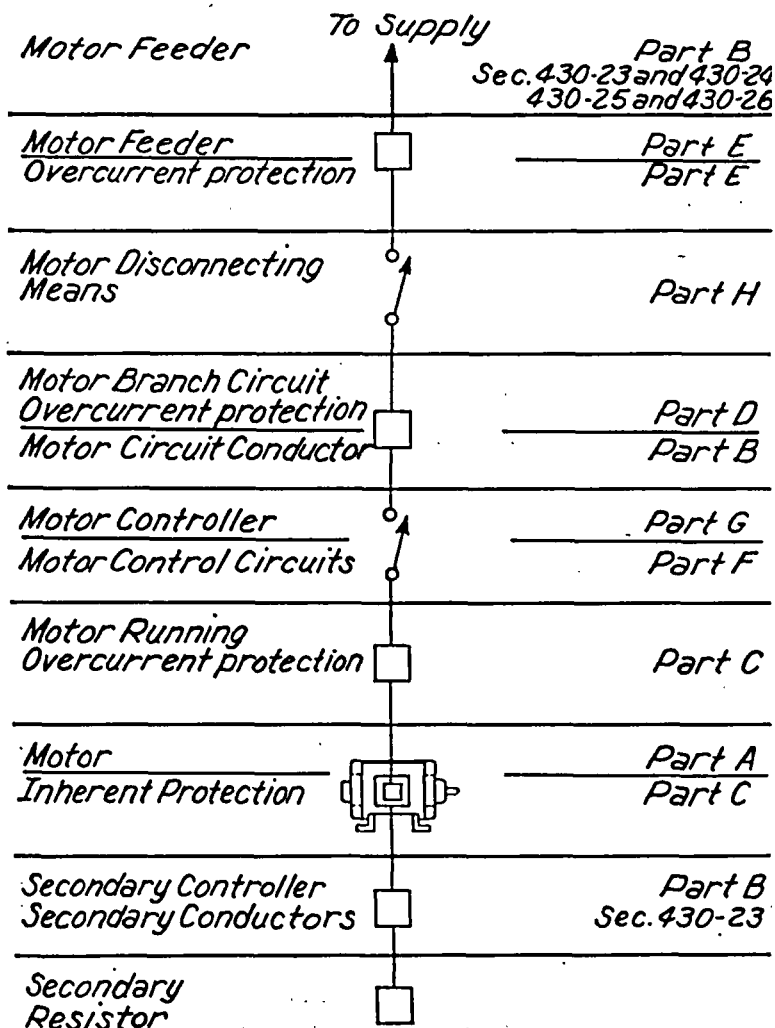
**430-5. Other Articles.** Motors and controllers shall also comply with the applicable provisions of the following:

Capacitors .....	Section 460-9
Cranes and Hoists .....	Article 610
Elevators .....	Article 620
Garages, Aircraft Hangars, Gasoline Dispensing and Service Stations, Bulk Storage Plants, Finishing Processes and Flammable Anesthetics....	Articles 511, 513, 514, 515, 516 and 517
Hazardous Locations .....	Articles 500-503
Machine Tools .....	Article 670
Motion-picture Projectors .....	Sections 540-12, 540-17
Motion-picture Studios .....	Article 530
Organs .....	Section 650-3
Resistors and Reactors .....	Article 470
Theaters .....	Section 520-48

**430-6. Current-Carrying Capacity Determination.** Current-carrying capacities shall be determined as follows:

## Section 430-1. Motor Feeder and Branch Circuits.

General.....	Part A
Requirements for over 600 volts.....	Part J
Protection of live parts all voltages....	Part K
Grounding.....	Part L
Tables.....	Part M



(a) **General Motor Applications.** Except as noted in Paragraph 430-6(b), whenever the current rating of a motor is used to determine the current-carrying capacity of conductors, switches, branch-circuit overcurrent devices, etc., the values given in Tables 430-147, 430-148, 430-149, and 430-150, including notes, shall be used instead of actual current rating marked on the motor nameplate. Motor running overcurrent protection shall be based on the motor nameplate current rating. When a motor is marked in amperes, but not horsepower, the horsepower rating shall be assumed to be that corresponding to the value given in Tables 430-147, 430-148, 430-149, and 430-150 interpolated if necessary.

(b) **Sealed (Hermetic-Type) Refrigeration Compressor Motors.** For sealed (hermetic-type) refrigeration compressor motors the full-load current marked on the nameplate for the compressor shall be used to determine the current-carrying capacity of the branch-circuit conductors (see Sections 430-22 and 430-24), branch-circuit overcurrent protection, and motor-running overcurrent protection. For motor controllers and disconnecting means, see Paragraph 430-83 Exception No. 3, and Section 430-110.

#### **430-7. Marking on Motors.**

(a) **Usual Motor Applications.** A motor shall be provided with a nameplate showing the maker's name, the rating in volts and amperes, including those of the secondary if a wound-rotor type of motor, the normal full-load speed and the interval during which it can operate at full load starting cold, before reaching its rated temperature. The time interval shall be 5, 15, 30, or 60 minutes, or continuous. A motor rated at  $\frac{1}{8}$  horsepower or larger shall have the horsepower rating marked on the nameplate except that the motors of arc welders may be marked in amperes. A motor provided with a protective device integral with the motor, that complies with Paragraph 430-32(a-2) or 430-32(c-2) shall be permanently marked "Thermal Protection." An alternating-current motor rated at  $\frac{1}{2}$  horsepower or larger, unless it is a polyphase wound-rotor motor, shall have the nameplate marked with a code letter to show its input in kilovolt-amperes with locked rotor, selected from Table 430-7(b).

(b) **Locked Rotor Indicating Code Letters.** Code letters marked on motor nameplates to show motor input with locked rotor shall be in accordance with Table 430-7(b).

**Table 430-7(b). Locked Rotor Indicating Code Letters**

Code Letter	Kilovolt-Amperes per Horsepower with Locked Rotor		
A .....	0	—	3.14
B .....	3.15	—	3.54
C .....	3.55	—	3.99
D .....	4.0	—	4.49
E .....	4.5	—	4.99
F .....	5.0	—	5.59
G .....	5.6	—	6.29
H .....	6.3	—	7.09
J .....	7.1	—	7.99
K .....	8.0	—	8.99
L .....	9.0	—	9.99
M .....	10.0	—	11.19
N .....	11.2	—	12.49
P .....	12.5	—	13.99
R .....	14.0	—	15.99
S .....	16.0	—	17.99
T .....	18.0	—	19.99
U .....	20.0	—	22.39
V .....	22.4	—	and up

The above table is an adopted standard of the National Electrical Manufacturers Association.

The code letter indicating motor input with locked rotor must be in an individual block on the nameplate, properly designated. This code letter is to be used for determining branch-circuit overcurrent protection by reference to Table 430-152, as provided in Section 430-52.

**(c) Sealed (Hermetic-Type) Refrigeration Compressor Motors.** Sealed (hermetic-type) refrigeration compressors shall be provided with a nameplate which shall give the manufacturer's name; the phase, voltage, frequency, and the full load current in amperes of the motor (operating current when the compressor is delivering rated output). The locked-rotor current of single-phase motors having full load currents in amperes of more than 9 amperes at 115 volts and more than 4.5 amperes at 230 volts and all poly-phase motors shall also be marked on the nameplate. When a protective device integral with a motor is used (see Section 430-32), the nameplate shall be marked with the words "Thermal Protection."

**430-8. Marking on Controllers.** A controller shall be marked with the maker's name or identification, the voltage, the current or horsepower rating, and such other data as may be needed to properly indicate the motors for which it is suitable.

Where a controller is built in as an integral part of a motor or of a motor-generator set, the controller need not be individually marked when the necessary data is on the motor nameplate.

**430-9. Marking at Terminals.** Terminals of motors and controllers shall be suitably marked or colored where necessary to indicate the proper connections.

**430-10. Wiring Space in Enclosures.** Enclosures for controllers and disconnecting means for motors shall not be used as junction boxes, troughs, or raceways for conductors feeding through or tapping off to other apparatus unless designs are employed which provide adequate space for this purpose.

**430-11. Protection Against Liquids.** Suitable guards or enclosures shall be provided to protect exposed current-carrying parts of motors and the insulation of motor leads where installed directly under equipment, or in other locations where dripping or spraying oil, water, or other injurious liquid may occur, unless the motor is designed for the existing conditions.

**430-12. Motor Terminal Housings.** Motor terminal housings shall be of ample size to properly make connections and shall be of substantial metal construction.

**430-13. Bushings.** Soft-rubber bushings used to protect lead wires where they pass through the frame of a motor shall not be exposed to oils, grease, oily vapors, or other substances having a deleterious effect on rubber.

For conductors, see Section 310-7.

**430-14. Location of Motors.**

(a) **Ventilation and Maintenance.** Motors shall be located so that adequate ventilation is provided and so that maintenance such as lubrication of bearings and replacing of brushes can be readily accomplished.

(b) **Open Motors.** Open motors having commutators or collector rings shall be located or protected so that sparks

cannot reach adjacent combustible material. This does not prohibit the installation of these motors on wooden floors or supports.

**430-16. Overheating From Dust Accumulations.** In locations where dust or flying material will collect on or in motors in such quantities as to seriously interfere with the ventilation or cooling of motors, and thereby cause dangerous temperatures, suitable types of enclosed motors which will not overheat under the prevailing conditions, shall be used. Especially severe conditions may require the use of enclosed pipe ventilated motors, or enclosure in separate dust-tight rooms, properly ventilated from a source of clean air.

## B. Motor Circuit Conductors

**430-21. General.** The provisions of Part B specify sizes of conductors capable of carrying the motor current without overheating under the conditions specified.

### 430-22. Single Motor.

(a) Branch-circuit conductors supplying a single motor shall have a carrying capacity not less than 125 per cent of the motor full-load current rating.

Any motor application is considered to be for continuous duty unless the nature of the apparatus which it drives is such that the motor will not operate continuously with load under any condition of use.

For long runs, it may be necessary in order to avoid excessive voltage drop, to use conductors of sizes larger than the minimum sizes selected from Tables 310-12 to 310-15 inclusive.

See Example No. 8, Ch. 9, and Diagram in Section 430-1.

*Exception: Conductors for a motor used for short-time, intermittent, periodic, or varying duty may have a carrying capacity not less than the percentage of the motor nameplate current rating as shown in Table 430-22 (a-Exception) unless the authority enforcing the code grants special permission for conductors of smaller size.*

(b) The conductors between a stationary motor rated one horsepower or less, and the separate terminal enclosures permitted in Paragraph 430-145(b) may be smaller than No. 14 but not smaller than No. 18, provided they have current-carrying capacity as specified above.

Table 430-22 (a-Exception)

Classification of Service	Percentages of Nameplate Current Rating			
	5-Minute Rated Motor	15-Minute Rated Motor	30 & 60 Minute Rated Motor	Continuous Rated Motor
Short-Time Duty				
Operating valves, raising or lowering rolls, etc. ....	110	120	150	...
Intermittent Duty				
Freight and passenger elevators, tool heads, pumps, drawbridges, turntables, single-operator arc welders for manual welding, etc.	85	85	90*	140
Periodic Duty				
Rolls, ore and coal-handling machines, etc. ....	85	90	95	140
Varying Duty ....	110	120	150	200

\*This figure also applies for conductors which supply a motor-generator single-operator arc welder which has a 60 per cent duty cycle rating.

**430-23. Wound-Rotor Secondary.** For continuous duty the conductors connecting the secondary of a wound-rotor alternating-current motor to its controller shall have a carrying capacity which is not less than 125 per cent of the full-load secondary current of the motor.

*Exception: For other than continuous duty, these conductors shall have a carrying capacity, in per cent of full load secondary current, not less than that specified in Table 430-22 (a-Exception).*

*Where the secondary resistor is separate from the controller, the carrying capacity of the conductors between controller and resistor shall be not less than that given in Table 430-23 (Exception).*

Table 430-23 (Exception)

Resistor Duty Classification	Carrying Capacity of Wire in Per Cent of Full-Load Secondary Current
Light starting duty .....	35
Heavy starting duty .....	45
Extra heavy starting duty .....	55
Light intermittent duty .....	65
Medium intermittent duty .....	75
Heavy intermittent duty .....	85
Continuous duty .....	110

**430-24. Conductors Supplying Several Motors.** Conductors supplying two or more motors shall have a current-carrying capacity of not less than 125 per cent of the full-load current rating of the highest rated motor in the group plus the sum of the full-load current ratings of the remainder of the motors in the group.

See Example No. 8, Chapter 9.

**430-25. Combination Load.** Conductors supplying a motor load, and in addition a lighting or appliance load as computed from Article 220 and other applicable Sections, shall have a current-carrying capacity sufficient for the lighting or appliance load plus the required capacity for the motor load determined in accordance with Section 430-24, or, for a single motor, in accordance with Section 430-22.

**430-26. Feeder Demand-Factor.** Where a reduced heating of the conductors results from motors operating on duty-cycle, intermittently, or from all motors not operating at one time the authority enforcing this Code may grant permission for feeder conductors to be of a capacity less than specified in the Sections 430-24 and 430-25, provided the conductor is of sufficient carrying capacity for the maximum load determined by the sizes and number of motors supplied and the character of their loads and duties.

**430-27. Capacitors with Motors:** For provisions covering conductors where capacitors are installed on motor circuits, see Sections 460-7, 460-8, 460-9.

### C. Motor Running Overcurrent (Overload) Protection

**430-31. General.** The provisions of Part C specify overcurrent devices intended to protect the motors, the motor-control apparatus, and the branch-circuit conductors against excessive heating due to motor overloads.

(a) Overload in electrical apparatus is an operating overcurrent which, when it persists for a sufficient length of time, would cause damage or dangerous over-heating of the apparatus. It does not include short-circuits or ground faults.

(b) These provisions shall not be interpreted as requiring overcurrent protection where it might introduce additional

or increased hazards as in the case of fire pumps [see NFPA Standard for Centrifugal Fire Pumps (No. 20)].

#### **430-32. Continuous Duty Motors.**

**(a) More Than One Horsepower.** Each continuous duty motor rated more than one horsepower shall be protected against running overcurrent by one of the following means:

(1) A separate overcurrent device which is responsive to motor current. This device shall be rated or selected to trip at not more than 125 per cent of the motor full-load current rating for sealed (hermetic-type) refrigeration compressor motors and motors marked to have a temperature rise not over 40°C, and at not more than 115 per cent for all other types of motors. This value may be modified as permitted by Section 430-34.

(2) A thermal protector integral with the motor, approved for use with the motor which it protects on the basis that it will prevent dangerous overheating of the motor due to overload or failure to start. If the motor current interrupting device is separate from the motor and its control circuit is operated by a protective device integral with the motor, it shall be so arranged that the opening of the control circuit will result in interruption of current to the motor.

(3) For motors larger than 1500 horsepower, a protective device employing embedded temperature detectors which cause current to the motor to be interrupted when the motor attains a temperature rise greater than marked on the nameplate in an ambient of 40°C.

Standards for the application of embedded temperature detectors are given in the American Standards for Rotating Machinery, ASA C-50 (paragraph 3.080).

**(b) One Horsepower or Less, Manually Started.** Each continuous duty motor rated at one horsepower or less which is not permanently installed, is manually started and is within sight from the controller location, shall be considered as protected against overcurrent by the overcurrent device protecting the conductors of the branch circuit. This branch circuit overcurrent device shall not be larger than that specified in Table 430-146, except that any such motor may be

used at 125 volts or less on a branch circuit protected at 20 amperes. Any such motor which is not in sight from the controller location shall be protected as specified in Paragraph 430-32(c). Any motor rated at one horsepower or less which is permanently installed, shall be protected in accordance with Paragraph 430-32(c).

**(c) One Horsepower or Less, Automatically Started.** Any motor of one horsepower or less which is started automatically shall be protected against overcurrent by the use of one of the following means:

(1) A separate overcurrent device which is responsive to motor current. This device shall be rated or selected to trip at not more than 125 per cent of the motor full-load current rating for sealed (hermetic-type) refrigeration compressor motors and motors marked to have a temperature rise not over 40°C, and at not more than 115 per cent for all other types of motors. This value may be modified as permitted by Section 430-34.

(2) A thermal protector integral with the motor, approved for use with the motor which it protects on the basis that it will prevent dangerous overheating of the motor due to overload or failure to start. Where the motor current interrupting device is separate from the motor and its control circuit is operated by a protective device integral with the motor, it shall be so arranged that the opening of the control circuit will result in interruption of current to the motor.

(3) The motor shall be considered as being properly protected where it is part of an approved assembly which does not normally subject the motor to overloads and which is also equipped with other safety controls (such as the safety combustion controls of a domestic oil burner) which protect the motor against damage due to stalled rotor current. Where such protective equipment is used it shall be indicated on the nameplate of the assembly where it will be visible after installation.

(4) In case the impedance of the motor windings is sufficient to prevent overheating due to failure to start, the

motor may be protected as specified in Paragraph 430-32 (b) for manually started motors.

Many alternating-current motors of less than 1/20 horsepower, such as clock motors, series motors, etc., and also some larger motors such as torque motors, come within this classification. It does not include split-phase motors having automatic switches to disconnect the starting windings.

(d) **Wound-Rotor Secondaries.** The secondary circuits of wound-rotor alternating-current motors, including conductors, controllers, resistors, etc., shall be considered as protected against overcurrent by the motor-running overcurrent device.

**430-33. Intermittent and Similar Duty.** A motor used for a condition of service which is inherently short time, intermittent, periodic, or varying duty, as illustrated by Table 430-22 (a-Exception), is considered as protected against overcurrent by the branch-circuit overcurrent device, provided the overcurrent protection does not exceed that specified in Tables 430-152 and 430-153.

Any motor application is considered to be for continuous duty unless the nature of the apparatus which it drives is such that the motor cannot operate continuously with load under any condition of use.

**430-34. Selection or Setting of Protective Device.** Where the values specified for motor-running overcurrent protection do not correspond to the standard sizes or ratings of fuses, non-adjustable circuit-breakers, thermal cut-outs, thermal relays, the heating elements of thermal trip motor switches, or possible settings of adjustable circuit-breakers adequate to carry the load, the next higher size, rating, or setting may be used, but not higher than 140 per cent of the full-load current rating of sealed (hermetic-type) refrigeration compressor motors and motors marked to have a temperature rise not over 40°C, and not higher than 130 per cent of the full-load current rating for all other motors.

In case it is not shunted during the starting period of the motor (see Section 430-35), the protective device shall have sufficient time delay to permit the motor to start and accelerate its load.

**430-35. Shunting During Starting Period.**

(a) In the case of a motor that is manually started (including starting with a magnetic starter having push-button control), the running overcurrent protection may be shunted or cut out of circuit during the starting period of the motor, provided the device by which the overcurrent protection is shunted or cut out cannot be left in the starting position, and fuses or time-delay circuit-breakers rated or set at not over 400 per cent of the full-load current of the motor, are so located in the circuit as to be operative during the starting period of the motor.

(b) The motor-running overcurrent protection shall not be shunted or cut out during the starting period if the motor is automatically started.

**430-36. Fuses—In Which Conductor.** Where fuses are used for motor-running protection, a fuse shall be inserted in each ungrounded conductor.

*Exception: A fuse shall also be inserted in a grounded conductor under the circumstances set forth in the note following Table 430-37 for circuits supplied by wye-delta or delta-wye connected transformers.*

**430-37. Devices Other Than Fuses—In Which Conductor.** Where devices other than fuses are used for motor-running overload protection, Table 430-37 shall govern the minimum allowable number and location of overcurrent units such as trip coils, relays, or thermal cutouts.

**430-38. Number of Conductors Opened by Overcurrent Device.** Motor-running protective devices, other than fuses, thermal cutouts, or thermal protectors, shall simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

**430-39. Motor Controller as Running Overcurrent Protection.** A motor controller may also serve as the running overcurrent device where the number of overcurrent units complies with Section 430-37 and where these overcurrent units are operative in both the starting and running position in the case of a direct-current motor, and in the running position in the case of an alternating-current motor. When a non-automatic motor controller serves as the running

Table 430-37

Kind of Motor	Supply System	Number and location of over-current units, such as trip coils, relays or thermal cutouts
1-phase A.C. or D.C.	2-wire, 1-phase A.C. or D.C. ungrounded	1 in either conductor
1-phase A.C. or D.C.	2-wire, 1-phase A.C. or D.C., one conductor grounded	1 in ungrounded conductor
1-phase A.C. or D.C.	3-wire, 1-phase A.C. or D.C., grounded-neutral	1 in either ungrounded conductor
2-phase A.C.	3-wire, 2-phase A.C., ungrounded	2, one in each phase
2-phase A.C.	3-wire, 2-phase A.C., one conductor grounded	2 in ungrounded conductors
2-phase A.C.	4-wire, 2-phase A.C. grounded or ungrounded	2, one per phase in ungrounded conductors
2-phase A.C.	5-wire, 2-phase, A.C., grounded neutral or ungrounded	2, one per phase in any ungrounded phase wire
3-phase A.C.	3-wire, 3-phase A.C., ungrounded	*2 in any 2 conductors
3-phase A.C.	3-wire, 3-phase A.C., one conductor grounded	*2 in ungrounded conductors
3-phase A.C.	3-wire, 3-phase A.C. grounded-neutral	*2 in any 2 conductors
3-phase A.C.	4-wire, 3-phase A.C. grounded-neutral or ungrounded	*2 in any 2 conductors except the neutral

\*Note. In the case of distribution systems supplying wye-delta or delta-wye connected transformers (having the wye neutral point in the primary ungrounded or not connected to the circuit) the authority enforcing this code may require that three running overcurrent units be provided for the protection of three-phase 3-wire motors, if field experience in the territory of the authority indicates that a third unit is desirable because of motor winding failures at times of primary single phase failures, unless the motors are otherwise adequately protected.

overcurrent device, it is recommended that all ungrounded conductors be opened.

**430-40. Thermal Cutouts and Relays.** Thermal cutouts, thermal relays, and other devices for motor-running protection which are not capable of opening short-circuits, shall be protected by fuses or circuit-breakers with ratings or

settings of not over 4 times the rating of the motor for which they are designed, unless approved for group installation, and marked to indicate the maximum size of fuse by which they must be protected.

**430-41. Rating of Protective Device.** Motor-running overcurrent devices other than fuses shall have a rating not less than 115 per cent of the full-load current rating of the motor.

**430-42. Motors on General Purpose Branch Circuits.** Overcurrent protection for motors used on general purpose branch circuits as permitted in Article 210, shall be provided as follows:

(a) One or more motors without individual running overcurrent protection may be connected to general purpose branch-circuits only where the limiting conditions specified for each of two or more motors in Paragraph 430-53(a) are complied with.

(b) Motors of larger ratings than specified in Paragraph 430-53(a) may be connected to general purpose branch circuits only in case each motor is protected by running overcurrent protection selected to protect the motor as specified in Section 430-32. Both the controller and the motor-running overcurrent device shall be approved for group installation with the protective device of the branch circuit to which the motor is connected. See Section 430-53.

(c) Where a motor is connected to a branch circuit by means of a plug and receptacle, and individual running overcurrent protection is omitted as provided in Paragraph 430-42(a), the rating of the plug and receptacle shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts. Where individual overcurrent protection is required as provided in Paragraph 430-42(b) for a motor or motor-operated appliance provided with an attachment plug for attaching to the branch circuit through a receptacle, the running overcurrent device shall be an integral part of the motor or of the appliance. The rating of the plug and receptacle shall be assumed to determine the rating of the circuit to which the motor may be connected, as provided in Article 210.

(d) The overcurrent device protecting a branch circuit to which a motor or motor-operated appliance is connected shall have sufficient time delay to permit the motor to start and accelerate its load.

**430-43. Automatic Restarting.** A motor-running protective device which can restart a motor automatically after overcurrent tripping shall not be installed unless approved for use with the motor which it protects. A motor which can restart automatically after shutdown shall not be installed so that its automatic restarting can result in injury to persons.

#### **D. Motor-Branch-Circuit Short Circuit and Ground Fault Protection**

**430-51. General.** The provisions of Part D specify overcurrent devices intended to protect the motor-branch-circuit conductors, the motor control apparatus, and the motors against overcurrent due to short-circuits or grounds. They are in addition to or amendatory of the provisions of Article 240.

**430-52. Rating or Setting for Individual Motor Circuit.** The motor-branch-circuit overcurrent device shall be capable of carrying the starting current of the motor. Overcurrent protection shall be considered as being obtained when this overcurrent device has a rating or setting not exceeding the values given in Table 430-152 or 430-153; provided that where the overcurrent protection specified in the Table is not sufficient for the starting current of the motor, it may be increased, but shall in no case exceed 400 per cent of the motor full-load current.

Fuse ratings calculated on this basis are given in columns 4, 5, 6 and 7 of Table 430-146.

See Example No. 8, Chapter 9, and Diagram in Section 430-1.

**430-53. Several Motors on One Branch Circuit.** Two or more motors may be connected to the same branch circuit under the following conditions:

(a) Two or more motors each not exceeding one horsepower in rating and each having a full-load rated capacity not exceeding 6 amperes, may be used on a branch circuit

protected at not more than 20 amperes at 125 volts or less, or 15 amperes at 600 volts or less. Individual running overcurrent protection is unnecessary for such motors unless required by the provisions of Section 430-32.

(b) Two or more motors of any ratings, each having individual running overcurrent protection, may be connected to one branch circuit provided all of the following conditions are complied with:

(1) Each motor-running overcurrent device must be approved for group installation.

(2) Each motor controller must be approved for group installation.

(3) The branch circuit must be protected by fuses having a rating equal to that specified in Section 430-52 for the largest motor connected to the branch circuit plus an amount equal to the sum of the full load current ratings of all other motors connected to the circuit.

(4) The branch circuit fuses must not be larger than allowed by Section 430-40 for the thermal cutout or relay protecting the smallest motor of the group.

(5) The conductors of any tap supplying a single motor need not have individual branch circuit protection, provided they comply with either of the following: (1) no conductor to the motor shall have a current-carrying capacity less than that of the branch circuit conductors, or (2) no conductor to the motor shall have a current-carrying capacity less than one-third that of the branch circuit conductors, with a minimum in accordance with Section 430-22; the conductors to the motor-running protective device being not more than 25 feet long and being protected from physical damage.

**430-54. Combined Overcurrent Protection.** Motor-branch-circuit overcurrent protection and motor-running overcurrent protection may be combined in a single overcurrent device when the rating or setting of the device provides the running overcurrent protection specified in Section 430-32.

**430-55. Overcurrent Devices — In Which Conductor.** Overcurrent devices shall comply with the provisions of Section 240-11.

**430-56. Size of Fuseholder.** Where fuses are used for motor-branch-circuit protection, the fuse-holders shall not be of a smaller size than required to accommodate the fuses specified by Table 430-146.

*Exception: Where fuses having time delay appropriate for the starting characteristics of the motor are used, fuse-holders of smaller size than specified in Table 430-146 may be used.*

**430-57. Rating of Circuit-Breaker.** A circuit-breaker for motor branch-circuit protection shall have a continuous current rating of not less than 115 per cent of the full load current rating of the motor.

**430-58. Feeder Taps in Inaccessible Location.** If the location of the connection of a tap to the feeder conductors is not accessible, the motor-branch-circuit overcurrent device may be placed where it will be accessible, provided the conductors between the tap and the overcurrent device have the same current-carrying capacity as the feeder; or provided they have a current-carrying capacity of at least  $\frac{1}{3}$  that of the feeder and are not more than 25 feet long and are protected from physical damage.

**430-59. Selection or Setting of Protective Device.** In case the values for branch circuit protective devices determined by Table 430-152 or 430-153 do not correspond to the standard sizes or ratings of fuses, non-adjustable circuit-breakers, or thermal devices, or possible settings of adjustable circuit-breakers adequate to carry the load, the next higher size, rating or setting may be used. (See Sections 240-6 and 240-7 for Standard Ratings.)

## **E. Motor-Feeder Short-Circuit and Ground Fault Protection**

**430-61. General.** The provisions of Part E specify overcurrent devices intended to protect feeder conductors supplying motors against overcurrents due to short-circuits or grounds.

**430-62. Rating or Setting — Motor Load.**

(a) A feeder which supplies a specific fixed motor load and consisting of conductor sizes based on Section 430-24 shall be provided with overcurrent protection which shall not be greater than the largest rating or setting of the

branch-circuit protective device, for any motor of the group (based on Tables 430-152 and 430-153), plus the sum of the full-load currents of the other motors of the group.

Where two or more motors of equal horsepower rating are the largest in the group, one of these motors should be considered as the largest for the above calculations.

Where two or more motors of a group must be started simultaneously, it may be necessary to install larger feeder conductors and correspondingly larger ratings or settings of feeder overcurrent protection.

See Example No. 8, Chapter 9.

(b) For large capacity installations, where heavy capacity feeders are installed to provide for future additions or changes, the feeder overcurrent protection may be based on the rated current-carrying capacity of the feeder conductors.

**430-63. Rating or Setting—Power and Light Loads.** Where a feeder supplies a motor load, and in addition a lighting or a lighting and appliance load, the feeder overcurrent protective device may have a rating or setting sufficient to carry the lighting or the lighting and appliance load as determined in accordance with Articles 210 and 220, plus, for a single motor, the rating permitted by Section 430-52, and for two or more motors, the rating permitted by Section 430-62.

## F. Motor-Control Circuits

**430-71. General.** Part F contains modifications of the general requirements and applies to the particular conditions of motor control circuits.

**Control Circuit (Definition)**—The control circuit of a control apparatus or system is the circuit which does not carry the main load current, and by means of which the electric signals directing the performance of the controller are transmitted.

**430-72. Overcurrent Protection.** Conductors of control circuits shall be protected against overcurrent in accordance with Paragraph 240-5, Exception No. 5.

*Exception. Such conductors shall be considered as being properly protected by the branch-circuit overcurrent devices under any one of the following conditions:*

(1) *Where the rating or setting of the branch-circuit overcurrent device is not more than 500 per cent of the carrying capacity of the control-circuit conductors.*

(2) *Where the controlled device and the point of control (start and stop buttons, pressure switch, thermostatic switch, etc.) are both located on the same machine and the control circuit does not extend beyond the machine.*

(3) *Where the opening of the control circuit would create a hazard; as for example, the control circuit of fire-pump motors, and the like.*

**430-73. Mechanical Protection of Conductor.** Where damage to a control circuit would constitute a hazard, all conductors of such remote-control circuit shall be installed in a raceway or be otherwise suitably protected from physical damage outside the control device itself.

It is recommended that control circuits be so arranged that an accidental ground will not start the motor.

#### **430-74. Disconnection.**

(a) Control circuits shall be so arranged that they will be disconnected from all sources of supply when the disconnecting means is in the open position. The disconnecting means may consist of two separate devices, one of which disconnects the motor and the controller from the source of power supply for the motor, and the other, the control circuit from its power supply. Where the two separate devices are used, they should be located immediately adjacent one to the other.

(b) Where a transformer or other device is used to obtain a reduced voltage for the control circuit and is located in the controller, such transformer or other device shall be connected to the load side of the disconnecting means for the control circuit.

### **G. Motor Controllers**

**430-81. General.** The provisions of Part G are intended to require suitable controllers for all motors.

(a) **Definition.** For definition of "Controller," see Article 100. For the purpose of this Article, the term "Controller" includes any switch or device normally used to start and stop the motor.

(b) **Stationary Motor of  $\frac{1}{8}$  Horsepower or Less.** For a stationary motor rated at  $\frac{1}{8}$  horsepower or less, that is normally left running and is so constructed that it cannot be damaged by overload or failure to start, such as clock

motors and the like, the branch-circuit overcurrent device may serve as the controller.

(c) **Portable Motor of  $\frac{1}{3}$  Horsepower or Less.** For a portable motor rated at  $\frac{1}{3}$  horsepower or less, the controller may be an attachment plug and receptable.

#### 430-82. Controller Design.

(a) Each controller shall be capable of starting and stopping the motor which it controls, and for an alternating-current motor shall be capable of interrupting the stalled-rotor current of the motor.

(b) **Auto-Transformer.** An auto-transformer starter shall provide an off position, a running position, and at least one starting position. It shall be so designed that it cannot rest in the starting position, or in any position which will render inoperative the overcurrent protective device in the circuit.

(c) **Rheostats.** Rheostats shall conform to the following:

(1) **Internal Connections.** Motor-starting rheostats shall be so designed that the contact arm cannot be left on intermediate segments. The point or plate on which the arm rests when in the starting position shall have no electrical connection with the resistor.

(2) **Under-voltage Release, Direct-Current Motors.** Motor-starting rheostats for direct-current motors shall be equipped with automatic devices which will interrupt the supply before the speed of the motor has fallen to less than one-third its normal value.

**430-83. Rating.** The controller shall have a horsepower rating, which shall not be lower than the horsepower rating of the motor, except as follows:

*Exception No. 1. Stationary Motor of 2 Horsepower or Less.* For a stationary motor rated at 2 horsepower or less, and 300 volts or less, the controller may be a general-use switch having an ampere rating at least twice the full-load current rating of the motor.

*On AC circuits, general use snap switches suitable only for use on AC (not general use AC-DC snap switches) may be used to control a motor having a full-load current rating not exceeding 80 per cent of the ampere rating of the switch.*

*Exception No. 2. Circuit-Breaker as Controller. A branch-circuit circuit-breaker, rated in amperes only, may be used as a controller. Where this circuit-breaker is also used for overcurrent protection, it shall conform to the appropriate provisions of this Article governing overcurrent protection.*

*Exception No. 3. Sealed (Hermetic-type) Refrigeration Compressor Motors. The motor controller shall have both a continuous duty full-load current rating, and a locked-rotor current rating, not less than the nameplate full-load current and locked-rotor current, respectively, of the compressor. In case the motor controller is rated in horsepower, but is without one or both of the foregoing current ratings, equivalent currents shall be determined from the rating as follows: Use Table 430-148, 430-149, or 430-150 to determine the equivalent full-load current rating. Use Table 430-151 to determine the equivalent locked-rotor current rating.*

**430-84. Need Not Open All Conductors.** Except when it serves also as a disconnecting means (see Section 430-111), the controller need not open all conductors to the motor.

**430-85. In Grounded Conductors.** One pole of the controller may be placed in a permanently grounded conductor provided the controller is so designed that the pole in the grounded conductor cannot be opened without simultaneously opening all conductors of the circuit.

**430-86. Motor Not in Sight From Controller.** Where a motor and the driven machinery are not in sight from the controller location, the controller shall comply with one of the following conditions:

(a) The controller or its disconnecting means is capable of being locked in the open position, unless special permission is given by the authority enforcing this Code.

(b) A manually-operable switch, which will prevent the starting of the motor, is placed within sight from the motor location. This switch may be placed in the control circuit of the magnetic controller.

(c) As otherwise specified in Articles 500 to 517 of this Code.

**430-87. Number of Motors Served by Each Controller.** Each motor shall be provided with an individual controller.

*Exception: For motors of 600 volts or less a single controller may serve a group of motors under any one of the following conditions:*

(a) *Where a number of motors drive several parts of a single machine or piece of apparatus such as metal and wood-working machines, cranes, hoists, and similar apparatus.*

(b) *Where a group of motors is under the protection of one overcurrent device as permitted in Paragraph 430-53(a).*

(c) *Where a group of motors is located in a single room within sight from the controller location.*

**430-88. Adjustable-Speed Motors.** Adjustable-speed motors that are controlled by means of field regulation shall be so equipped and connected that they cannot be started under weakened field, unless the motor is designed for such starting.

**430-89. Speed Limitation.** Machines of the following types shall be provided with speed limiting devices.

(a) Separately-excited direct-current motors.

(b) Series motors.

(c) Motor-generators and converters which can be driven at excessive speed from the direct-current end, as by a reversal of current or decrease in load.

*Exception No. 1. Unless the inherent characteristics of the machines, the system, or the load and the mechanical connection thereto, are such as to safely limit the speed.*

*Exception No. 2. Unless the machine is always under the manual control of a qualified operator.*

**430-90. Combination Fuseholder and Switch as Controller.** The rating of a combination fuseholder and switch used as a motor-controller shall be such that the fuseholder will accommodate the size of fuse specified in Table 430-146, for motor-running overcurrent protection.

*Exception: Where fuses having time delay appropriate for the starting characteristics of the motor are used, fuseholders of smaller size than specified in Table 430-146 may be used.*

## H. Disconnecting Means

**430-101. General.** The provisions of Part H are intended to require disconnecting means capable of disconnecting motors and controllers from the circuit.

See Diagram in Section 430-1.

**430-102. In Sight from Controller Location.** The disconnecting means shall be located in sight from the controller location or be arranged to be locked in the open position.

**430-103. To Disconnect Both Motor and Controller.** The disconnecting means shall disconnect both the motor and the controller from all ungrounded supply conductors. The disconnecting means may be in the same enclosure with the controller.

**430-104. To Be Indicating.** The disconnecting means shall plainly indicate whether it is in the open or closed position.

**430-105. Grounded Conductors.** One pole of the disconnecting means may disconnect a permanently grounded conductor, provided the disconnecting means is so designed that the pole in the grounded conductor cannot be opened without simultaneously disconnecting all conductors of the circuit.

**430-106. Service Switch as Disconnecting Means.** Where an installation consists of a single motor, the service switch may serve as the disconnecting means, provided it conforms to

the requirements of this Article, and is within sight from the controller location or is arranged to be locked in an open position.

**430-107. Readily Accessible.** The disconnecting means shall be readily accessible.

**430-108. Every Switch.** Every switch in the motor branch circuit within sight from the controller location shall comply with the requirements of Part H.

**430-109. Type.** The disconnecting means shall be a motor-circuit switch, rated in horsepower, or a circuit-breaker, except as permitted in Paragraphs 430-109 (a, b, c, d, or e).

**(a) One-Eighth Horsepower or Less.** For stationary motors of  $\frac{1}{8}$  horsepower or less, the branch-circuit over-current device may serve as the disconnecting means.

**(b) Two Horsepower or Less.** For stationary motors rated at 2 horsepower or less and 300 volts or less, the disconnecting means may be a general-use switch having an ampere rating not less than twice the full-load current rating of the motor.

On AC circuits, general use snap switches suitable only for use on AC (not general use AC-DC snap switches) may be used to disconnect a motor having a full-load current rating not exceeding 80 per cent of the ampere rating of the switch.

**(c) Over Two Horsepower to and Including 50 Horsepower.** The separate disconnecting means required for a motor with an auto-transformer type of controller may be a general-use switch where all of the following provisions are complied with:

(1) The motor drives a generator which is provided with overcurrent protection.

(2) The controller (1) is capable of interrupting the stalled-rotor current of the motor, (2) is provided with a no-voltage release, and (3) is provided with running-over-current protection not exceeding 125 per cent of the motor full-load current rating.

(3) Separate fuses or a circuit-breaker, rated or set at not more than 150 per cent of the motor full-load current, are provided in the motor branch circuit.

**(d) Exceeding 50 Horsepower.** For stationary motors rated at more than 50 horsepower, the disconnecting means may be a motor-circuit switch also rated in amperes, a general-use switch, or an isolating switch.

Isolation switches for motors exceeding 50 horsepower, not capable of interrupting stalled-rotor currents, shall be plainly marked "Do not open under load."

**(e) Portable Motors.** For portable motors an attachment plug and receptacle may serve as the disconnecting means.

#### **430-110. Carrying Capacity and Interrupting Capacity.**

**(a)** The disconnecting means shall have a carrying capacity of at least 115 per cent of the nameplate current rating of the motor.

**(b)** The disconnecting means for sealed (hermetic-type) refrigeration compressors shall be selected on the basis of the nameplate full-load current and locked-rotor current, respectively of the compressor motor as follows:

**(1)** The carrying capacity shall be at least 115 per cent of the nameplate full-load current.

**(2)** To determine the equivalent horsepower in complying with the requirements of Section 430-109, select the horsepower rating from Tables 430-148, 430-149, and 430-150 corresponding to the full-load current, and also the horsepower rating from Table 430-151 corresponding to the locked-rotor current. In case the nameplate full-load current and locked-rotor current do not correspond to the currents shown in Tables in Sections 430-148, 430-149, and 430-150, respectively, the horsepower rating corresponding to the next higher value shall be selected. In case two different horsepower ratings are obtained when applying Tables 430-148, 430-149, and 430-150, and Table 430-151, a horsepower rating at least equal to the larger of the two values obtained shall be selected.

**430-111. Switch or Circuit-Breaker as Both Controller and Disconnecting Means.** A switch or circuit-breaker complying with the provisions of Section 430-83 may serve as both controller and disconnecting means provided it opens all ungrounded conductors to the motor, is protected by an overcurrent device (which may be the branch circuit fuses)

which opens all ungrounded conductors to the switch or circuit-breaker, and is of one of the following types:

(a) An air-break switch, operable directly by applying the hand to a lever or handle.

(b) A circuit-breaker operable directly by applying the hand to a lever or handle.

(c) An oil switch used on a circuit whose rating does not exceed 600 volts or 100 amperes, or by special permission on a circuit exceeding this capacity where under expert supervision.

The oil switch or circuit-breaker specified above may be both power and manually operable. If power operable, provision should be made to lock it in the open position.

The overcurrent device protecting the controller may be part of the controller assembly or may be separate.

An autotransformer type of controller is not included above and will require a separate disconnecting means.

**430-112. Motors Served by a Single Disconnecting Means.** Each motor shall be provided with individual disconnecting means.

*Exception: For motors of 600 volts or less a single disconnecting means may serve a group of motors under any one of the following conditions:*

(a) *Where a number of motors drive several parts of a single machine or piece of apparatus such as metal and woodworking machines, cranes, and hoists.*

(b) *Where a group of motors is under the protection of one set of overcurrent devices as permitted by Paragraph 430-53(a).*

(c) *Where a group of motors is in a single room within sight from the location of the disconnecting means.*

The disconnecting means shall have a rating not less than is required by Section 430-109 for a single motor the rating of which equals the sum of the horsepowers or currents of all the motors of the group.

## **J. Requirements for Over 600 Volts**

**430-121. General.** The provisions of Part J recognize the additional hazard due to the use of high voltage. They are in addition to or amendatory of the other provisions of this article. Other requirements for circuits and equipment operating at more than 600 volts are in Article 710.

**430-122. More Than 7500 Volts.** Motors operating at more than 7500 volts between conductors shall be installed in fire-resistant motor rooms.

**430-123. Motor Running Overcurrent (Overload) Protection.** Running overcurrent protection for a motor of over 600 volts shall consist either of a circuit-breaker, or of overcurrent units integral with the controller which shall simultaneously open all ungrounded conductors to the motor. The overcurrent device shall have a setting as specified elsewhere in this Article for motor-running overcurrent (overload) protection.

**430-124. Short-Circuit and Ground Fault Protection.** Each motor branch circuit and feeder of more than 600 volts shall be protected against overcurrent by one of the following means:

(a) A circuit-breaker of suitable rating so arranged that it can be serviced without hazard.

(b) Fuses of the oil-filled or other suitable type. Fuses shall be used with suitable disconnecting means or they shall be of a type which can also serve as the disconnecting means. They shall be so arranged that they cannot be re-fused or replaced while they are energized.

(c) Differential protection may be employed to protect an alternating-current motor, the motor control apparatus, and the branch-circuit conductors against overcurrent due to short circuits or grounds. When all these elements are included within the protected zone of a differential protective system, the ratings or settings specified in Section 430-52 do not apply.

**Note:** A differential protective system is a combination of two or more sets of current transformers and a relay or relays energized from their interconnected secondaries.

The primaries of the current transformers are connected on both sides of the equipment to be protected, both ends of the motor phase windings being brought out for this purpose. All of the apparatus and circuits included between the sets of current transformer primaries constitute the protected zone. The current transformer secondaries and the relay elements are so interconnected that the relay elements respond only to a predetermined difference between the currents entering and leaving the protected zone. When actuated, the relay or relays serve to trip the branch-circuit circuit breaker, thus disconnecting the motor, control apparatus in the motor circuit and the branch-circuit conductors from the source of power and, in the case of a synchronous motor, de-energizing its field circuit.

**430-126. Disconnecting Means.** The circuit-breaker or the fuses specified in Section 430-124 may constitute the disconnecting means if they conform to the other applicable requirements of this Article.

## K. Protection of Live Parts — All Voltages

**430-131. General.** The provisions of Part K specify that live parts shall be protected in a manner judged adequate to the hazard involved.

**430-132. Where Required.** Exposed live parts of motors and controllers operating at 50 volts or more between terminals, shall be guarded against accidental contact by enclosure, or by location as follows:

(a) By installation in a room or enclosure which is accessible only to qualified persons;

(b) By installation on a suitable balcony, gallery or platform, so elevated and arranged as to exclude unqualified persons;

(c) By elevation 8 feet or more above the floor;

(d) So that it will be protected by a guard rail when the motor operates at 600 volts or less.

*Exception: Stationary motors having commutators, collectors and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground.*

**430-133. Guards for Attendants.** Where the live parts of motors or controllers operating at more than 150 volts to ground are guarded against accidental contact only by location as specified in Section 430-132, and where adjustment or

other attendance may be necessary during the operation of the apparatus, suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms. Where necessary, steps and hand-rails should be installed on or about large machines to afford safe access to parts which must be examined or adjusted during operation.

## L. Grounding

**430-141. General.** The provisions of Part L specify the grounding of motor and controller frames to prevent a potential above ground in the event of accidental contact between live parts and frames. Insulation, isolation, or guarding are suitable alternatives to grounding of motors under certain conditions.

**430-142. Stationary Motors.** The frames of stationary motors shall be grounded where any of the following conditions exist:

- (a) supplied by means of metal-clad wiring.
- (b) located in a wet place and not isolated nor guarded.
- (c) in a hazardous location. (See Articles 500 to 517 inclusive.)
- (d) the motor operates with any terminal at more than 150 volts to ground.

Grounding of the motor frame is preferable, but where the frame of the motor is not grounded, it shall be permanently and effectively insulated from the ground.

**430-143. Portable Motors.** The frames of portable motors which operate at more than 150 volts to ground shall be guarded or grounded. See Paragraph 250-45(d) on grounding of portable appliances in other than residential occupancies.

It is recommended that the frames of motors which operate at less than 150 volts to ground be grounded where this can be readily accomplished.

See Paragraph 250-59(b) for color of grounding conductor.

**430-144. Controllers.** Controller cases, except those attached to ungrounded portable equipment and except the lined covers of snap switches, shall be grounded regardless of voltage.

**430-145. Method of Grounding.** Grounding where required shall be done in the manner specified in Article 250.

**(a) Grounding Through Terminal Housings.** Where the wiring to fixed motors is in armored cable or metal raceways, junction boxes to house motor terminals shall be provided, and the armor of the cable or the metal raceways shall be connected to them in the manner specified in Article 250.

**(b) Separation of Junction Box from Motor.** The junction box required by Paragraph 430-145(a) may be separated from the motor not more than 6 feet provided the leads to the motor are armored cable or armored cord or are stranded leads enclosed in flexible or rigid conduit or electrical metallic tubing not smaller than  $\frac{3}{8}$  inch electrical trade size, the armor or raceway being connected both to the motor and to the box. Where stranded leads are used, protected as specified above, they shall not be larger than No. 10, and shall comply with other requirements of the code for conductors to be used in raceways.

**Table 430-146. Overcurrent Protection for Motors**  
(See Tables 430-152 and 430-153)

These values are in accordance with Sections 430-6, 430-22, 430-32, 430-34, 430-52, 430-59, except as follows: The current values in Column 1 are to be taken from Tables 430-147 through 430-150, including footnotes, but the values shown for running protection in Columns 2 and 3 must be modified if nameplate full load current values are different, as provided in Section 430-6. The current values shown in Columns 2 and 3 must be reduced by 8 per cent for all motors other than open type motors marked to have a temperature rise

of not over 40°C. as required by Section 430-32. For certain exceptions to the values in Columns 4, 5, 6, and 7, see Sections 430-52, and 430-59. See Section 430-53 for values to be used for several motors on one branch circuit. For running protection of motors, see Section 430-32. For setting of motor-branch-circuit protective devices, see Tables in Sections 430-152 and 430-153. For grouping of small motors under the protection of a single set of sizes, see Section 430-53.

Col. No. 1	2	3	Maximum Allowable Rating or Setting of Branch Circuit Protective Devices								7
Full load current rating of motor amperes	For Running Protection of Motors		With Code Letters Single phase, squirrel cage and synchronous. Full voltage, resistor or reactor starting, Code letters F to V inclusive.		With Code Letters Single phase, squirrel cage and synchronous. Full voltage, resistor or reactor start, Code letters B to E inclusive. Auto transformer start, Code letters F to V inclusive.		With Code Letters Squirrel cage and synchronous auto transformer start, Code letters B to E inclusive.		With Code Letters All motors code letter A.		
	Maximum rating of nonadjustable protective devices.	Maximum setting of adjustable protective devices.	Without Code Letters Same as above.		Without Code Letters (Not more than 30 Amperes) squirrel cage and synchronous, auto transformer start, high reactance squirrel cage.*		Without Code Letters (More than 30 amperes) Squirrel cage and synchronous auto transformer start, high reactance squirrel cage.*		Without Code Letters DC and wound rotor motors.		
			Fuses	Circuit Breakers (Non-adjustable Over-load Trip)	Fuses	Circuit Breakers (Non-adjustable Over-load Trip)	Fuses	Circuit Breakers (Non-adjustable Over-load Trip)	Fuses	Circuit Breakers (Non-adjustable Over-load Trip)	
											Amperes
1	2	1.25	15	15	15	15	15	15	15	15	
2	3	2.50	15	15	15	15	15	15	15	15	
3	4	3.75	15	15	15	15	15	15	15	15	
4	6	5.0	15	15	15	15	15	15	15	15	
5	8	6.25	15	15	15	15	15	15	15	15	
6	8	7.50	20	15	15	15	15	15	15	15	
7	10	8.75	25	20	20	15	15	15	15	15	
8	10	10.0	25	20	20	20	20	20	15	15	

\*See note at end of table.

9	12	11.25	30	30	25	20	20	20	15	15
10	15	12.50	30	30	25	20	20	20	15	15
11	15	13.75	35	30	30	30	25	30	20	20
12	15	15.00	40	30	30	30	25	30	20	20
13	20	16.25	40	40	35	30	30	30	20	20
14	20	17.50	45	40	35	30	30	30	25	30
15	20	18.75	45	40	40	30	30	30	25	30
16	20	20.00	50	40	40	40	35	40	25	30
17	25	21.25	60	50	45	40	35	40	30	30
18	25	22.50	60	50	45	40	40	40	30	30
19	25	23.75	60	50	50	40	40	40	30	30
20	25	25.00	60	50	50	40	40	40	30	30
22	30	27.50	70	70	60	50	45	50	35	40
24	30	30.00	80	70	60	50	50	50	40	40
26	35	32.50	80	70	70	70	60	70	40	40
28	35	35.00	90	70	70	70	60	70	45	50
30	40	37.50	90	100	80	70	60	70	45	50
32	40	40.00	100	100	80	70	70	70	50	50
34	45	42.50	110	100	90	70	70	70	60	70
36	45	45.00	110	100	90	100	80	100	60	70
38	50	47.50	125	100	100	100	80	100	60	70
40	50	50.00	125	100	100	100	80	100	60	70
42	50	52.50	125	125	110	100	90	100	70	70
44	60	55.00	125	125	110	100	90	100	70	70
46	60	57.50	150	125	125	100	100	100	70	70
48	60	60.00	150	125	125	100	100	100	80	100
50	60	62.50	150	125	125	100	100	100	80	100
52	70	65.00	175	150	150	125	110	125	80	100
54	70	67.50	175	150	150	125	110	125	90	100
56	70	70.00	175	150	150	125	125	125	90	100
58	70	72.50	175	150	150	125	125	125	90	100
60	80	75.00	200	150	150	125	125	125	90	100
62	80	77.50	200	175	175	125	125	125	100	100
64	80	80.00	200	175	175	150	150	150	100	100
66	80	82.50	200	175	175	150	150	150	100	100
68	90	85.00	225	175	175	150	150	150	110	125
70	90	87.50	225	175	175	150	150	150	110	125
72	90	90.00	225	200	200	150	150	150	110	125
74	90	92.50	225	200	200	150	150	150	125	125
76	100	95.00	250	200	200	175	175	175	125	125

Col. No. 1	2		3		4				5		6		7	
	For Running Protection of Motors				Maximum Allowable Rating or Setting of Branch Circuit Protective Devices									
					With Code Letters Single phase, squirrel cage and synchronous. Full voltage, resistor or reactor starting, Code letters F to V inclusive.		Without Code Letters Same as above.		With Code Letters Single phase, squirrel cage and synchronous. Full voltage, resistor or reactor start, Code letters B to E inclusive. Auto transformer start, Code letters F to V inclusive.		With Code Letters Squirrel cage and synchronous auto transformer start, Code letters B to E inclusive.		With Code Letters All motors code letter A.	
Full load current rating of motor amperes	Maximum rating of nonadjustable protective devices.		Maximum setting of adjustable protective devices.		Circuit Breakers (Non-adjustable Over-load Trip)				Without Code Letters (Not more than 30 Amperes) squirrel cage and synchronous, auto transformer start, high reactance squirrel cage.*		Without Code Letters (More than 30 amperes) Squirrel cage and synchronous auto transformer start, high reactance squirrel cage.*		Without Code Letters DC and wound rotor motors.	
	Amperes	Amperes	Fuses	Fuses	Fuses	Circuit Breakers (Non-adjustable Over-load Trip)	Fuses	Circuit Breakers (Non-adjustable Over-load Trip)	Fuses	Circuit Breakers (Non-adjustable Over-load Trip)	Fuses	Circuit Breakers (Non-adjustable Over-load Trip)	Fuses	Circuit Breakers (Non-adjustable Over-load Trip)
78	100	97.50	250	200	200	175	175	175	125	125	125	125	125	125
80	100	100.00	250	200	200	175	175	175	125	125	125	125	125	125
82	110	102.50	250	225	225	175	175	175	125	125	125	125	125	125
84	110	105.00	250	225	225	175	175	175	150	150	150	150	150	150
86	110	107.50	300	225	225	175	175	175	150	150	150	150	150	150
88	110	110.00	300	225	225	200	200	200	150	150	150	150	150	150
90	110	112.50	300	225	225	200	200	200	150	150	150	150	150	150
92	125	115.00	300	250	250	200	200	200	150	150	150	150	150	150
94	125	117.50	300	250	250	200	200	200	150	150	150	150	150	150
96	125	120.00	300	250	250	200	200	200	150	150	150	150	150	150
98	125	122.50	300	250	250	200	200	200	150	150	150	150	150	150
100	125	125.00	300	250	250	200	200	200	150	150	150	150	150	150
105	150	131.50	350	300	300	225	225	225	175	175	175	175	175	175
110	150	137.50	350	300	300	225	225	225	175	175	175	175	175	175
115	150	144.00	350	300	300	250	250	250	175	175	175	175	175	175
120	150	150.00	400	300	300	250	250	250	200	200	200	200	200	200
125	175	156.50	400	350	350	250	250	250	200	200	200	200	200	200
130	175	162.50	400	350	350	300	300	300	225	225	225	225	225	225
135	175	169.00	450	350	350	300	300	300	225	225	225	225	225	225
140	175	175.00	450	350	350	300	300	300	225	225	225	225	225	225

145	200	181.50	450	400	400	800	300	300	225	225
150	200	187.50	450	400	400	800	300	300	225	225
155	200	194.00	500	400	400	850	350	350	250	250
160	200	200.00	500	400	400	850	350	350	250	250
165	225	206.00	500	500	450	350	350	350	250	250
170	225	213.00	500	500	450	350	350	350	300	300
175	225	219.00	600	500	450	350	350	350	300	300
180	225	225.00	600	500	450	400	400	400	300	300
185	250	231.00	600	500	500	400	400	400	300	300
190	250	238.00	600	500	500	400	400	400	300	300
195	250	244.00	600	500	500	400	400	400	300	300
200	250	250.00	600	500	500	400	400	400	300	300
210	250	263.00	800	600	600	500	450	500	350	350
220	300	275.00	800	600	600	500	450	500	350	350
230	300	288.00	800	600	600	500	500	500	350	350
240	300	300.00	800	600	600	500	500	500	400	400
250	300	313.00	800	700	800	500	500	500	400	400
260	350	325.00	800	700	800	600	600	600	400	400
270	350	338.00	1000	700	800	600	600	600	450	500
280	350	350.00	1000	700	800	600	600	600	450	500
290	350	363.00	1000	800	800	600	600	600	450	500
300	400	375.00	1000	800	800	600	600	600	450	500
320	400	400.00	1000	800	800	700	800	700	500	500
340	450	425.00	1200	...	1000	700	800	700	600	600
360	450	450.00	1200	...	1000	800	800	800	600	600
380	500	475.00	1200	...	1000	800	800	800	600	600
400	500	500.00	1200	...	1000	800	800	800	600	600
420	600	525.00	1600	...	1200	...	1000	...	800	700
440	600	550.00	1600	...	1200	...	1000	...	800	700
460	600	575.00	1600	...	1200	...	1000	...	800	700
480	600	600.00	1600	...	1200	...	1000	...	800	800
500	...	625.00	1600	...	1600	...	1000	...	800	800

\* High-reactance squirrel-cage motors are those designed to limit the starting current by means of deepslot secondaries or double-wound secondaries and are generally started on full voltage.

**Table 430-147. Full Load Currents in Amperes  
Direct Current Motors**

The following values of full-load currents are for motors running at usual speed.

HP	115V	230V	550V
$\frac{1}{4}$	3	1.5	..
$\frac{1}{3}$	3.8	1.9	..
$\frac{1}{2}$	5.4	2.7	..
$\frac{3}{4}$	7.4	3.7	1.6
1	9.6	4.8	2.0
1½	13.2	6.6	2.7
2	17	8.5	3.6
3	25	12.5	5.2
5	40	20	8.3
7½	58	29	12
10	76	38	16
15	112	56	23
20	148	74	31
25	184	92	38
30	220	110	46
40	292	146	61
50	360	180	75
60	430	215	90
75	536	268	111
100		355	148
125		443	184
150		534	220
200		712	295

**Table 430-148. Full Load Currents in Amperes  
Single Phase Alternating Current Motors**

The following values of full-load currents are for motors running at usual speeds and motors with normal torque characteristics. Motors built for especially low speeds or high torques may have higher full-load currents, in which case the nameplate current ratings should be used.

To obtain full-load currents of 208 and 200-volt motors, increase corresponding 230-volt motor full-load currents by 10 and 15 per cent, respectively.

HP	115V	230V	440V
$\frac{1}{8}$	4.4	2.2	..
$\frac{1}{4}$	5.8	2.9	..
$\frac{1}{3}$	7.2	3.6	..
$\frac{1}{2}$	9.8	4.9	..
$\frac{3}{4}$	13.8	6.9	..
1	16	8	..
1½	20	10	..
2	24	12	..
3	34	17	..
5	56	28	..
7½	80	40	21
10	100	50	26

**Table 430-149. Full-Load Current  
Two-Phase A.C. Motors (4-wire)**

The following values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, in which case the nameplate current rating should be used. Current in common conductor of 2-phase, 3-wire system will be 1.41 times value given.

HP	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type †Unity Power Factor Amperes			
	110V	220V	440V	550V	2300V	220V	440V	550V	2300V
1/2	4	2	1	.8					
3/4	4.8	2.4	1.2	1.0					
1	6.4	3.2	1.6	1.3					
1 1/2	8.8	4.4	2.2	1.8					
2	11.2	5.6	2.8	2.2					
3		8	4	3.2					
5		13	7	6					
7 1/2		19	9	8					
10		24	12	10					
15		34	17	14					
20		45	23	18					
25		55	28	22	6	47	24	19	4.7
30		67	34	27	7.5	56	29	23	5.7
40		88	44	35	9	75	37	31	7
50		108	54	43	11	94	47	38	9
60		129	65	52	13	111	56	44	11
75		158	79	63	16	140	70	57	13
100		212	106	85	21	182	93	74	17
125		268	134	108	26	228	114	93	22
150		311	155	124	31		137	110	26
200		415	208	166	41		182	145	35

†For 90 and 80 per cent P. F. the above figures should be multiplied by 1.1 and 1.25 respectively.

**Table 430-150. Full-Load Current\***  
**Three-Phase A.C. Motors**

HP	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type †Unity Power Factor Amperes			
	110V	220V	440V	550V	2300V	220V	440V	550V	2300V
½	4	2	1	.8					
¾	5.6	2.8	1.4	1.1					
1	7	3.5	1.8	1.4					
1½	10	5	2.5	2.0					
2	13	6.5	3.3	2.6					
3		9	4.5	4					
5		15	7.5	6					
7½		22	11	9					
10		27	14	11					
15		40	20	16					
20		52	26	21					
25		64	32	26	7	54	27	22	5.4
30		78	39	31	8.5	65	33	26	6.5
40		104	52	41	10.5	86	43	35	8
50		125	63	50	13	108	54	44	10
60		150	75	60	16	128	64	51	12
75		185	93	74	19	161	81	65	15
100		246	123	98	25	211	106	85	20
125		310	155	124	31	264	132	106	25
150		360	180	144	37		158	127	30
200		480	240	192	48		210	168	40

For full-load currents of 208 and 200 volt motors, increase the corresponding 220-volt motor full-load current by 6 and 10 per cent, respectively.

\*These values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, in which case the nameplate current rating should be used.

†For 90 and 80 per cent P. F. the above figures should be multiplied by 1.1 and 1.25 respectively.

Table 430-151

## Locked-Rotor Current Conversion Table

As Determined from Horsepower and Voltage Rating  
For Use Only With Sections 430-83, Exception No. 3, and 430-110(b)

## Conversion Table

Max HP Rating	Maximum Interrupting Capacity—Amperes					
	Single Phase		Two or Three Phase			
	115 V	230 V	110 V	220 V	440 V	550 V
$\frac{1}{2}$	58.8	29.4	24	12	6	4.8
$\frac{3}{4}$	82.8	41.4	33.6	16.8	8.4	6.6
1	96	48	42	21	10.8	8.4
$1\frac{1}{2}$	120	60	60	30	15	12
2	144	72	78	39	19.8	15.6
3	204	102	—	54	27	24
5	336	168	—	90	45	36
$7\frac{1}{2}$	480	240	—	132	66	54
10	600	300	—	162	84	66
15	—	—	—	240	120	96
20	—	—	—	312	156	126
25	—	—	—	384	192	156
30	—	—	—	468	234	186
40	—	—	—	624	312	246
50	—	—	—	750	378	300
60	—	—	—	900	450	360
75	—	—	—	1110	558	444
100	—	—	—	1476	738	588
125	—	—	—	1860	930	744
150	—	—	—	2160	1080	864
200	—	—	—	2880	1440	1152

**Table 430-152. Maximum Rating or Setting of Motor-Branch-Circuit Protective Devices for Motors Marked with a Code Letter Indicating Locked Rotor KVA**

Type of Motor	Fuse Rating	Per Cent of Full-Load Current	Setting
	See also Table 430-146, Columns 4, 5, 6, 7)	Circuit-Breaker Instan- taneous Type	Time Limit Type
<hr/>			
All AC single-phase and polyphase squirrel cage and synchronous motors with full-voltage, resis- tor or reactor starting:			
Code Letter A_____	150	_____	150
Code Letter B to E____	250	_____	200
Code Letter F to V____	300	_____	250
 All AC squirrel cage and synchronous motors with auto-transformer starting:			
Code Letter A_____	150	_____	150
Code Letter B to E____	200	_____	200
Code Letter F to V____	250	_____	200

For certain exceptions to the values specified see Sections 430-52 and 430-54. The values given in the last column also cover the ratings of non-adjustable, time-limit types of circuit-breakers which may also be modified as in Section 430-52.

Synchronous motors of the low-torque, low-speed type (usually 450 RPM or lower), such as are used to drive reciprocating compressors, pumps, etc., which start up unloaded, do not require a fuse rating or circuit-breaker setting in excess of 200 per cent of full-load current.

For motors not marked with a Code Letter, see Table 430-153.

**Table 430-153. Maximum Rating or Setting of Motor-Branch-Circuit Protective Devices for Motors not Marked with a Code Letter Indicating Locked Rotor KVA**

Type of Motor	Per Cent of Full-Load Current		Time Limit Type
	Fuse Rating (See also Table 430-146, Columns 4, 5, 6, 7)	Circuit-Breaker Setting Instantaneous Type	
Single-phase, all types.....	300	-----	250
Squirrel-cage and synchronous (full-voltage, resistor and reactor starting) .....	300	-----	250
Squirrel-cage and synchronous (auto-transformer starting)			
Not more than 30 amperes .....	250	-----	200
More than 30 amperes..	200	-----	200
High-reactance squirrel-cage			
Not more than 30 amperes .....	250	-----	250
More than 30 amperes..	200	-----	200
Wound-rotor .....	150	-----	150
Direct-current			
Not more than 50 H.P.	150	250	150
More than 50 H.P. ....	150	175	150

For certain exceptions to the values specified see Sections 430-52, and 430-59. The values given in the last column also cover the ratings of non-adjustable, time-limit types of circuit-breakers which may also be modified as in Section 430-52.

Synchronous motors of the low-torque low-speed type (usually 450 R.P.M. or lower) such as are used to drive reciprocating compressors, pumps, etc., which start up unloaded, do not require a fuse rating or circuit-breaker setting in excess of 200 per cent of full-load current.

For motors marked with a Code Letter, see Table 430-152.

## ARTICLE 445 — GENERATORS

**445-1. Location.** Generators shall be located in dry places, and also so as to meet the requirements for motors in Section 430-14. Generators installed in hazardous locations as described in Articles 500-503, or in other locations as described in Articles 510-517, 520, 530, and 665, shall also comply with the provisions of those Articles.

It is recommended that waterproof covers be provided for use in emergency.

**445-2. Marking.** Each generator shall be provided with a nameplate giving the maker's name, the rating in kilowatts or kilovolt-amperes, the normal volts and amperes corresponding to the rating, and the revolutions per minute.

**445-3. Drip Pans.** Generators shall be provided with suitable drip pans if required by the authority enforcing this Code.

**445-4. Overcurrent Protection.**

(a) **Constant-Potential Generators.** Constant-potential generators, except alternating-current generators and their exciters, shall be protected from excessive current by circuit-breakers or fuses.

(b) **Two-Wire Generators.** Two-wire, direct-current generators may have overcurrent protection in one conductor only if the overcurrent device is actuated by the entire current generated, except that in the shunt field. The overcurrent device shall not open the shunt field.

(c) **65 Volts or Less.** Generators operating at 65 volts or less and driven by individual motors shall be considered as protected by the overcurrent device protecting the motor if these devices will operate when the generators are delivering not more than 150 per cent of their full-load rated current.

(d) **Balancer Sets.** Two-wire, direct-current generators used in conjunction with balancer sets to obtain neutrals for 3-wire systems shall be equipped with overcurrent devices which will disconnect the 3-wire system in the case of excessive unbalancing of voltages or currents.

**(e) 3-Wire, Direct-Current Generators.** Three-wire, direct-current generators, whether compound or shunt wound, shall be equipped with overcurrent devices, one in each armature lead, and so connected as to be actuated by the entire current from the armature. Such overcurrent devices shall consist either of a double-pole, double-coil circuit-breaker, or of a 4-pole circuit-breaker connected in the main and equalizer leads and tripped by two overcurrent devices, one in each armature lead. Such protective devices shall be so interlocked that no one pole can be opened without simultaneously disconnecting both leads of the armature from the system.

**445-5. Size of Conductors.** The conductors from the generator terminals to supplied equipment shall have a carrying capacity not less than 115 per cent of the nameplate current rating of the generator. Neutral conductors shall be the same size as the conductors of the outside legs.

**445-6. Protection of Live Parts.** Live parts of generators of more than 150 volts to ground shall not be exposed to accidental contact where accessible to unqualified persons.

**445-7. Guards for Attendants.** Where necessary for the safety of attendants the provisions of Section 430-133 shall be complied with.

**445-8. Grounding.** If a generator operates at a terminal voltage in excess of 150 volts to ground, the frame shall be grounded in the manner specified in Article 250. If the frame is not grounded, it shall be permanently and effectively insulated from the ground.

**445-9. Bushings.** Soft-rubber bushings used to protect lead wires where they pass through the frame of generators, shall not be exposed to oils, grease, oily vapors, or other substances having a deleterious effect on rubber.

## ARTICLE 450 — TRANSFORMERS AND TRANSFORMER VAULTS

(Including Secondary Ties)

**450-1. Application.** This Article applies to the installation of all transformers except: (1) current transformers; (2) dry-type transformers which constitute a component part of other apparatus and which conform to the requirements for such apparatus; (3) transformers for use with X-ray and high-frequency; (4) transformers used with Class 1 low-voltage power circuits or Class 2 remote control low energy power and signal circuits which shall conform to Article 725; (5) transformers for sign and outline lighting which shall conform to Article 600; and (6) transformers for electric discharge lighting which shall conform to Article 410.

This Article applies to the installation of transformers in hazardous locations except as modified by Article 500.

Supplementary rules are found also in Article 710, Circuits and Equipment Operating at More than 600 Volts Between Conductors; and Service Installations Over 600 Volts as referred to in Article 230.

### A. General Provisions

**450-2. Location.** Transformers and transformer vaults shall be readily accessible to qualified personnel for inspection and maintenance. The location of oil insulated transformers and transformer vaults is covered in Sections 450-24, 450-25, and 450-41; dry type transformers in Section 450-21 and askarel insulated in Section 450-23.

**450-3. Overcurrent Protection.** Overcurrent protection shall conform to the following. As used in this Section, the word "transformer" means a transformer or a bank of transformers operating as a unit.

(a) **Primary Side.** Each transformer shall be protected by an individual overcurrent device in the primary connection, rated or set at not more than 250 per cent of the rated primary current of the transformer, except that an individual overcurrent device is not required when the primary cir-

cuit overcurrent device provides the protection specified in this Paragraph, and except as provided in Paragraph 450-3(b).

**(b) Primary and Secondary Side.** A transformer having an overcurrent device in the secondary connection, rated or set at not more than 250 per cent of the rated secondary current of the transformer, or a transformer equipped with a coordinated thermal overload protection by the manufacturer, is not required to have an individual overcurrent device in the primary connection provided the primary feeder overcurrent device is rated or set to open at a current value not more than six times the rated current of the transformer for transformers having not more than six per cent impedance, and not more than four times rated current of the transformer for transformers having more than six but not more than ten per cent impedance.

**(c) Potential (Voltage) Transformers.** Potential transformers should be protected with primary fuses. The fuse rating should not exceed 10 amperes for circuits of 600 volts or less, and 3 amperes for circuits of more than 600 volts. A resistor should be connected in series with high tension fuses when necessary to limit the possible short-circuit current to a value within the interrupting capacity of the fuse.

**450-5. Secondary Ties.** As used in this Section, the word "transformer" means a transformer or a bank of transformers operating as a unit. A secondary tie is a circuit operating at 600 volts or less between phases which connects two power sources or power supply points, such as the secondaries of two transformers. The tie may consist of one or more conductors per phase.

**(a) Tie Circuits.** Tie circuits shall be provided at each end with overcurrent protection as required in Article 240 of this Code, except under the conditions described in Paragraphs 450-5(a-1 and a-2), in which cases the overcurrent protection may be in accordance with Paragraph 450-5(a-3).

**(1) Loads at Transformer Supply Points Only.** Where all loads are connected at the transformer supply points at each end of the tie and overcurrent protection is not provided in accordance with Article 240, the rated current-carrying capacity of the tie shall be not less than 67 per cent of the rated secondary current of the largest transformer connected to the secondary tie system.

(2) **Loads Connected Between Transformer Supply Points.** Where load is connected to the tie at any point between transformer supply points and overcurrent protection is not provided in accordance with Article 240, the rated current-carrying capacity of the tie shall be not less than 100 per cent of the rated secondary current of the largest transformer connected to the secondary tie system except as otherwise provided in Paragraphs 450-5(a-2 and a-4).

(3) **Tie Circuit Protection.** Under the conditions described in Paragraphs 450-5(a-1 and 2), both ends of each tie conductor shall be equipped with a protective device which will open at a predetermined temperature of the tie conductor under short circuit conditions. This protection shall consist of one of the following: (1) a fusible link cable connector, terminal or lug, commonly known as a limiter, each being of a size corresponding with that of the conductor and of approved construction and characteristics according to the operating voltage and the type of insulation on the tie conductors, or (2) automatic circuit-breakers actuated by devices having comparable current-time characteristics.

(4) **Interconnection of Phase Conductors Between Transformer Supply Points.** Where the tie consists of more than one conductor per phase, the conductors of each phase shall be interconnected in order to establish a load supply point, and the protection specified in Paragraph 450-5(a-3) shall be provided in each tie conductor at this point, except as follows:

*Exception: Loads may be connected to the individual conductors of a multiple-conductor tie without interconnecting the conductors of each phase and without the protection specified in Paragraph 450-5(a-3) at load connection points provided; the tie conductors of each phase have a combined capacity not less than 133 per cent of the rated secondary current of the largest transformer connected to the secondary tie system; the total load of such taps does not exceed the rated secondary current of the largest transformer; the loads are equally divided on each phase and on the individual conductors of each phase as far as practicable.*

(5) **Tie Circuit Control.** Where the operating voltage exceeds 150 volts to ground, secondary ties provided with limiters shall have a switch at each end which when open will de-energize the associated tie conductors and limiters.

The current rating of the switch shall be not less than the rated current of the conductors connected to the switch. It shall be capable of opening its rated current, and it shall be constructed so that it will not open under the magnetic forces resulting from short-circuit current.

**(b) Overcurrent Protection for Secondary Connections.** When secondary ties are used an overcurrent device rated or set at not more than 250 per cent of the rated secondary current of the transformers shall be provided in the secondary connections of each transformer, and in addition an automatic circuit-breaker actuated by a reverse-current relay set to open the circuit at not more than the rated secondary current of the transformer shall be provided in the secondary connection of each transformer.

**450-6. Parallel Operation.** Transformers may be operated in parallel and protected as a unit when their electrical characteristics are such that they will divide the load in proportion to their rating.

**450-7. Guarding.** Transformers shall be guarded as follows:

**(a) Mechanical Protection.** Appropriate provisions shall be made to minimize the possibility of damage to transformers from external causes where the transformers are located where they are exposed to physical damage.

**(b) Case or Enclosure.** Dry-type transformers shall be provided with a noncombustible moisture-resistant case or enclosure which will provide reasonable protection against the accidental insertion of foreign objects.

**(c) Exposed Live Parts.** The transformer installation shall conform with the provisions for guarding of live parts in Section 110-16.

**(d) Voltage Warning.** The operating voltage of exposed live parts of transformer installations shall be indicated by signs or visible markings on the equipment or structures.

**450-8. Grounding.** Exposed non-current carrying metal parts of transformer installations including fences, guards, etc. shall be grounded where required under the conditions and in the manner prescribed for electrical equipment and other exposed metal parts in Article 250.

**450-9. Marking.** Each transformer shall be provided with a nameplate giving the name of the manufacturer; rated kilovolt-amperes, frequency, primary and secondary voltage; and the amount and kind of insulating liquid where used and the transformer rating exceeds 25 kva. Where Class B insulation as defined in American Standard for Transformers C 57.10 - 1953 is used in the construction of dry-type transformers of more than 100 kva, the nameplate shall so indicate.

### **B. Specific Provisions Applicable to Different Types of Transformers**

**450-21. Dry-Type Transformers Installed Indoors.** Transformers rated  $112\frac{1}{2}$  kva or less shall have a separation of at least 12 inches from combustible material unless separated therefrom by a fire-resistant heat-insulating barrier, or unless of a rating not exceeding 600 volts and completely enclosed except for ventilating openings.

Transformers of more than  $112\frac{1}{2}$  kva rating shall be installed in a transformer room of fire-resistant construction unless they are constructed with Class B ( $80^{\circ}\text{C}$  rise) or Class H ( $150^{\circ}\text{C}$  rise) insulation, and are separated from combustible material not less than 6 feet horizontally and 12 feet vertically or are separated therefrom by a fire-resistant heat-insulating barrier.

Transformers rated more than 15,000 volts shall be installed in a vault. See Part C of this Article.

**450-23. Askarel-Insulated Transformers Installed Indoors.** Askarel-insulated transformers rated in excess of 25 kva shall be furnished with a pressure-relief vent. Where installed in a poorly ventilated place they shall be furnished with a means for absorbing any gases generated by arcing inside the case, or the pressure relief vent shall be connected to a chimney or flue which will carry such gases outside the building. Askarel-insulated transformers rated more than 15,000 volts shall be installed in a vault.

**450-24. Oil-Insulated Transformers Installed Indoors.** Oil-insulated transformers shall be installed in a vault constructed as specified in this Article except as follows:

(a) **Not Over  $112\frac{1}{2}$  kva Total Capacity.** The provisions for transformer vaults specified in Part C of this Article

apply except that the vault may be constructed of reinforced concrete not less than 4 inches thick.

(b) **Not Over 600 Volts.** A vault is not required provided suitable arrangements are made where necessary to prevent a transformer oil fire igniting other materials, and the total transformer capacity in one location does not exceed 10 kva in a section of the building classified as combustible, or 75 kva where the surrounding structure is classified as fire-resistant construction.

(c) **Furnace Transformers.** Electric furnace transformers of a total rating not exceeding 75 kva may be installed without a vault in a building or room of fire-resistant construction provided suitable arrangements are made to prevent a transformer oil fire spreading to other combustible material.

(d) **Detached Buildings.** Transformers may be installed in a building which does not conform with the provisions specified in this Code for transformer vaults, provided neither the building nor its contents present a fire hazard to any other building or property, and provided the building is used only in supplying electric service and the interior is accessible only to qualified persons.

**450-25. Oil-Insulated Transformers Installed Outdoors.** Combustible material, combustible buildings and parts of buildings, fire escapes, door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on, attached to, or adjacent to a building or combustible material. Space separations, fire-resistant barriers and enclosures which confine the oil of a ruptured transformer tank are recognized safeguards. One or more of these safeguards shall be applied according to the degree of hazard involved in cases where the transformer installation presents a fire hazard. Oil enclosures may consist of fire-resistant dikes, curbed areas or basins, or trenches filled with coarse crushed stone. Oil enclosures shall be provided with trapped drains in cases where the exposure and the quantity of oil involved are such that removal of oil is important.

### **C. Provisions for Transformer Vaults**

**450-41. Location.** Vaults shall be located where they can be ventilated to the outside air without using flues or ducts wherever such an arrangement is practicable.

**450-42. Walls, Roof, and Floor.** The walls and roofs of vaults shall consist of reinforced concrete not less than 6 inches thick, masonry of brick not less than 8 inches thick, of 12-inch load-bearing hollow tile or 12-inch load-bearing hollow concrete building units. The inside wall and roof surface of vaults constructed of hollow tile and hollow concrete building units shall have a coating of cement or gypsum plaster not less than  $\frac{3}{4}$  inches thick. The vault shall have a concrete floor not less than 4 inches thick. Building walls and floors which meet these requirements may serve for the floor, roof and one or more walls of the vault. Other forms of fire-resistive construction are also acceptable provided they have adequate structural strength for the conditions and a minimum fire resistance of two and one-half hours according to ASTM Fire Test Standard E119. The quality of the material used in the construction of the vault shall be of the grade approved by the inspection authority having jurisdiction.

**450-43. Doorways.** Any doorway leading from the vault into the building shall be protected as follows:

(a) **Type of Door.** Each doorway shall be provided with a tight-fitting door of a type approved for openings in Class A situations as defined in the NFPA Standard for Protection of Openings in Walls and Partitions Against Fire, No. 80 (National Fire Codes, Vol. III). The authority enforcing this Code may require such a door on each side of the wall where conditions warrant.

(b) **Sills.** A door sill or curb of sufficient height to confine within the vault the oil from the largest transformer shall be provided and in no case shall the height be less than 4 inches.

(c) **Locks.** Entrance doors shall be equipped with locks, and doors shall be kept locked, access being allowed only to qualified persons. Locks and latches shall be so arranged that the door may be readily and quickly opened from the inside.

**450-44. Ventilation.** The ventilation shall be adequate to prevent a transformer temperature in excess of the values prescribed in American Standard for Transformers, C 57.10-1953.

**450-45. Ventilation Openings.** When required by Section 450-44, openings for ventilation shall be provided in accordance with the following:

(a) **Location.** Ventilation openings shall be located as far away as possible from doors, windows, fire escapes, and combustible material.

(b) **Arrangement.** Vaults ventilated by natural circulation of air may have roughly half of the total area of openings required for ventilation in one or more openings near the floor and the remainder in one or more openings in the roof or in the sidewalls near the roof; or all of the area required for ventilation may be provided in one or more openings in or near the roof.

(c) **Size.** In the case of vaults ventilated to an outdoor area without using ducts or flues the combined net area of all ventilating openings after deducting the area occupied by screens, gratings, or louvers, shall be not less than 3 square inches per kva of transformer capacity in service, except that the net area shall be not less than 1 square foot for any capacity under 50 kva.

(d) **Covering.** Ventilation openings shall be covered with durable gratings, screens, or louvers, according to the treatment required in order to avoid unsafe conditions.

(e) **Dampers.** Where automatic dampers are used in the ventilation openings of vaults containing oil-insulated transformers, the actuating device should be made to function at a temperature resulting from fire and not at a temperature which might prevail as a result of an overheated transformer or bank of transformers. Automatic dampers should be so designed and constructed to minimize the possibility of accidental closing.

(f) **Ducts.** Ventilating ducts shall be constructed of fire-resistant material.

**450-46. Drainage.** Where practicable, vaults containing more than 100 kva transformer capacity shall be provided with a drain or other means which will carry off any accumulation of oil or water in the vault unless local conditions make this impracticable. The floor shall be pitched to the drain when provided.

**450-47. Water Pipes and Accessories.** Any pipe or duct systems foreign to the electrical installation should not enter

or pass through a transformer vault. Where the presence of such foreign systems cannot be avoided, appurtenances thereto which require maintenance at regular intervals shall not be located inside the vault. Arrangements shall be made where necessary to avoid possible trouble from condensation, leaks and breaks in such foreign systems. Piping or other facilities provided for fire protection or for water-cooled transformers are not deemed to be foreign to the electrical installation.

**450-48. Storage in Vaults.** Materials shall not be stored in transformer vaults.

## ARTICLE 460—CAPACITORS

**460-1. Application.** This Article applies to installation of capacitors on electric circuits in or on buildings.

*Exception No. 1. Capacitors that are components of other apparatus shall conform to the requirements for such apparatus.*

*Exception No. 2. Capacitors in hazardous locations shall comply with additional requirements in Articles 500-517.*

**460-2. Location.** An installation of capacitors in which any single unit contains more than three gallons of combustible liquid shall be in a vault conforming to Part C of Article 450.

**460-3. Mechanical Protection.** Capacitors shall be protected from physical damage by location or by suitable fences, barriers or other enclosures.

**460-4. Cases and Supports.** Capacitors shall be provided with noncombustible cases and supports.

**460-5. Transformers Used with Capacitors.** Transformers that are components of capacitor installations and are used for the purpose of connecting the capacitor to a power circuit shall be installed in accordance with Article 450. The kva rating shall not be less than 135 per cent of the capacitor rating in kvar.

**460-6. Drainage of Stored Charge.** Capacitors shall be provided with a means of draining the stored charge.

(a) **Time of Discharge.** The residual voltage of a capacitor shall be reduced to 50 volts or less within one minute after the capacitor is disconnected from the source of supply in the case of capacitors rated 600 volts or less and in five minutes in the case of capacitors rated more than 600 volts..

(b) **Means of Discharge.** The discharge circuit shall be either permanently connected to the terminals of the capacitor or capacitor bank, or provided with automatic means of connecting it to the terminals of the capacitor bank on removal of voltage from the line. Manual means of switching or connecting the discharge circuit shall not be used.

The windings of motors, of transformers, or of other equipment directly connected to capacitors without a switch or overcurrent device interposed, constitutes a suitable discharge means.

**460-7. Power Factor Correction — Motor Circuit.** The total kvar rating of capacitors which are connected on the load side of a motor controller shall not exceed the value required to raise the no-load power factor of the motor to unity.

**460-8. Conductor Rating.**

(a) The current-carrying capacity of capacitor circuit conductors shall be not less than 135 per cent of the rated current of the capacitor. The current-carrying capacity of conductors which connect a capacitor to the terminals of a motor or to motor circuit conductors, shall be not less than one-third the carrying capacity of the motor circuit conductors but not less than 135 per cent of the rated current of the capacitor.

**(b) Overcurrent Protection.**

(1) An overcurrent device shall be provided in each ungrounded conductor.

*Exception: A separate overcurrent device is not required on the load-side of a motor running overcurrent device.*

(2) The rating or setting of the overcurrent device shall be as low as practicable.

**(c) Disconnecting Means.**

(1) A disconnecting means shall be provided in each ungrounded conductor.

*Exception: A separate disconnecting means is not required for a capacitor connected on the load side of a motor overcurrent device.*

(2) The disconnecting device need not open all ungrounded conductors simultaneously.

(3) The disconnecting device may be used for disconnecting the capacitor from the line as a regular operating procedure.

(4) The continuous current carrying capacity of the disconnecting device shall be not less than 135 per cent of the rated current of the capacitor.

**460-9. Rating or Setting of the Motor-Running Overcurrent Device.** Where a motor installation includes a capacitor connected on the load side of the motor-running overcurrent device, and the overcurrent device used can be adjusted, the rating or setting of the motor overcurrent device shall be determined as provided in Section 430-32, except that instead of using the full-load rated current of the motor as provided in that Section a lower value corresponding with the improved power-factor of the motor circuit shall be used. Section 430-22 applies with respect to the rating of the motor circuit conductors.

**460-10. Grounding.** Capacitor cases shall be grounded in accordance with Article 250.

**460-11. Guarding.** All live parts of capacitors which are connected to circuits of more than 600 volts between conductors and are accessible to unqualified persons, shall be enclosed or isolated. For isolation by elevation, see Section 710-36.

**460-12. Marking.** Each capacitor shall be provided with a nameplate giving the maker's name, rated voltage, frequency, kvar, or amperes, number of phases, and if filled with a combustible liquid, the amount of liquid in gallons. When filled with a nonflammable liquid, the nameplate shall so state. The nameplate shall also indicate if a capacitor has a discharge device inside the case.

## ARTICLE 470 — RESISTORS AND REACTORS

For Rheostats see Section 430-82.

**470-1. Location.** Resistors and reactors shall not be placed where exposed to physical damage. Where in the immediate vicinity of easily ignitable material they shall be of the oil-immersed type or shall be enclosed in metal boxes or cabinets. See Article 500 for Hazardous Locations.

**470-2. Space Separation.** Unless attached to a switchboard or other noncombustible material, or unless mounted as provided in Section 470-3, resistors and reactors shall be separated from combustible material by a distance of not less than 1 foot.

**470-3. On or In a Proximity to Combustible Material.** Where placed within a distance of 1 foot from combustible material, resistors and reactors shall be installed as follows:

(a) **Slab or Panel.** They shall be attached to a slab or panel of noncombustible, nonabsorptive material such as slate, soapstone, or marble.

(b) **Size of Slab.** The slab shall extend beyond the edges of the device and shall have a thickness proportioned to the size and weight of the device but shall not be less than  $\frac{1}{2}$  inch thick.

(c) **Supports.** The slab shall be secured in position by supports independent of those fastening the device to the slab. Bolts which support the device shall be countersunk at least  $\frac{1}{8}$  inch below the rear surface of the slab and shall be covered with insulating material.

**470-4. Contacts.** Fixed and movable contacts shall be so designed that arcing will be kept at a minimum.

**470-5. Reactor Materials.** Reactors shall be composed of noncombustible materials, and shall be mounted on noncombustible bases.

**470-6. Mounting.** Enclosures when mounted on plain surfaces shall make contact with such surfaces only at the point of support, an air space of at least  $\frac{1}{4}$  inch being maintained between the enclosures and surfaces.

**470-7. Conductor Insulation.** Insulated conductors used for connection between resistance elements and controllers shall be suitable for an operating temperature of not less than 90°C (194°F). For elevator motor starting service, see Section 620-11(a).

*Exception: For motor starting service other conductor insulations may be used.*

**470-8. Incandescent Lamps as Resistors.** Incandescent lamps may be used as protective resistors for automatic controllers, or may by special permission be used as resistors in series with other devices and shall conform to the following:

(a) **Mounting.** They shall be mounted in porcelain receptacles on noncombustible supports.

(b) **Voltage.** They shall be so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated.

(c) **Nameplate.** They shall be provided with a nameplate, permanently attached, giving the wattage and voltage of the lamp to be used in each receptacle.

(d) **Not Carry Main Current.** They shall not carry or control the main current nor constitute the regulating resistance of the device.

## ARTICLE 480 — STORAGE BATTERIES

**480-1. Scope.** The provisions of this Article shall apply to all stationary installations of storage batteries using acid or alkali as the electrolyte and consisting of a number of cells connected in series with a nominal voltage in excess of 16 volts.

**480-2. Definition of Nominal Battery Voltage.** The nominal battery voltage shall be calculated on the basis of 2.0 volts per cell for the lead-acid type, and 1.2 volts per cell for the alkali type.

**480-3. Wiring and Apparatus Supplied From Batteries.** Wiring, appliances, and apparatus supplied from storage batteries shall be subject to the requirements of this Code applying to wiring, appliances, and apparatus operating at the same voltage, except as otherwise provided for communication systems in Article 800.

**480-4. Insulation of Batteries of Not Over 250 Volts.** The provisions of this Section shall apply to storage batteries having the cells so connected as to operate at a nominal battery voltage not exceeding 250 volts.

(a) **Lead-Acid Batteries.** Cells in lead-lined wood tanks, where the number of cells in series does not exceed 25, shall be supported individually on glass or glazed porcelain insulators. Where the number of the cells in series exceeds 25, the cells shall be supported individually on oil insulators.

(b) **Alkali-Type Batteries.** Cells of the alkali type in jars made of conducting material shall be installed in trays of nonconducting material, with not over 20 cells in a series circuit in any one such tray, or the cells may be supported singly or in groups on porcelain or other suitable insulators.

(c) **Unsealed Jars.** Cells in unsealed jars made of non-conductive material shall be assembled in trays of glass or supported on glass or glazed porcelain insulators; or, where installed on a rack, shall be supported singly or in groups on glass or other suitable insulators.

(d) **Sealed Rubber Jars.** Cells in sealed rubber or composition containers shall require no additional insulating support where the total nominal voltage of all cells in series

does not exceed 150 volts. Where the total voltage exceeds 150 volts, batteries shall be sectionalized into groups of 150 volts or less and each group shall have the individual cells installed in trays or on racks. Where trays or racks are required for this type of cell, such trays or racks shall be supported on glass or glazed porcelain insulators or oil-type insulators.

(e) **Sealed Glass or Plastic Jars.** Cells in sealed glass jars or in sealed jars of approved heat resistant plastic, with or without wood trays, require no additional insulation.

**480-5. Insulation of Batteries of Over 250 Volts.** The provisions of Section 480-4 shall apply to storage batteries having the cells so connected as to operate at a nominal voltage exceeding 250 volts and, in addition, the provisions of this section shall also apply to such batteries. Cells shall be installed in groups having a total nominal voltage of not over 250 volts, in trays or on racks supported on oil insulators.

*Exception No. 1. Where each individual cell, or sub-group in the tray or rack, is supported on oil insulators, no additional insulation for the group need be provided.*

*Exception No. 2. Cells of not over 10 ampere-hour capacity in sealed glass jars may be grouped in trays, the total nominal voltage of all cells in such group not to exceed 250 volts, and each such tray to be supported on glass or glazed porcelain insulators, the trays being mounted on racks supported on oil insulators with a total nominal voltage of not over 500 volts for all cells in series on each such insulated rack.*

Maximum protection is secured by sectionalizing high-voltage batteries into cell groups insulated from each other.

**480-6. Racks and Trays.** Racks and trays shall conform to the following:

(a) **Racks.** Racks, as required in this Article, refer to frames designed to support cells or trays. They shall be substantial, and made of:

(1) Wood, so treated as to be resistant to deteriorating action by the electrolyte; or

(2) Metal, so treated as to be resistant to deteriorating action by the electrolyte, and provided with nonconducting

members directly supporting the cells or with suitable insulating material on conducting members; or

**(3) Other similar suitable construction.**

**(b) Trays.** Trays refer to frames such as crates or shallow boxes usually of wood or other nonconducting material, so constructed or treated as to be resistant to deteriorating action by the electrolyte.

**480-7. Battery Rooms.** Battery rooms shall conform to the following:

**(a) Use.** Separate battery rooms or enclosures shall be required only for batteries in unsealed jars and tanks where the aggregate capacity at the 8-hour discharge rate exceeds 5 kilowatt hours.

**(b) Ventilation.** Provision shall be made for sufficient diffusion and ventilation of the gases from the battery to prevent the accumulation of an explosive mixture in the battery room.

**(c) Wiring Method.** In storage battery rooms, bare conductors, open wiring, Type MI cable or conductors in rigid conduit or electrical metallic tubing shall be used as the wiring method. Rigid metal conduit, or electrical metallic tubing, where used, shall be of corrosion-resistant material or shall be suitably protected from corrosion.

**(d) Varnished-Cambric Conductors.** Varnished-cambric-covered conductors, Type V, shall not be used.

**(e) Bare Conductors.** Bare conductors shall not be taped.

**(f) Terminals.** Where metal raceway or other metallic covering is used in the battery room, at least 12 inches of the conductor at the end connected to a cell terminal shall be free from the raceway or metallic covering and shall be bushed by a substantial glazed insulating bushing. The end of the raceway shall be sealed tightly to resist the entrance of electrolyte by spray or by creepage. Sealing compound, rubber insulating tape or other suitable material shall be used for this purpose.

## Chapter 5. Special Occupancies

### ARTICLE 500—HAZARDOUS LOCATIONS

**500-1. Scope.** The provisions of Articles 500-503 apply to locations in which the authority enforcing this Code judges the apparatus and wiring to be subject to the conditions indicated by the following classifications. It is intended that each room, section or area (including motor and generator rooms, and rooms for the enclosure of control equipment) shall be considered individually in determining its classification. Except as modified in Articles 500-503, all other applicable rules contained in this Code shall apply to electrical apparatus and wiring installed in hazardous locations. For definitions of "approved" and "explosion-proof" as used in these Articles, refer to Article 100; "dust-ignition-proof" is defined in Section 502-1.

Equipment and associated wiring approved as intrinsically safe may be installed in any hazardous location for which it is approved, and the provisions of Articles 500-517 need not apply to such installation. Intrinsically safe equipment and wiring is incapable of releasing sufficient electrical energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture. Abnormal conditions will include accidental damage to any part of the equipment or wiring, insulation or other failure of electrical components, application of over-voltage, adjustment and maintenance operations, and other similar conditions.

Through the exercise of ingenuity in the layout of electrical installations for hazardous locations, it is frequently possible to locate much of the equipment in less hazardous or in non-hazardous areas and thus to reduce the amount of special equipment required. In some cases, hazards may be reduced or hazardous areas limited or eliminated by adequate positive-pressure ventilation from a source of clean air in conjunction with effective safeguards against ventilation failure. It is recommended that the authority enforcing this Code be consulted before such layouts are prepared. It is recommended also that the Code enforcing authority be familiar with such recorded industrial experience as well as with such standards of the National Fire Protection Association as may be of use in the classification of various areas with respect to hazard.

For recommendations for protection against static electricity hazards, refer to the standards of the National Fire Protection Association on this subject.

**500-2. Special Precaution.** The intent of Articles 500-503 is to require a form of construction of equipment, and of installation that will insure safe performance under conditions of proper use and maintenance. It, therefore, is assumed that inspection authorities and users will exercise more than ordinary care with regard to installation and maintenance.

The characteristics of various atmospheric mixtures of hazardous gases, vapors and dusts depend on the specific hazardous material involved. It is necessary therefore that equipment be approved not only for the class of location but also for the specific gas, vapor or dust that will be present.

For purposes of testing and approval, various atmospheric mixtures have been grouped on the basis of their hazardous characteristics, and facilities have been made available for testing and approval of equipment for use in the following atmospheric groups:

Group A, Atmospheres containing acetylene;

Group B, Atmospheres containing hydrogen, or gases or vapors of equivalent hazard such as manufactured gas;

Group C, Atmospheres containing ethyl-ether vapors, ethylene, or cyclo-propane;

Group D, Atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, alcohol, acetone, benzol, lacquer solvent vapors, or natural gas;

Group E, Atmospheres containing metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics.

Group F, Atmospheres containing carbon black, coal or coke dust;

Group G, Atmospheres containing flour, starch, or grain dusts.

**500-3. Specific Occupancies.** See Articles 510 to 517 inclusive for rules applying to garages, aircraft hangars, gasoline dispensing and service stations, bulk storage plants, finishing processes, and flammable anesthetics.

**500-4. Class I Locations.** Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations shall include the following:

(a) **Class I, Division 1.** Locations (1) in which hazardous concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions, (2) in which hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage, or

(3) in which breakdown or faulty operation of equipment or processes which might release hazardous concentrations of flammable gases or vapors, might also cause simultaneous failure of electrical equipment.

This classification would usually include locations where flammable volatile liquids or liquefied flammable gases are transferred from one container to another; interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks or vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; locations containing fat and oil extraction apparatus using volatile flammable solvents; portions of cleaning and dyeing plants where hazardous liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; and all other locations where hazardous concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

(b) Class I, Division 2. Locations (1) in which flammable volatile liquids or flammable gases are handled, processed or used, but in which the hazardous liquids, vapors or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment, (2) in which hazardous concentrations of gases or vapors are normally prevented by positive mechanical ventilation, but which might become hazardous through failure or abnormal operation of the ventilating equipment, or (3) which are adjacent to Class I, Division 1 locations, and to which hazardous concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

This classification would usually include locations where flammable volatile liquids or flammable gases or vapors are used, but which, in the judgment of the Code enforcing authority, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of hazardous material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that should receive consideration in determining the classification and extent of each hazardous area.

Piping without valves, checks, meters and similar devices would not ordinarily be deemed to introduce a hazardous condition even though used for hazardous liquids or gases. Locations used for the storage

of hazardous liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless subject to other hazardous conditions also.

**500-5. Class II Locations.** Class II locations are those which are hazardous because of the presence of combustible dust. Class II locations shall include the following:

(a) **Class II, Division 1.** Locations (1) in which combustible dust is or may be in suspension in the air continuously, intermittently, or periodically under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures, (2) where mechanical failure or abnormal operation of machinery or equipment might cause such mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electrical equipment, operation of protection devices, or from other causes, or (3) in which dusts of an electrically conducting nature may be present.

This classification would usually include the working areas of grain handling and storage plants; rooms containing grinders or pulverizers, cleaners, graders, scalpers, open conveyors or spouts, open bins or hoppers, mixers or blenders, automatic or hopper scales, packing machinery, elevator heads and boots, stock distributors, dust and stock collectors (except all-metal collectors vented to the outside), and all similar dust producing machinery and equipment in grain processing plants, starch plants, sugar pulverizing plants, malting plants, hay grinding plants, and other occupancies of similar nature; coal pulverizing plants (except where the pulverizing equipment is essentially dust-tight); all working areas where metal dusts and powders are produced, processed, handled, packed or stored (except in tight containers); and all other similar locations where combustible dust may, under normal operating conditions, be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Combustible dusts which are electrically non-conducting will include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Electrically conducting non-metallic dusts will include dusts from pulverized coal, coke and charcoal. Metallic dusts from magnesium, aluminum and aluminum bronze are particularly hazardous and every precaution must be taken to avoid ignition and explosion.

(b) **Class II, Division 2.** Locations in which combustible dust will not normally be in suspension in the air, or will not be likely to be thrown into suspension by the normal operation of equipment or apparatus, in quantities sufficient to produce explosive or ignitable mixtures, but (1) where

deposits or accumulations of such dust may be sufficient to interfere with the safe dissipation of heat from electrical equipment or apparatus, or (2) where such deposits or accumulations of dust on, in, or in the vicinity of electrical equipment might be ignited by arcs, sparks or burning material from such equipment.

Locations where dangerous concentrations of suspended dust would not be likely, but where dust accumulations might form on, or in the vicinity of electrical equipment, would include rooms and areas containing only closed spouting and conveyors, closed bins or hoppers, or machines and equipment from which appreciable quantities of dust would escape only under abnormal operating conditions; rooms or areas adjacent to locations described in Paragraph 500-5(a), and into which explosive or ignitable concentrations of suspended dust might be communicated only under abnormal operating conditions; rooms or areas where the formation of explosive or ignitable concentrations of suspended dust is prevented by the operation of effective dust control equipment; warehouses and shipping rooms where dust producing materials are stored or handled only in bags or containers; and other similar locations.

**500-6. Class III Locations.** Class III locations are those which are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in air in quantities sufficient to produce ignitable mixtures. Class III locations shall include the following:

(a) **Class III, Division 1.** Locations in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured or used.

Such locations would include some parts of rayon, cotton and other textile mills; combustible fiber manufacturing and processing plants; cotton gins and cotton-seed mills; flax processing plants; clothing manufacturing plants; woodworking plants; and establishments and industries involving similar hazardous processes or conditions.

Easily ignitable fibers and flyings will include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior and other materials of similar nature.

(b) **Class III, Division 2.** Locations in which easily ignitable fibers are stored or handled (except in process of manufacture).

## ARTICLE 501 — CLASS I INSTALLATIONS — HAZARDOUS LOCATIONS

**501-1. General.** The general rules of this Code shall apply to the installation of electrical wiring and equipment in locations classified as Class I under Section 500-4 except as modified by this Article.

**501-2. Transformers and Capacitors.** The installation of transformers and capacitors shall conform to the following:

(a) **Class I, Division 1.** In Class I, Division 1 locations, transformers and capacitors shall conform to the following:

(1) **Containing a Liquid that Will Burn.** Transformers and capacitors containing a liquid that will burn shall be installed only in approved vaults, which shall conform to Sections 450-41 to 450-48 inclusive, and in addition, (1) there shall be no door or other communicating opening between the vault and the hazardous area, (2) ample ventilation shall be provided for the continuous removal of hazardous gases or vapor, (3) vent openings or ducts shall lead to a safe location outside of buildings, and (4) vent ducts and openings shall be of sufficient area to relieve explosion pressures within the vault, and all portions of vent ducts within the buildings shall be of reinforced concrete construction.

(2) **Not Containing a Liquid that Will Burn.** Transformers and capacitors which do not contain a liquid that will burn shall (1) be installed in vaults conforming to the requirements of Paragraph 501-2(a-1), or (2) be approved for Class I locations (explosion-proof).

(b) **Class I, Division 2.** In Class I, Division 2 locations, transformers and capacitors shall conform to Sections 450-21 to 450-25 inclusive.

**501-3. Meters, Instruments and Relays.** The installation of meters, instruments and relays shall conform to the following:

(a) **Class I, Division 1.** In Class I, Division 1 location, meters, instruments and relays, including kilowatt-hour meters, instrument transformers and resistors, rectifiers

and thermionic tubes, shall be provided with enclosures approved for Class I locations.

It is recommended that such equipment be located outside of the hazardous area where practicable.

**(b) Class I, Division 2.** In Class I, Division 2 locations, meters, instruments and relays shall conform to the following:

**(1) With Make or Break Contacts.** Meters, instruments, and relays in which are incorporated contacts for making or breaking current shall conform to Paragraph 501-3(a) unless general purpose enclosures are provided and such contacts are (1) immersed in oil, or (2) enclosed within a chamber hermetically sealed against the entrance of gases or vapors.

**(2) Resistors and Similar Equipment.** Resistors, resistance devices, thermionic tubes, and rectifiers, which are used in or in connection with meters, instruments and relays, shall conform to Paragraph 501-3(a), except that enclosures may be of general purpose type when such equipment is without make and break or sliding contacts (other than slide-wire contacts in potentiometers used in conjunction with thermocouples) and when the maximum operating temperature of any exposed surface will not exceed eighty per cent (80%) of the ignition temperature in degrees Centigrade of the gas or vapor involved as determined by A.S.T.M. test procedure (Designation D286-30).

**(3) Without Make or Break Contacts.** Transformer windings, impedance coils, solenoids, and other windings which do not incorporate sliding or make or break contacts shall be provided with enclosures which may be of general purpose type where vents adequate to permit prompt escape of any gases or vapors are provided.

**(4) General Purpose Assemblies.** Where an assembly is made up of components for which general purpose enclosures are acceptable under Paragraphs 501-3(b-1, 2, 3), a single general purpose enclosure is acceptable for the assembly. Where such an assembly includes any of the equipment described in Paragraph 501-3(b-2) the maximum obtainable surface temperature of any component of the assembly shall be clearly and permanently indicated on the outside of the enclosure.

**501-4. Wiring Methods.** Wiring methods shall conform to the following:

(a) **Class I, Division 1.** In Class I, Division 1 locations, threaded rigid metal conduit or Type MI cable with termination fittings approved for the location shall be the wiring method employed. All boxes, fittings, and joints shall be threaded for connection to conduit or cable terminations, and shall be explosion-proof. Threaded joints shall be made up with at least five threads fully engaged. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings. Where necessary to employ flexible connections, as at motor terminals, flexible fittings approved for Class I locations (explosion-proof) shall be used.

(b) **Class I, Division 2.** In Class I, Division 2 locations, threaded rigid metal conduit or Type MI cable with termination fittings approved for Class I locations shall be the wiring method employed. Type MI cable shall be installed in a manner to avoid tensile stress at the termination fittings. Where provision must be made for limited flexibility, as at motor terminals, flexible metal fittings, flexible metal conduit with approved fittings, or flexible cord approved for extra hard usage and provided with approved bushed fittings shall be used. An additional conductor for grounding shall be included in the flexible cord unless other acceptable means of grounding are provided.

**501-5. Sealing.** Seals are provided in conduit systems to prevent the passage of gases, vapors or flames from one portion of the electrical installation to another through the conduit. Such communication through Type MI cable is inherently prevented by construction of the cable, but sealing compound is used in cable termination fittings to exclude moisture and other fluids from the cable insulation, and shall be of a type approved for the conditions of use. Seals in conduit systems shall conform to the following:

(a) **Class I, Division 1.** In Class I, Division 1 locations, seals shall be located as follows:

(1) In each conduit run entering an enclosure for switches, circuit-breakers, fuses, relays, resistors or other apparatus which may produce arcs, sparks or high temperatures. Seals shall be placed as close as practicable and in no case more than 18 inches from such enclosures.

(2) In each conduit run of 2-inch size or larger entering the enclosure or fitting housing terminals, splices or taps, and within 18 inches of such enclosure or fitting.

Where two or more enclosures for which seals are required under Paragraphs 501-5(a-1, 2) are connected by nipples or by runs of conduit not more than 36 inches long, a single seal in each such nipple connection or run of conduit would be sufficient if located not more than 18 inches from either enclosure. Ordinary conduit fittings of the "L," "T" or "Cross" type would not usually be classed as enclosures when not larger than the trade size of the conduit.

(3) In each conduit run leaving the Class I, Division 1 hazardous area. The sealing fitting may be located on either side of the boundary of such hazardous area, but shall be so designed and installed that any gases or vapors which may enter the conduit system, within the Division 1 hazardous area, will not enter or be communicated to the conduit beyond the seal. There shall be no union, coupling, box or fitting in the conduit between the sealing fitting and the point at which the conduit leaves the Division 1 hazardous area.

(b) Class I, Division 2. In Class I, Division 2 locations, seals shall be located as follows:

(1) For conduit connections to enclosures which are required to be approved for Class I locations, seals shall be provided in conformance to Paragraphs 501-5(a-1, 2). All portions of the conduit run or nipple between the seal and such enclosure shall conform to Paragraph 501-4(a).

(2) In each conduit run passing from the Class I, Division 2 hazardous area into a non-hazardous area. The sealing fitting may be located on either side of the boundary of such hazardous area, but shall be so designed and installed that any gases or vapors which may enter the conduit system, within the Division 2 hazardous area, will not enter or be communicated to the conduit beyond the seal. Rigid conduit shall be used between the sealing fitting and the point at which the conduit leaves the hazardous area, and a threaded connection shall be used at the sealing fitting. There shall be no union, coupling, box or fitting in the conduit between the sealing fitting and the point at which the conduit leaves the hazardous area.

(c) Class I, Divisions 1 and 2. Where seals are required, they shall conform to the following:

(1) **Fittings.** Enclosures for connections or for equipment shall be provided with approved integral means for sealing, or sealing fittings approved for Class I locations shall be used.

(2) **Compound.** Sealing compound shall be approved for the purpose, shall not be affected by the surrounding atmosphere or liquids, and shall not have a melting point of less than 93°C. (200°F.).

(3) **Thickness of Compound.** In the completed seal, the minimum thickness of the sealing compound shall be not less than the trade size of the conduit, and in no case less than  $\frac{5}{8}$  inch.

(4) **Splices and Taps.** Splices and taps shall not be made in fittings intended only for sealing with compound, nor shall other fittings in which splices or taps are made be filled with compound.

(5) **Drainage.** Where there is probability that liquid or other condensed vapor may be trapped within enclosures for control equipment or at any point in the raceway system, approved means shall be provided to prevent accumulation or to permit periodic draining of such liquid or condensed vapor.

(6) **Motors and Generators.** Where the authority enforcing this Code judges that there is probability that liquid or condensed vapor may accumulate within motors or generators, joints and conduit systems shall be arranged to minimize entrance of liquid. If means to prevent accumulation or to permit periodic draining are judged necessary, such means shall be provided at the time of manufacture, and shall be deemed an integral part of the machine.

(7) **Assemblies.** In an assembly where equipment which may produce arcs, sparks or high temperatures is located in a compartment separate from the compartment containing splices or taps, and an integral seal is provided where conductors pass from one compartment to the other, the entire assembly shall be approved for Class I locations. Seals in conduit connections to the compartment containing splices or taps shall be provided in Class I, Division 1 locations where required by Paragraph 501-5(a-2).

**501-6. Switches, Circuit-Breakers, Motor Controllers and Fuses.** Switches, circuit-breakers, motor controllers and fuses shall conform to the following:

(a) **Class I, Division 1.** In Class I, Division 1 locations, switches, circuit-breakers, motor controllers and fuses, including push buttons, relays and similar devices, shall be provided with enclosures, and the enclosure in each case together with the enclosed apparatus shall be approved as a complete assembly for use in Class I locations.

(b) **Class I, Division 2.** Switches, circuit-breakers, motor controllers and fuses in Class I, Division 2 locations shall conform to the following:

(1) **Type Required.** Circuit-breakers, motor controllers and switches intended to interrupt current in the normal performance of the function for which they are installed shall be provided with enclosures approved for Class I locations, unless general purpose enclosures are provided and (1) the interruption of current occurs within a chamber hermetically sealed against the entrance of gases and vapors, or (2) the current interrupting contacts are oil-immersed and the device is approved for locations of this class and division.

This will include service and branch circuit switches and circuit-breakers; motor controllers, including push-buttons, pilot switches, relays and motor-overload protective devices; and switches and circuit-breakers for the control of lighting and appliance circuits. Oil-immersed circuit-breakers and controllers of ordinary general use type may not confine completely the arc produced in the interruption of heavy overloads, and specific approval for locations of this class and division is therefore necessary.

(2) **Isolating Switches.** Enclosures for disconnecting and isolating switches without fuses and which are not intended to interrupt current may be of general purpose type.

(3) **Fuses.** For the protection of motors, appliances and lamps, except as provided in Paragraph 501-6(b-4), (1) standard plug or cartridge fuses may be used provided they are placed within enclosures approved for the purpose and for the location, or (2) fuses of a type in which the operating element is immersed in oil or other approved liquid, or is enclosed within a chamber hermetically sealed against the entrance of gases and vapors may be used pro-

vided they are approved for the purpose and are placed within general purpose enclosures.

**(4) Fuses or Circuit-Breakers for Overcurrent Protection.** When not more than 10 sets of approved enclosed fuses, or not more than 10 circuit-breakers which are not intended to be used as switches for the interruption of current, are installed for branch or feeder circuit protection in any one room, area or section of this class and division, the enclosures for such fuses or circuit-breakers may be of general purpose type, provided the fuses or circuit-breakers are for the protection of circuits or feeders supplying lamps in fixed positions only.

A set of fuses shall be construed to mean a group containing as many fuses as are required to perform a single protective function in a circuit. For example, a group of 3 fuses protecting an ungrounded three-phase circuit, and a single fuse protecting the ungrounded conductor of an identified two-wire single-phase circuit, would each be considered as a set of fuses. Fuses conforming to Paragraph 501-6(b-3) need not be included in counting the 10 sets of fuses permitted in general purpose enclosures.

**501-7. Control Transformers and Resistors.** Transformers, impedance coils and resistors used as or in conjunction with control equipment for motors, generators and appliances shall conform to the following:

**(a) Class I, Division 1.** In Class I, Division 1 locations, transformers, impedance coils and resistors, together with any switching mechanism associated with them, shall be provided with enclosures approved for Class I locations (explosion-proof).

**(b) Class I, Division 2.** In Class I, Division 2 locations, control transformers and resistors shall conform to the following:

**(1) Switching Mechanisms.** Switching mechanisms used in conjunction with transformers, impedance coils and resistors shall conform to Paragraph 501-6(b).

**(2) Coils and Windings.** Enclosures for windings of transformers, solenoids or impedance coils may be of general purpose type, but shall be provided with vents adequate to permit prompt escape of gases or vapors that may enter the enclosure.

**(3) Resistors.** Resistors shall be provided with enclosures and the assembly shall be approved for Class I loca-

tions, unless resistance is non-variable and maximum operating temperature, in degrees Centigrade, will not exceed eighty per cent (80%) of the ignition temperature of the gas or vapor involved as determined by A.S.T.M. test procedure (Designation D 286-30).

**501-8. Motors and Generators.** Motors and generators shall conform to the following:

(a) **Class I, Division 1.** In Class I, Division 1 locations, motors, generators and other rotating electrical machinery shall be approved for Class I locations (explosion-proof).

(b) **Class I, Division 2.** In Class I, Division 2 locations, motors, generators and other rotating electrical machinery in which are employed sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent devices), or integral resistance devices, either while starting or while running, shall be approved for Class I locations (explosion-proof), unless such sliding contacts, switching mechanisms and resistance devices are provided with enclosures approved for such locations.

This rule does not prohibit installation of open or non-explosion-proof enclosed motors, such as squirrel cage induction motors, without brushes, switching mechanism, etc., in Class I, Division 2 locations.

**501-9. Lighting Fixtures.** Lamps shall be installed in fixtures which shall conform to the following:

(a) **Class I, Division 1.** In Class I, Division 1 locations, lighting fixtures shall conform to the following:

(1) **Approved Fixtures.** Each fixture shall be approved as a complete assembly for locations of this class, and shall be clearly marked to indicate the maximum wattage of lamps for which it is approved. Fixtures intended for portable use shall be specifically approved as a complete assembly for that use.

(2) **Physical Damage.** Each fixture shall be protected against physical damage by a suitable guard or by location.

(3) **Pendent Fixtures.** Pendent fixtures shall be suspended by and supplied through threaded rigid conduit stems and threaded joints shall be provided with set-screws or other effective means to prevent loosening. For stems longer than 12 inches, permanent and effective bracing

against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or flexible connector approved for the purpose and for the location shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting.

(4) **Supports.** Boxes, box assemblies or fittings used for the support of lighting fixtures shall be approved for the purpose and for Class I locations.

(b) **Class I, Division 2.** In Class I, Division 2 locations, lighting fixtures shall conform to the following:

(1) **Portable Lamps.** Portable lamps shall conform to Paragraph 501-9(a-1).

(2) **Fixed Lighting.** Lighting fixtures for fixed lighting shall be protected from physical damage by suitable guards or by location. Where there is danger that falling sparks or hot metal from lamps or fixtures might ignite localized concentrations of flammable vapors or gases, suitable enclosures or other effective protective means shall be provided. Where lamps are of a size or type which may, under normal operating conditions, reach surface temperatures exceeding eighty per cent (80%) of the ignition temperature in degrees Centigrade of the gas or vapor involved, as determined by A.S.T.M. test procedure (Designation D 286-30), fixtures shall conform to Paragraph 501-9(a-1).

(3) **Pendent Fixtures.** Pendent fixtures shall be suspended by threaded rigid conduit stems or by other approved means. For rigid stems longer than 12 inches, permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or flexible connector approved for the purpose shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting.

(4) **Supports.** Boxes, box assemblies, or fittings used for the support of lighting fixtures shall be approved for the purpose.

(5) **Switches.** Switches which are a part of an assembled fixture or of an individual lampholder shall conform to the requirements of Paragraph 501-6(b-1).

**(6) Starting Equipment.** Starting and control equipment for mercury-vapor and fluorescent lamps shall conform to the requirements of Paragraph 501-7(b).

**501-10. Appliances, Fixed and Portable.** Appliances, fixed and portable, shall conform to the following:

**(a) Class I, Division 1.** In Class I, Division 1 locations, appliances, including electrically-heated and motor-driven appliances, shall be approved for Class I locations.

**(b) Class I, Division 2.** In Class I, Division 2 locations, appliances, fixed and portable, shall conform to the following:

**(1) Heaters.** Electrically-heated appliances shall be approved for Class I locations.

**(2) Motors.** Motors of motor-driven appliances shall conform to Paragraph 501-8(b).

**(3) Switches, Circuit-breakers, and Fuses.** Switches, circuit-breakers and fuses shall conform to Paragraph 501-6(b).

**501-11. Flexible Cords, Class I, Divisions 1 and 2.** A flexible cord may be used only for connection between a portable lamp or a portable appliance and the fixed portion of its supply circuit and where used shall (1) be of a type approved for extra hard usage, (2) contain, in addition to the conductors of the circuit, a grounding conductor conforming to Section 400-13, (3) be connected to terminals or to supply conductors in an approved manner, (4) be supported by clamps or by other suitable means in such a manner that there will be no tension on the terminal connections, and (5) suitable seals shall be provided where the flexible cord enters boxes, fittings or enclosures of explosion-proof type.

Where flexible cords may be exposed to liquids having a deleterious effect on the conductor insulation, they should conform also to Section 501-13.

**501-12. Receptacles and Attachment Plugs, Class I, Divisions 1 and 2.** Receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of the flexible cord, and shall be approved for Class I locations.

**501-13. Conductor Insulation Class I, Divisions 1 and 2.** Where condensed vapors or liquids may collect on or come in contact with the insulation on conductors, such insulation shall be of a type approved for use under such conditions or the insulation shall be protected by a sheath of lead or by other approved means.

**501-14. Signal, Alarm, Remote-control and Communication Systems.** Signal, alarm, remote-control and communication systems shall conform to the following:

(a) **Class I, Division 1.** In Class I, Division 1 locations, all apparatus and equipment of signalling, alarm, remote-control and communication systems, irrespective of voltage, shall be approved for Class I locations, and all wiring shall conform to Paragraphs 501-4(a) and 501-5(a and c).

(b) **Class I, Division 2.** In Class I, Division 2 locations, signal, alarm, remote-control and communication systems shall conform to the following:

(1) **Contacts.** Switches and circuit-breakers, and make and break contacts of push buttons, relays, and alarm bells or horns, shall have enclosures approved for Class I locations, unless general purpose enclosures are provided and current interrupting contacts are (1) immersed in oil, or (2) enclosed within a chamber hermetically sealed against the entrance of gases or vapors.

(2) **Resistors and Similar Equipment.** Resistors, resistance devices, thermionic tubes and rectifiers shall conform to Paragraph 501-3(b-2).

(3) **Protectors.** Enclosures which may be of general purpose type shall be provided for lightning protective devices and for fuses.

**501-15. Live Parts, Class I, Divisions 1 and 2.** There shall be no exposed live parts.

**501-16. Grounding, Class I, Divisions 1 and 2.** Wiring and equipment shall be grounded in conformity with the following:

(a) **Exposed Parts.** The exposed non-current-carrying metal parts of equipment such as the frames or metal exteriors of motors, fixed or portable lamps or appliances, lighting fixtures, cabinets, cases, and conduit, shall be grounded as specified in Article 250 of this Code.

**(b) Bonding.** The locknut-bushing and double-locknut types of contacts shall not be depended upon for bonding purposes, but bonding jumpers with proper fittings or other approved means shall be used. Where flexible conduit is used as permitted in Paragraph 501-4(b), bonding jumpers with proper fittings shall be provided around such conduit.

**(c) Lightning Protection.** Each ungrounded service conductor of a wiring system in a Class I location, when supplied from an ungrounded overhead electrical supply system in an area where lightning disturbances are prevalent, shall be protected by a lightning protective device of proper type. Lightning protective devices shall be connected to the service conductors on the supply side of the service disconnecting means, and shall be bonded to the raceway system at the service entrance.

**(d) Grounded Service Conductor Bonded to Raceway.** Wiring in a Class I location, when supplied from a grounded alternating current supply system in which a grounded conductor is a part of the service, shall have the grounded service conductor bonded to the raceway system and to the grounding conductor for the raceway system. The bonding connection to the grounded service conductor shall be made on the supply side of the service disconnecting means.

**(e) Transformer Ground Bonded to Raceway.** Wiring in a Class I location, when supplied from a grounded alternating current supply system in which no grounded conductor is a part of the service, shall be provided with a metallic connection between the supply system ground and the raceway system at the service entrance. The metallic connection shall have a current carrying capacity not less than  $1/5$  that of the service conductors, and shall in no case be smaller than No. 10 when of soft copper, or No. 12 when of medium or hard-drawn copper.

**(f) Multiple Grounds.** Where, in the application of Section 250-21, it is necessary to abandon one or more grounding connections to avoid objectional passage of current over the grounding conductors, the connection required in Section 501-16(d and e) shall not be abandoned while any other grounding connection remains connected to the supply system.

## ARTICLE 502 — CLASS II INSTALLATIONS — HAZARDOUS LOCATIONS

**502-1. General.** The general rules of this Code shall apply to the installation of electrical wiring and apparatus in locations classified as Class II under Section 500-5 except as modified by this Article.

“Dust-ignition-proof,” as used in this Article, shall mean enclosed in a manner which will exclude ignitable amounts of dusts or amounts which might affect performance or rating and which, when installation and protection are in conformance with this Code, will not permit arcs, sparks or heat otherwise generated or liberated inside of the enclosure, to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.

Equipment installed in Class II locations should be able to function at full rating without developing surface temperatures high enough to cause excessive dehydration or gradual carbonization of any organic dust deposits that may occur. Dust which is carbonized or is excessively dry is highly susceptible to spontaneous ignition. In general, maximum surface temperatures under actual operating conditions should not exceed 165°C. (329°F.) for equipment which is not subject to overloading, and 120°C. (248°F.) for equipment such as motors, power transformers, etc., which may be overloaded.

Equipment and wiring of the type defined in Article 100 as explosion-proof is not required in Class II locations, and may not be acceptable unless approved for such locations.

**502-2. Transformers and Capacitors.** The installation of transformers and capacitors shall conform to the following:

(a) **Class II, Division 1.** In Class II, Division 1 locations, transformers and capacitors shall conform to the following:

(1) **Containing a Liquid that Will Burn.** Transformers and capacitors containing a liquid that will burn shall be installed only in approved vaults conforming to Sections 450-41 to 450-48 inclusive, and in addition (1) door or other openings communicating with the hazardous area shall have self-closing fire doors on both sides of the wall, and the doors shall be carefully fitted and provided with suitable seals (such as weather stripping) to minimize the entrance of dust into the vault, (2) vent openings and

ducts shall communicate only with the outside air, and (3) suitable pressure-relief openings communicating with the outside air shall be provided.

**(2) Not Containing a Liquid that Will Burn.** Transformers and capacitors which do not contain a liquid that will burn shall (1) be installed in vaults conforming to Sections 450-41 to 450-48 inclusive, or (2) be approved as a complete assembly including terminal connections for Class II locations.

**(3) Metal Dusts.** No transformer or capacitor shall be installed in a location where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present.

**(b) Class II, Division 2.** In Class II, Division 2 locations, transformers and capacitors shall conform to the following:

**(1) Containing a Liquid that Will Burn.** Transformers and capacitors containing a liquid that will burn shall be installed in vaults conforming to Sections 450-41 to 450-48 inclusive.

**(2) Containing Askarel.** Transformers containing askarel and rated in excess of 25 kva shall (1) be provided with pressure-relief vents, (2) be provided with means for absorbing any gases generated by arcing inside the case, or the pressure-relief vents shall be connected to a chimney or flue which will carry such gases outside the building and (3) have an air space of not less than 6 inches between the transformer cases and any adjacent combustible material.

**(3) Dry-Type Transformers.** Dry-type transformers shall be installed in vaults or shall (1) have their windings and terminal connections enclosed in tight metal housings without ventilating or other openings, and (2) operate at voltages not exceeding 600 volts.

**502-3. Surge Protection, Class II, Divisions 1 and 2.** In geographical locations where lightning disturbances are prevalent, wiring systems in Class II locations shall, when supplied from overhead supply systems, be suitably protected against high-voltage surges. This protection shall include suitable lightning protective devices, interconnection of all grounds, and surge-protective capacitors.

Suitable lightning protective devices should include primary devices, and also secondary devices where overhead secondary lines exceed 300 feet in length or where secondary is ungrounded.

Interconnection of all grounds should include grounds for primary and secondary lightning protective devices, secondary system grounds if any, and grounds of conduit and equipment of the interior wiring system. For ungrounded secondary systems, secondary lightning protective devices may be provided both at the service and at the point where the secondary system receives its supply, and the intervening secondary conductors may be accepted as the metallic connection between the secondary protective devices, provided grounds for the primary and secondary devices are metallically interconnected at the supply end of the secondary system and the secondary devices are grounded to the raceway system at the load end of the secondary system.

Surge protective capacitors should be of a type especially designed for the duty, should be connected to each ungrounded service conductor, and should be grounded to the interior conduit system. Capacitors should be protected by 30-ampere fuses of suitable type and voltage rating, or by automatic circuit-breakers of suitable type and rating and should be connected to the supply conductors on the supply side of the service disconnecting means.

**502-4. Wiring Methods.** Wiring methods shall conform to the following:

(a) **Class II, Division 1.** In Class II, Division 1 locations, threaded rigid metal conduit or Type MI cable with termination fittings approved for the location shall be the wiring method employed. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings.

(1) **Fittings and Boxes.** Fittings and boxes shall be provided with threaded bosses for connection to conduit or cable terminations, shall have close fitting covers, and shall have no openings (such as holes for attachment screws) through which dust might enter, or through which sparks or burning material might escape. Fittings and boxes in which taps, joints or terminal connections are made, or which are used in locations where dusts are of an electrically-conducting nature shall be dust-ignition-proof and approved for Class II locations.

(2) **Flexible Connections.** Where necessary to employ flexible connections, dust-tight flexible connectors, flexible metal conduit with approved fittings, or flexible cord approved for extra-hard usage and provided with bushed fittings shall be used, except that where dusts are of an

electrically-conducting nature, flexible metal conduit shall not be used, and flexible cords shall be provided with dust-tight seals at both ends. An additional conductor for grounding shall be provided in the flexible cord unless other acceptable means of grounding is provided. Where flexible connections are subject to oil or other corrosive conditions, the insulation of the conductors shall be of a type approved for the condition or shall be protected by means of a suitable sheath.

(b) **Class II, Division 2.** In Class II, Division 2 locations, rigid metal conduit, electrical metallic tubing or Type MI cable with approved termination fittings shall be the wiring method employed.

(1) **Fittings and Boxes.** Fittings and boxes in which taps, joints or terminal connections are made shall be designed to minimize the entrance of dust, and (1) shall be provided with telescoping or close fitting covers, or other effective means to prevent the escape of sparks or burning material, and (2) shall have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which adjacent combustible material might be ignited.

(2) **Flexible Connections.** Where flexible connections are necessary the provisions of Paragraph 502-4(a-2) shall apply.

**502-5. Sealing, Class II, Divisions 1 and 2.** Where a raceway provides communication between an enclosure which is required to be dust-ignition-proof and one which is not, suitable means shall be provided to prevent the entrance of dust into the dust-ignition-proof enclosure through the raceway. This means may be (1) a permanent and effective seal, (2) a horizontal section not less than 10 feet long in the raceway, or (3) a vertical section of raceway not less than 5 feet long and extending downward from the dust-ignition-proof enclosure.

**502-6. Switches, Circuit-breakers, Motor Controllers, and Fuses.** Switches, circuit-breakers, motor controllers and fuses shall conform to the following:

(a) **Class II, Division 1.** In Class II, Division 1 locations, switches, circuit-breakers, motor controllers and fuses shall conform to the following:

**(1) Type Required.** Switches, circuit-breakers, motor controllers and fuses, including push buttons, relays and similar devices, which are intended to interrupt current in the normal performance of the function for which they are installed, or which are installed where dusts of an electrically-conducting nature may be present, shall be provided with dust-ignition-proof enclosures which, together with the enclosed apparatus in each case, shall be approved as a complete assembly for Class II locations.

This will include service and branch circuit fuses, switches and circuit-breakers, motor controllers (including push buttons, pilot switches, relays, and motor overload protective devices), and switches, fuses and circuit-breakers for the control and protection of lighting and appliance circuits.

**(2) Isolating Switches.** Disconnecting and isolating switches containing no fuses and not intended to interrupt current, and which are not installed where dusts may be of an electrically conducting nature, shall be provided with tight metal enclosures which shall be designed to minimize the entrance of dust, and which shall (1) be equipped with telescoping or close fitting covers, or with other effective means to prevent the escape of sparks or burning material, and (2) have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which exterior accumulations of dust or adjacent combustible material might be ignited.

**(3) Metal Dusts.** In locations where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, fuses, switches, motor controllers and circuit-breakers shall have enclosures specifically approved for such locations.

**(b) Class II, Division 2.** In Class II, Division 2 locations, enclosures for fuses, switches, circuit-breakers and motor controllers including push buttons, relays and similar devices, shall conform to the requirements of Paragraph 502-6(a-2).

**502-7. Control Transformers and Resistors.** Transformers, solenoids, impedance coils and resistors used as or in conjunction with control equipment for motors, generators and appliances shall conform to the following:

(a) **Class II, Division 1.** In Class II, Division 1 locations, control transformers, solenoids, impedance coils and resistors, and any overcurrent devices or switching mechanisms associated with them shall have dust-ignition-proof enclosures approved for Class II locations. No control transformer, impedance coil or resistor shall be installed in a location where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present unless provided with an enclosure specifically approved for such locations.

(b) **Class II, Division 2.** In Class II, Division 2 locations, transformers and resistors shall conform to the following:

(1) **Switching Mechanisms.** Switching mechanisms (including overcurrent devices) associated with control transformers, solenoids, impedance coils and resistors, shall be provided with enclosures conforming to Paragraph 502-6(a-2).

(2) **Coils and Winding.** Where not located in the same enclosure with switching mechanisms, control transformers, solenoids and impedance coils shall be provided with tight metal housings without ventilating openings.

(3) **Resistors.** Resistors and resistance devices shall have dust-ignition-proof enclosures approved for Class II locations, except that where the maximum normal operating temperature of the resistor will not exceed 120°C. (248°F.) non-adjustable resistors and resistors which are part of an automatically timed starting sequence may have enclosures conforming to Paragraph 502-7(b-2).

**502-8. Motors and Generators.** Motors and generators shall conform to the following:

(a) **Class II, Division 1.** In Class II, Division 1 locations, motors, generators and other rotating electrical machinery shall be totally-enclosed not ventilated, totally-enclosed pipe ventilated, or totally-enclosed fan-cooled, and shall be approved as dust-ignition-proof for Class II locations. Motors, generators or other rotating electrical machinery shall not be installed in locations where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present unless such machines are totally-enclosed, or totally-enclosed fan-cooled, and specifically approved for such locations.

(b) **Class II, Division 2.** In Class II, Division 2 locations, motors, generators and other rotating electrical machinery shall be totally-enclosed not ventilated, totally-enclosed pipe ventilated, or totally-enclosed fan-cooled, except that in locations where, in the judgment of the code enforcing authority, only moderate accumulations of non-conducting, non-abrasive dust are likely to occur, and where the equipment is readily accessible for routine cleaning and maintenance self-cleaning textile motors of the squirrel-cage type, standard open type machines without sliding contacts, centrifugal or other types of switching mechanism (including motor overcurrent devices), or integral resistance devices, or standard open type machines having such contacts, switching mechanisms or resistance devices enclosed within tight metal housings without ventilating or other openings, may be installed. Motors, generators or other rotating electrical machinery of partially enclosed or splashproof type shall not be installed in such locations.

**502-9. Ventilating Piping.** Vent pipes for motors, generators or other rotating electrical machinery, or for enclosures for electrical apparatus or equipment, shall be of metal not lighter than No. 24 USS gauge, or of equally substantial noncombustible material, and shall (1) lead directly to a source of clean air outside of buildings, (2) be screened at the outer ends to prevent the entrance of small animals or birds, (3) be protected against physical damage and against rusting or other corrosive influences. In addition, vent pipes shall conform to the following:

(a) **Class II, Division 1.** In Class II, Division 1 locations, vent pipes, including their connections to motors or to the dust-ignition-proof enclosures for other equipment or apparatus, shall be dust-tight throughout their length. For metal pipes, seams and joints shall be (1) riveted (or bolted) and soldered, (2) welded, or (3) rendered dust-tight by some other equally effective means.

(b) **Class II, Division 2.** In Class II, Division 2 locations, vent pipes and their connections shall be sufficiently tight to prevent the entrance of appreciable quantities of dust into the ventilated equipment or enclosure, and to prevent the escape of sparks, flame or burning material which might ignite dust accumulations or combustible material in the vicinity. For metal pipes, lock seams and riveted or

welded joints may be used, and tight-fitting slip joints may be used where some flexibility is necessary as at connections to motors.

**502-10. Appliances, Fixed and Portable.** Appliances, fixed and portable, shall conform to the following:

(a) **Class II, Division 1.** In Class II, Division 1 locations, appliances, including electrically-heated and motor-driven appliances, shall be dust-ignition-proof approved for Class II locations. Where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, such appliances shall be specifically approved for such locations.

(b) **Class II, Division 2.** In Class II, Division 2 locations, appliances, fixed and portable, shall conform to the following:

(1) **Heaters.** Electrically-heated appliances shall be dust-ignition-proof approved for Class II locations.

(2) **Motors.** Motors of motor-driven appliances shall conform to Paragraph 502-8(b).

(3) **Switches, Circuit-breakers and Fuses.** Enclosures for switches, circuit-breakers, and fuses shall conform to Paragraph 502-6(a-2).

(4) **Transformers, Impedance Coils and Resistors.** Transformers, solenoids, impedance coils and resistors shall conform to Paragraph 502-7(b).

Where there is a possibility that a portable appliance may be used in both Division 1 or Division 2 locations of this class, such appliance should conform to the requirements for Division 1 locations.

**502-11. Lighting Fixtures.** Lamps shall be installed in fixtures which shall conform to the following:

(a) **Class II, Division 1.** In Class II, Division 1 locations, lighting fixtures for fixed and portable lighting shall conform to the following:

(1) **Approved Fixtures.** Each fixture shall be dust-ignition-proof and approved for Class II locations, and shall be clearly marked to indicate the maximum wattage of the lamp for which it is approved. In locations where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, fixtures for fixed or portable lighting, and all auxiliary equipment, shall be specifically approved for such locations.

**(2) Physical Damage.** Each fixture shall be protected against physical damage by a suitable guard or by location.

**(3) Pendent Fixtures.** Pendent fixtures shall be suspended by threaded rigid conduit stems or chains with approved fittings, or by other approved means. For rigid stems longer than 12 inches permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose and for the location shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting. Threaded joints shall be provided with set-screws or other effective means to prevent loosening. Where wiring between an outlet box or fitting and a pendent fixture is not enclosed in conduit, flexible cord approved for hard usage shall be used, and suitable seals shall be provided where the cord enters the fixture and the outlet box or fitting. Flexible cord shall not serve as the supporting means for a fixture.

**(4) Supports.** Boxes, box assemblies or fittings used for the support of lighting fixtures shall be approved for the purpose and for Class II locations.

**(b) Class II, Division 2.** In Class II, Division 2 locations, lighting fixtures shall conform to the following:

**(1) Portable Lamps.** Portable lamps shall be dust-ignition-proof and approved for Class II locations. They shall be clearly marked to indicate the maximum wattage of lamps for which they are approved.

**(2) Fixed Lighting.** Lighting fixtures for fixed lighting, when not of a type approved for Class II locations, shall provide enclosures for lamps and lampholders which shall be designed to minimize the deposit of dust on lamps and to prevent the escape of sparks, burning material or hot metal. Each fixture shall be clearly marked to indicate the maximum wattage of lamp which may be used without exceeding a maximum exposed surface temperature of 165°C. (329°F.) under normal conditions of use.

**(3) Physical Damage.** Lighting fixtures for fixed lighting shall be protected from physical damage by suitable guards or by location.

(4) **Pendent Fixtures.** Pendent fixtures shall be suspended by threaded rigid conduit stems or chains with approved fittings, or by other approved means. For rigid stems longer than 12 inches permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting. When wiring between an outlet box or fitting and a pendent fixture is not enclosed in conduit, flexible cord approved for hard usage shall be used. Flexible cord shall not serve as the supporting means for a fixture.

(5) **Supports.** Boxes, box assemblies and fittings used for the support of lighting fixtures shall be approved for that purpose.

(6) **Electric Discharge Lamps.** Starting and control equipment for mercury vapor and fluorescent lamps shall conform to the requirement of Paragraph 502-7(b).

**502-12. Flexible Cords, Class II, Divisions 1 and 2.** Flexible cords used in Class II locations shall (1) be of a type approved for extra hard usage, (2) contain, in addition to the conductors of the circuit, a grounding conductor conforming to Section 400-13, (3) be connected to terminals or to supply conductors in an approved manner, (4) be supported by clamps or by other suitable means in such a manner that there will be no tension on the terminal connections, and (5) be provided with suitable seals to prevent the entrance of dust where the flexible cord enters boxes or fittings which are required to be dust-ignition-proof.

### **502-13. Receptacles and Attachment Plugs.**

(a) **Class II, Division 1.** In Class II, Division 1 locations, receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of the flexible cord, and shall be dust-ignition-proof approved for Class II locations.

(b) **Class II, Division 2.** In Class II, Division 2 locations, receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of the flexible cord and shall be so designed that connection to the

supply circuit cannot be made or broken while live parts are exposed.

**502-14. Signal, Alarm, Remote-Control, and Local Loud-Speaker Intercommunication Systems.** Signal, alarm, remote-control and local loud-speaker intercommunication systems shall conform to the following:

Refer to Article 800 for rules governing the installation of communication circuits as defined in Article 100.

(a) **Class II, Division 1.** In Class II, Division 1 locations, signal, alarm, remote-control and local loud-speaker intercommunication systems shall conform to the following:

(1) **Wiring Method.** Where accidental damage or breakdown of insulation might cause arcs, sparks or high temperatures, rigid metal conduit, electrical metallic tubing, or Type MI cable with approved termination fittings shall be the wiring method employed. For conduit or electrical metallic tubing, the number of conductors shall be limited only by the requirement that the cross-sectional area of all conductors shall not exceed 40 per cent of the area of the raceway. Where limited flexibility is desirable or where exposure to physical damage is not severe, flexible cord approved for extra-hard usage may be used.

(2) **Contacts.** Switches, circuit-breakers, relays, contactors and fuses which may interrupt other than voice currents, and current-breaking contacts for bells, horns, howlers, sirens and other devices in which sparks or arcs may be produced, shall be provided with enclosures approved for the location, unless current-breaking contacts are immersed in oil, or unless the interruption of current occurs within a chamber sealed against the entrance of dust, in which case enclosures may be of general purpose type.

(3) **Resistors and Similar Equipment.** Resistors, transformers and choke coils which may carry other than voice currents, and rectifiers, thermionic tubes, and other heat generating equipment or apparatus shall be provided with dust-ignition-proof enclosures approved for Class II locations.

(4) **Rotating Machinery.** Motors, generators and other rotating electrical machinery shall conform to Paragraph 502-8(a).

(5) **Electrical Conducting Dusts.** Where dusts are of an electrically-conducting nature, all wiring and equipment shall be approved for Class II locations.

(6) **Metal Dusts.** Where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, all apparatus and equipment shall be specifically approved for such conditions.

(b) **Class II, Division 2.** In Class II, Division 2 locations, signal, alarm, remote-control and local loudspeaker intercommunication systems shall conform to the following:

(1) **Contacts.** Enclosures shall conform to Paragraph 502-14(a-2) or contacts shall have tight metal enclosures designed to minimize the entrance of dust, and shall have telescoping or tight fitting covers and no openings through which, after installation, sparks or burning material might escape.

(2) **Transformers and Similar Equipment.** The windings and terminal connections of transformers and choke coils shall be provided with tight metal enclosures without ventilating openings.

(3) **Resistors and Similar Equipment.** Resistors, resistance devices, thermionic tubes, and rectifiers shall conform to Paragraph 502-14(a-3) except that enclosures for thermionic tubes, non-adjustable resistors or rectifiers for which maximum operating temperature will not exceed 120°C. (248°F.) may be of general purpose type.

(4) **Rotating Machinery.** Motors, generators and other rotating electrical machinery shall conform to Paragraph 502-8(b).

**502-15. Live Parts, Class II, Divisions 1 and 2.** There shall be no exposed live parts.

**502-16. Grounding, Class II, Divisions 1 and 2.** Wiring and equipment shall be grounded in conformity with the following:

(a) **Exposed Parts.** The exposed non-current-carrying metal parts of equipment such as the frames or metal exteriors of motors, fixed or portable lamps or appliances, lighting fixtures, cabinets, cases, and conduit, shall be grounded as specified in Article 250 of this Code.

**(b) Bonding.** The locknut-bushing and double-locknut types of contact shall not be depended upon for bonding purposes, but bonding jumpers with proper fittings or other approved means shall be used. Where flexible conduit is used as permitted in Section 502-4, bonding jumpers with proper fittings shall be provided around such conduit.

**(c) Lightning Protection.** Each ungrounded service conductor of a wiring system in a Class II location, when supplied from an ungrounded overhead electrical supply system in an area where lightning disturbances are prevalent, shall be protected by a lightning protective device of proper type. Lightning protective devices shall be connected to the service conductors on the supply side of the service disconnecting means, and shall be bonded to the raceway system at the service entrance.

**(d) Grounded Service Conductor Bonded to Raceway.** Wiring in a Class II location, when supplied from a grounded alternating-current supply system in which a grounded conductor is a part of the service, shall have the grounded service conductor bonded to the raceway system and to the grounding conductor for the raceway system. The bonding connection to the grounded service conductor shall be made on the supply side of the service disconnecting means.

**(e) Transformer Ground Bonded to Raceway.** Wiring in a Class II location, where supplied from a grounded alternating-current supply system in which no grounded conductor is a part of the service, shall be provided with a metallic connection between the supply system ground and the raceway system at the service entrance. The metallic connection shall have a current-carrying capacity not less than  $1/5$  that of the service conductors, and shall in no case be smaller than No. 10 when of soft copper, or No. 12 when of medium or hard-drawn copper.

**(f) Multiple Grounds.** Where, in the application of Section 250-21, it is necessary to abandon one or more grounding connections to avoid objectionable passage of current over the grounding conductors, the connection required in Paragraph 502-16(d or e) shall not be abandoned while any other grounding connection remains connected to the supply system.

## ARTICLE 503 — CLASS III INSTALLATIONS — HAZARDOUS LOCATIONS

**503-1. General.** The general rules of this Code shall apply to the installation of electrical wiring and apparatus in locations classified as Class III under Section 500-6 except as modified by this Article.

Equipment installed in Class III locations should be able to function at full rating without developing surface temperatures high enough to cause excessive dehydration or gradual carbonization of accumulated fibers or flyings. Organic material which is carbonized or is excessively dry is highly susceptible to spontaneous ignition. In general, maximum surface temperatures under actual operating conditions should not exceed 165°C. (329°F.) for equipment which is not subject to overloading, and 120°C. (248°F.) for equipment such as motors, power transformers, etc., which may be overloaded.

**503-2. Transformers and Capacitors, Class III, Divisions 1 and 2.** Transformers and capacitors shall conform to Paragraph 502-2(b).

**503-3. Wiring Methods.** Wiring methods shall conform to the following:

(a) **Class III, Division 1.** In Class III, Division 1 locations, rigid metal conduit or Type MI cable shall be the wiring method employed.

(1) **Boxes and Fittings.** Fittings and boxes in which taps, joints or terminal connections are made shall (1) be provided with telescoping or close fitting covers, or other effective means to prevent the escape of sparks or burning material, and (2) shall have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which adjacent combustible material might be ignited.

(2) **Flexible Connections.** Where flexible connections are necessary the provisions of Paragraph 502-4(a-2) shall apply.

(b) **Class III, Division 2.** In Class III, Division 2 locations, the wiring method shall conform to Paragraph 503-3(a), except that in sections, compartments or areas used solely for storage and containing no machinery, open wiring on insulators may be employed when installed to conform to Article 320, but only on condition that protection as required

by Section 320-12 be provided where conductors are not run in roof spaces, and well out of reach of sources of physical damage.

**503-4. Switches, Circuit-Breakers, Motor Controllers and Fuses, Class III, Divisions 1 and 2.** Switches, circuit-breakers, motor controllers and fuses, including pushbuttons, relays and similar devices, shall be provided with tight metal enclosures designed to minimize entrance of fibers and flyings, and which shall (1) be equipped with telescoping or close fitting covers, or with other effective means to prevent escape of sparks or burning material, and (2) have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which exterior accumulations of fibers or flyings or adjacent combustible material might be ignited.

**503-5. Control Transformers and Resistors, Class III, Divisions 1 and 2.** Transformers, impedance coils and resistors used as or in conjunction with control equipment for motors, generators and appliances, shall conform to Paragraph 502-7(b), with the exception that, in Class III, Division 1 locations, when these devices are in the same enclosure with switching devices of such control equipment, and are used only for starting or short time duty, the enclosure shall conform to the requirements of Section 503-4.

**503-6. Motors and Generators.** Motors and Generators shall conform to the following:

(a) **Class III, Division 1.** In Class III, Division 1 locations, motors, generators, and other rotating electrical machinery shall be totally-enclosed not ventilated, totally-enclosed pipe ventilated, or totally-enclosed fan-cooled, except that in locations where, in the judgment of the Code enforcing authority, only moderate accumulations of lint and flyings will be likely to collect on, in, or in the vicinity of a rotating electrical machine, and where such machine is readily accessible for routine cleaning and maintenance, self-cleaning textile motors of the squirrel-cage type, standard open type machines without sliding contacts, centrifugal or other types of switching mechanism (including motor overload devices), or standard open type machines having such contacts, switching mechanisms or resistance devices enclosed within tight metal housings without ventilating or other openings, may be installed.

(b) **Class III, Division 2.** In Class III, Division 2 locations, motors, generators, and other rotating electrical machinery shall be totally-enclosed not ventilated, totally-enclosed pipe ventilated, or totally-enclosed fan-cooled.

(c) **Partially Enclosed Type, Class III, Divisions 1 and 2.** Motors, generators or other rotating electrical machinery of the partially enclosed or splash-proof type shall not be installed in Class III locations.

**503-7. Ventilating Piping, Class III, Divisions 1 and 2.** Vent pipes for motors, generators or other rotating electrical machinery, or for enclosures for electrical apparatus or equipment, shall be of metal not lighter than No. 24 USS gauge, or of equally substantial noncombustible material, and shall (1) lead directly to a source of clean air outside of buildings, (2) be screened at the outer ends to prevent the entrance of small animals or birds, (3) be protected against physical damage and against rusting or other corrosive influences, and (4) vent pipes and their connections shall be sufficiently tight to prevent the entrance of appreciable quantities of fibers or flyings into the ventilated equipment or enclosure, and to prevent the escape of sparks, flame or burning material which might ignite accumulations of fibers or flyings or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints may be used, and tight fitting slip joints may be used where some flexibility is necessary as at connections to motors.

**503-8. Appliances, Fixed and Portable, Class III, Divisions 1 and 2.** Appliances shall conform to the following:

(a) **Heaters.** Electrically heated appliances shall be approved for Class III locations.

(b) **Motors.** Motors of motor-driven appliances shall conform to Paragraph 503-6(b). Appliances which may be readily moved from one location to another should conform to requirements for the most hazardous location.

(c) **Switches, Circuit-Breakers, Motor Controllers and Fuses.** Switches, circuit-breakers, motor controllers and fuses shall conform to Section 503-4.

**503-9. Lighting Fixtures, Class III, Divisions 1 and 2.** Lamps shall be installed in fixtures which shall conform to the following:

(a) **Fixed Lighting.** Lighting fixtures for fixed lighting shall provide enclosures for lamps and lampholders which shall be designed to minimize entrance of fibers and flyings, and to prevent the escape of sparks, burning material or hot metal. Each fixture shall be clearly marked to indicate the maximum wattage of lamp which may be used without exceeding a maximum exposed surface temperature of 165°C. (329°F.) under normal conditions of use.

(b) **Physical Damage.** A fixture which may be exposed to physical damage shall be protected by a suitable guard.

(c) **Pendent Fixtures.** Pendent fixtures shall be suspended by stems of threaded rigid conduit or threaded metal tubing of equivalent thickness. For stems longer than 12 inches, permanent and effective bracing against lateral displacement shall be provided at a level not more than 12 inches above the lower end of the stem, or flexibility in the form of a fitting or a flexible connector approved for the purpose shall be provided not more than 12 inches from the point of attachment to the supporting box or fitting.

(d) **Supports.** Boxes, box assemblies or fittings used for the support of lighting fixtures shall be of a type approved for the purpose.

(e) **Portable Lamps.** Portable lamps shall be equipped with handles and protected with substantial guards, and lampholders shall be of unswitched type with no exposed metal parts and without provision for receiving attachment plugs. In all other respects, portable lamps shall conform to Paragraph 503-9(a).

**503-10. Flexible Cords, Class III, Divisions 1 and 2.** Flexible cords shall conform to Section 502-12.

**503-11. Receptacles and Attachment Plugs, Class III, Divisions 1 and 2.** Receptacles and attachment plugs shall conform to Paragraph 502-13(b).

**503-12. Signal, Alarm, Remote-Control and Local Loud-Speaker Intercommunication Systems, Class III, Divisions 1 and 2.** Signal, alarm, remote-control and local loudspeaker intercommunication systems shall conform to Paragraph 502-14(a).

**503-13. Electric Cranes and Hoists, and Similar Equipment, Class III, Divisions 1 and 2.** Where installed for operation over combustible fibers or accumulations of flyings, traveling

cranes and hoists for material handling, traveling cleaners for textile machinery, and similar equipment shall conform to the following:

(a) Power supply to contact conductors shall be isolated from all other systems and shall be ungrounded, and shall be equipped with an acceptable recording ground detector which will give an alarm and will automatically de-energize the contact conductors in case of a fault to ground, or with an acceptable ground fault indicator which will give a visual and audible alarm, and maintain the alarm as long as power is supplied to the system and the ground fault remains.

(b) Contact conductors shall be so located or guarded as to be inaccessible to other than authorized persons, and shall be protected against accidental contact with foreign objects.

(c) Current collectors shall be arranged or guarded to confine normal sparking and to prevent escape of sparks or hot particles. To reduce sparking, two or more separate surfaces of contact shall be provided for each contact conductor. Reliable means shall be provided to keep contact conductors and current collectors free of accumulations of lint or flyings.

(d) Control equipment shall conform to Sections 503-4 and 503-5.

It is recommended that where the distance of travel permits, current to the crane be supplied through flexible cord approved for extra hard usage and equipped with approved type of reel or takeup device.

**503-14. Electric Trucks.** Electric trucks shall conform to NFPA Standard for the Use, Maintenance and Operation of Industrial Trucks (No. 505).

**503-15. Storage-Battery Charging Equipment, Class III, Divisions 1 and 2.** Storage-battery charging equipment shall be located in separate rooms built or lined with substantial noncombustible materials so constructed as to adequately exclude flyings or lint, and shall be well ventilated.

**503-16. Live Parts, Class III, Divisions 1 and 2.** There shall be no exposed live parts except as provided in Section 503-13.

**503-17. Grounding, Class III, Divisions 1 and 2.** Wiring and equipment shall be grounded in conformity with Section 502-16.

**ARTICLE 510—HAZARDOUS LOCATIONS—SPECIFIC**

**510-1. Scope.** The provisions of Articles 511 to 517 inclusive shall apply to occupancies or parts of occupancies which are or may be hazardous because of atmospheric concentrations of hazardous gases or vapors, or because of deposits or accumulations of materials which may be readily ignitable. It is the intent to assist Code enforcing authorities in the classification of areas with respect to hazardous conditions which may or may not require construction and equipment conforming to Articles 501 to 503 inclusive, and to set forth such additional special requirements as are applicable to the specific occupancy.

**510-2. General.** The general rules of this Code shall apply to the installation of electrical wiring and equipment in occupancies within the scope of Articles 511 to 517 inclusive, except as such rules are modified in those articles. Where unusual conditions exist in a specific occupancy, the Code enforcing authority shall judge with respect to the application of specific rules.

It is recommended that the Code enforcing authority be familiar with National Fire Protection Association standards applying to occupancies included within the scope of Articles 511 to 517 inclusive.

## ARTICLE 511—COMMERCIAL GARAGES, REPAIR AND STORAGE

**511-1. Scope.** These occupancies shall include locations used for service and repair operations in connection with self-propelled vehicles (including passenger automobiles, busses, trucks, tractors, etc.) in which volatile flammable liquids or flammable gases are used for fuel or power, and locations in which more than three such vehicles are or may be stored at one time.

For further information regarding classification of garages, refer to the NFPA Standard for Garages (No. 88).

**511-2. Hazardous Areas.** Classification under Article 500.

(a) For each floor at or above grade, the entire area up to a level 18 inches above the floor shall be considered to be a Class I, Division 2 location.

(b) For each floor below grade, the entire area up to a level 18 inches above the bottom of outside doors or other openings which are at or above grade level shall be considered to be Class I, Division 2 location. Where adequate positive-pressure ventilation is provided, the authority enforcing the Code may judge that the hazardous location extends up to a level of only 18 inches above each such floor.

(c) Any pit or depression below floor level shall be considered to be a Class I, Division 2 location which shall extend up to said floor level, except that an individual unventilated pit or depression may be judged by the Code enforcing authority to be a Class I, Division 1 location.

(d) Adjacent areas in which hazardous vapors are not likely to be released such as stock rooms, switchboard rooms and other similar locations, having floors elevated at least 18 inches above adjacent garage floor, or separated therefrom by tight curbs or partitions at least 18 inches high, shall not be classed as hazardous.

**511-3. Wiring and Equipment in Hazardous Areas.** Within hazardous areas as defined in Section 511-2, wiring and equipment shall conform to applicable provisions of Article 501.

**511-4. Sealing.** Approved seals conforming to the requirements of Section 501-5 shall be provided, and Paragraph 501-5(b-2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas. Raceways embedded in a masonry floor or buried beneath a floor shall be considered to be within the hazardous area above the floor if any connections or extensions lead into or through such area.

**511-5. Wiring in Spaces Above Hazardous Areas.**

(a) All fixed wiring shall be in metallic raceways or shall be Type MI cable. Cellular metal floor raceways may be used only for supplying ceiling outlets or extensions to the area below the floor, but such raceways shall have no connections leading into or through any hazardous area above the floor. No electrical conductor shall be installed in any cell, header or duct which contains a pipe for steam, water, air, gas, drainage, or other service except electrical.

(b) For pendants, flexible cord suitable for the type of service and approved for hard usage shall be used.

(c) For connection of portable lamps, motors or other appliances, flexible cord suitable for the type of service and approved for extra hard usage shall be used.

(d) When a circuit which supplies portables or pendants includes an identified grounded conductor as provided in Article 200, receptacles, attachment plugs, connectors, and similar devices shall be of polarized type, and the identified conductor of the flexible cord shall be connected to the screw shell of any lampholder or to the identified terminal of any appliance supplied.

(e) When a pendant is used to supply a portable lamp or appliance, the female portion of a polarized pin-plug connector or equivalent shall be attached to the lower end of the pendant, and the male portion shall be attached to the cord for the portable. The connector shall be designed to break apart readily in any position, and shall be suspended at a level not less than that specified in Section 511-2. Attachment plug receptacles in fixed position shall be located above the level specified in Section 511-2.

**511-6. Equipment Above Hazardous Areas.**

(a) Equipment which is less than 12 feet above floor level, and which may produce arcs, sparks or particles of hot

metal, such as cutouts, switches, receptacles, charging panels, generators, motors, or other equipment having make and break or sliding contacts, shall be of totally-enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles.

(b) Lamps and lampholders for fixed lighting which are located over lanes through which vehicles are commonly driven or which may otherwise be exposed to physical damage, shall be located not less than 12 feet above floor level unless of totally enclosed type or provided with suitable guards, screens or covers to prevent escape of sparks or hot metal particles.

(c) Portable lamps shall be equipped with handle, lamp-holder, hook and substantial guard attached to the lamp-holder or handle. All exterior surfaces which might come in contact with battery terminals, wiring terminals, or other objects shall be of non-conducting material or shall be effectively protected with insulation. Lampholders shall be of unswitched type, and shall not provide means for plug-in of attachment plugs. Outer shell shall be of moulded composition or other material approved for the purpose, and metal-shell, lined lampholders, either of switched or unswitched type, shall not be used. Unless the lamp and its cord are supported or arranged in such a manner that they cannot be used in the hazardous areas classified in Section 511-2, they shall be of a type approved for such hazardous locations.

**511-7. Battery-Charging Equipment.** Battery chargers and their control equipment, and batteries being charged shall not be located within hazardous areas classified in Section 511-2. Tables, racks, trays, and wiring shall, in addition, conform to the provisions of Article 480.

**511-8. Electric Vehicle Charging.**

(a) Flexible cords used for charging shall be suitable for the type of service and approved for extra hard usage. Their current carrying capacity shall be adequate for the charging current.

(b) Connectors shall have a rating not less than the current carrying capacity of the cord, and in no case less than 50 amperes.

(c) Connectors shall be so designed and installed that they will break apart readily at any position of the charging

cable, and live parts shall be guarded from accidental contact. No connector shall be located within a hazardous area defined in Section 511-2.

(d) Where plugs are provided for direct connection to vehicles, the point of connection shall not be within a hazardous area as defined in Section 511-2, and where the cord is suspended from overhead, it shall be so arranged that the lowest point of sag is at least 6 inches above the floor. Where the vehicle is equipped with an approved plug which will readily pull apart, and where an automatic arrangement is provided to pull both cord and plug beyond the range of physical damage, no additional connector is required in the cable or at the outlet.

## 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 non-hazardous 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.

## ARTICLE 513—AIRCRAFT HANGARS

**513-1. Definition.** This occupancy shall include locations used for storage or servicing of aircraft in which gasoline, jet fuels, or other volatile flammable liquids, or flammable gases, are used, but shall not include such locations when used exclusively for aircraft which have never contained such liquids or gases, or which have been drained and properly purged.

**513-2. Hazardous Areas.** Classification under Article 500.

(a) Any pit or depression below the level of the hangar floor shall be considered to be a Class I, Division 1 location which shall extend up to said floor level.

(b) The entire area of the hangar including any adjacent and communicating areas not suitably cut off from the hangar shall be considered to be a Class I, Division 2 location up to a level 18 inches above the floor.

(c) The area within 5 feet horizontally from aircraft power plants, aircraft fuel tanks or aircraft structures containing fuel shall be considered to be a Class I, Division 2 hazardous location which shall extend upward from the floor to a level 5 feet above the upper surface of wings and of engine enclosures.

(d) Adjacent areas in which hazardous vapors are not likely to be released such as stock rooms, electrical control rooms, and other similar locations, should not be classed as hazardous when adequately ventilated and when effectively cut off from the hangar itself by walls or partitions.

**513-3. Wiring and Equipment in Hazardous Areas.** All fixed and portable wiring and equipment which is or may be installed or operated within any of the hazardous locations defined in Section 513-2 shall conform to applicable provisions of Article 501. All wiring installed in or under the hangar floor shall conform to the requirements for Class I, Division 1. When such wiring is located in vaults, pits, or ducts, adequate drainage shall be provided, and the wiring shall not be placed within the same compartment with any other service except piped compressed air.

**513-4. Wiring Not Within Hazardous Areas.**

(a) All fixed wiring in a hangar, but not within a hazardous area as defined in Section 513-2, shall be installed in metallic raceways or shall be Type MI cable, except that wiring in non-hazardous locations as defined in Paragraph 513-2(d) may be of any type recognized in Chapter 3 of this Code.

(b) For pendants, flexible cord suitable for the type of service and approved for hard usage shall be used. Each such cord shall include a separate grounding conductor.

(c) For portable appliances and lamps, flexible cord suitable for the type of service and approved for extra hard usage shall be used. Each such cord shall include a separate grounding conductor.

(d) Where a circuit which supplies portables or pendants includes an identified grounded conductor as provided in Article 200, receptacles, attachment plugs, connectors, and similar devices shall be of polarized type, and the identified conductor of the flexible cord shall be connected to the screw shell of any lampholder or to the identified terminal of any appliance supplied. Acceptable means shall be provided for maintaining continuity of the grounding conductor between the fixed raceway system and the non-current-carrying metallic portions of pendent fixtures, portable lamps, and portable appliances.

**513-5. Equipment not Within Hazardous Areas.**

(a) In locations other than those described in Section 513-2, equipment which is less than 10 feet above wings and engine enclosures of aircraft and which may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, charging panels, generators, motors, or other equipment having make and break or sliding contacts, shall be of totally enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles, except that equipment in areas described in Paragraph 513-2(d) may be of general purpose type.

(b) Lampholders of metal shell, fiber-lined types shall not be used for fixed incandescent lighting.

(c) Portable lamps which are or may be used within a hangar shall be approved for Class I locations.

(d) Portable appliances which are or may be used within a hangar shall be of a type suitable for use in Class I, Division 2 locations.

#### **513-6. Stanchions, Rostrums and Docks.**

(a) Electric wiring, outlets and equipment (including lamps) on or attached to stanchions, rostrums or docks which are located or likely to be located in a hazardous area as defined in Paragraph 513-2(c) shall conform to the requirements for Class I, Division 2 locations.

(b) Where stanchions, rostrums, or docks are not located or likely to be located in a hazardous area as defined in Paragraph 513-2(c), wiring and equipment shall conform to Sections 513-4 and 513-5, except that such wiring and equipment not more than 18 inches above the floor in any position shall conform to Paragraph 513-6(a). Receptacles and attachment plugs shall be of locking type which will not break apart readily.

(c) Mobile stanchions with electrical equipment conforming to Paragraph 513-6(b) shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

**513-7. Sealing.** Approved seals shall be provided in conformance with Section 501-5 and Paragraphs 501-5(a-3) and 501-5(b-2) and shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas. Raceways embedded in a masonry floor or buried beneath a floor shall be considered to be within the hazardous area above the floor when any connections or extensions lead into or through such area.

**513-8. Aircraft Electrical Systems.** Aircraft electrical systems should be de-energized when the aircraft is stored in a hangar, and, whenever possible, while the aircraft is undergoing maintenance.

#### **513-9. Aircraft Battery—Charging and Equipment.**

(a) Aircraft batteries should not be charged when installed in an aircraft located inside or partially inside a hangar.

(b) Battery chargers and their control equipment shall not be located or operated within any of the hazardous areas defined in Section 513-2, and should preferably be located in

a separate building or in an area such as described in Paragraph 513-2(d). Mobile chargers shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS." Tables, racks, trays, and wiring shall not be located within a hazardous area, and shall, in addition, conform to the provisions of Article 480.

#### **513-10. Energizing Aircraft from External Power Sources.**

(a) Aircraft energizers shall be so designed and mounted that all electrical equipment and fixed wiring will be at least 18 inches above floor level and shall not be operated in a hazardous area as defined in Paragraph 513-2(c).

(b) Mobile energizers shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

(c) Aircraft energizers should be equipped with polarized external power plugs and should have automatic controls to isolate the ground power unit electrically from the aircraft in case excessive voltage is generated by the ground power unit.

#### **513-11. Mobile Servicing Equipment with Electrical Components.**

(a) Mobile servicing equipment (such as vacuum cleaners, air compressors, air movers, etc.) having electrical wiring and equipment not suitable for Class I, Division 2 locations shall be so designed and mounted that all such fixed wiring and equipment will be at least 18 inches above the floor. Such mobile equipment shall not be operated within the hazardous areas defined in Paragraph 513-2(c) and shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

(b) Flexible cords for mobile equipment shall be suitable for the type of service and approved for extra hard usage, and shall include a grounding conductor. Attachment plugs and receptacles shall be approved for the location in which they are installed, and shall provide for connection of the grounding conductor to the raceway system.

(c) Equipment not of a type suitable for Class I, Division 2 locations should not be operated in areas where mainte-

nance operations likely to release hazardous vapors are in progress.

**513-12. Grounding.** All metallic raceways, and all non-current-carrying metallic portions of fixed or portable equipment, regardless of voltage, shall be grounded as provided in Article 250.

## ARTICLE 514 — GASOLINE DISPENSING AND SERVICE STATIONS

**514-1. Definitions.** This classification shall include locations where gasoline or other volatile flammable liquids or liquefied flammable gases are transferred to the fuel tanks (including auxiliary fuel tanks) of self-propelled vehicles. Dispensing islands are areas elevated above surrounding surfaces and on which are mounted dispensing pumps or other dispensing devices. Where an individual pump or dispensing device is not mounted on an elevated island, an area extending 18 inches in all directions from the base of the pump or device shall be considered to be a dispensing island.

Other areas used as lubritoriums, service rooms and repair rooms, and offices, salesrooms, compressor rooms and similar locations shall conform to Article 511 with respect to electrical wiring and equipment.

### **514-2. Hazardous Areas.**

(a) The area of a dispensing island shall be considered to be a Class I, Division 1 location which shall extend upward to a level 4 feet above adjacent driveway level, and which shall include any space within or under the island which may contain electrical wiring or equipment.

(b) In an outside location, any area (including buildings not suitably cut off) within 20 feet horizontally from any dispensing island or pump, or from any tank fill-pipe or tank vent-pipe, shall be considered to be a Class I, Division 2 location which shall extend upward to a level 18 inches above driveway or ground level. Electrical wiring and equipment, any portion of which is below the surface of such areas, shall be considered to be within a Class I, Division 1 location which shall extend at least to the point of emergence.

**514-3. Wiring and Equipment Within Hazardous Areas.** All electrical equipment and wiring within the hazardous areas defined in Section 514-2 shall conform to applicable provisions of Article 501.

For special requirements for conductor insulation, see Section 501-13.

**514-4. Wiring and Equipment not Within Hazardous Areas.** Wiring and equipment not within hazardous areas defined in Section 514-2 shall conform to Sections 511-5 and 511-6.

**514-5. Circuit Disconnects.** Each circuit leading to or through a dispensing pump or island shall be provided with a switch or other acceptable means to disconnect simultaneously from the source of supply all conductors of the circuit including the grounded neutral, if any.

**514-6. Sealing.**

(a) An approved seal shall be provided in each conduit run entering or leaving a dispensing pump or other enclosure on a dispensing island. There shall be no union, coupling, box or fitting in the conduit between the sealing fitting and the point at which the conduit emerges into the pump or other equipment, or into any cavities or enclosures in direct communication therewith.

This paragraph states that the first fitting after the conduit emerges from the slab or from the concrete of the island must be the sealing fitting. Above the fitting, the remainder of the wiring and equipment up to the four foot level is required to conform to the rules for Class I, Division 1 locations.

(b) Additional seals shall be provided in conformance with Section 501-5 and Paragraphs 501-5(a-3) and 501-5(b-2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas.

**514-7. Grounding.** Metallic portions of dispensing pumps, metallic raceways, and all non-current-carrying portions of electrical equipment, regardless of voltage, shall be grounded as provided in Article 250.

## ARTICLE 515 — BULK-STORAGE PLANTS

**515-1. Definition.** This designation shall include locations where gasoline or other volatile flammable liquids are stored in tanks having an aggregate capacity of one carload or more, and from which such products are distributed (usually by tank truck).

### **515-2. Hazardous Areas.**

(a) Rooms containing pumps for volatile flammable liquids or in which are located valves in pipe lines handling such liquids under pressure shall be considered to be Class I, Division 1 locations.

(b) Rooms in which volatile flammable liquids are transferred to individual containers shall be considered to be Class I, Division 1 locations.

(c) In outdoor locations, areas adjacent to loading racks or platforms, or to aboveground tanks shall be considered to be Class I, Division 2 locations. Such areas shall be considered to extend 25 feet horizontally from such racks or tanks, and upward from adjacent ground level to a height of 15 feet, unless the Code enforcing authority judges otherwise.

(d) Basements, pits or depressions which are within 25 feet of aboveground tanks, within 25 feet and below the level of the top of underground tanks, or within 25 feet of any loading rack or platform shall be considered to be Class I, Division 2 locations, unless the Code enforcing authority judges otherwise.

(e) Storage and repair garages for tank trucks shall be considered to be Class I, Division 2 locations without limitation with respect to height above floor level.

(f) Office buildings, boiler rooms and other similar locations which are outside the limits of hazardous areas as defined herein, and which are not used for handling or storage of volatile flammable liquids or containers for such liquids, shall not be considered to be hazardous locations.

**515-3. Wiring and Equipment Within Hazardous Areas.** All electrical wiring and equipment within the hazardous

areas defined in Section 515-2 shall conform to applicable provisions of Article 501.

**515-4. Wiring and Equipment Above Hazardous Areas.** All fixed wiring above hazardous areas shall be in metallic raceways. Fixed equipment which may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, motors, or other equipment having make and break or sliding contacts, shall be of totally enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles. Portable lamps or appliances, and their flexible cords shall conform to the provisions of Article 501 for the class of location above which they are connected or used.

**515-5. Underground Wiring.**

(a) Underground wiring shall be installed in rigid metal conduit, or, where buried under not less than 2 feet of earth, may be installed in non-metallic conduit or duct or in the form of cable approved for the purpose. Where cable is used, it shall be enclosed in rigid metal conduit from the point of lowest buried cable level to the point of connection to the aboveground raceway.

(b) Conductor insulation shall conform to Section 501-13 of Article 501.

(c) Where cable with non-metallic sheath or non-metallic conduit is used, an additional grounding conductor shall be included to provide for metallic continuity of the raceway system and for grounding of non-current-carrying metallic parts of equipment.

**515-6. Sealing.** Approved seals shall be provided in conformance with Section 501-5 and Paragraphs 501-5(a-3) and 501-5(b-2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas. Buried raceways under defined hazardous areas shall be considered to be within such areas.

**515-7. Gasoline Dispensing.** Where gasoline dispensing is carried on in conjunction with bulk station operations, applicable provisions of Article 514 shall apply.

**515-8. Grounding.** All metallic raceways, and all non-current-carrying metallic portions of electrical equipment shall be grounded as provided in Article 250.

## ARTICLE 516—FINISHING PROCESSES

**516-1. Definition.** This Article shall apply to locations where paints, lacquers or other flammable finishes are regularly or frequently applied by spraying, dipping, brushing or by other means, and where volatile flammable solvents or thinners are used or where readily ignitable deposits or residues from such paints, lacquers or finishes may occur.

For further information regarding safeguards for finishing processes, see the NFPA Standard for Spray Finishing Using Flammable Materials (No. 33) and the NFPA Standard for Dip Tanks Containing Flammable or Combustible Liquids (No. 34).

**516-2. Hazardous Areas.** Classification with respect to flammable vapors. For deposits and residues, see Section 516-3.

(a) The interiors of spray booths and their exhaust ducts, all space within 20 feet horizontally in any direction from spraying operations more extensive than touch-up spraying and not conducted within spray booths, all space within 20 feet horizontally in any direction from dip tanks and their drain boards, and all other spaces where hazardous concentrations of flammable vapors are likely to occur, shall be considered to be Class I, Division 1 locations.

(b) All space within 20 feet horizontally in any direction from the open face of a spray booth, and all space within the room but beyond the limits for Class I, Division 1 as defined in Paragraph 516-2(a) for extensive open spraying, for dip tanks and drain boards and for other hazardous operations, shall be considered to be Class I, Division 2 locations unless the Code enforcing authority judges otherwise.

(c) Adjacent areas which are cut off from the defined hazardous areas by tight partitions without communicating openings, and within which hazardous vapors are not likely to be released, shall be classed as non-hazardous unless the Code enforcing authority judges otherwise.

(d) Drying and baking areas provided with positive mechanical ventilation adequate to prevent formation of flammable concentrations of vapors, and provided with effective interlocks to deenergize all electrical equipment (other than

equipment approved for Class I locations) in case the ventilating equipment is inoperative, may be classed as non-hazardous when the Code-enforcing authority so judges.

### **516-3. Wiring and Equipment in Hazardous Areas.**

(a) All electrical wiring and equipment within the hazardous areas defined in Section 516-2 shall conform to applicable provisions of Article 501.

(b) Unless specifically approved for the location, no electrical equipment shall be installed or used where it may be subject to hazardous accumulations of readily ignitable deposits or residues, except that wiring in rigid conduit or in threaded boxes or fittings containing no taps, splices or terminal connections may be installed in such locations.

(c) Illumination of readily ignitable areas through panels of glass or other transparent or translucent material is permissible only where: (a) fixed lighting units are used as the source of illumination, (b) the panel effectively isolates the hazardous area from the area in which the lighting unit is located, (c) the lighting unit is approved for its specific location, (d) the panel is of a material or is so protected that breakage will be unlikely and (e) the arrangement is such that normal accumulations of hazardous residue on the surface of the panel will not be raised to a dangerous temperature by radiation or conduction from the source of illumination.

(d) Portable electric lamps or appliances shall not be used within a hazardous area during operation of the finishing process. When such lamps or appliances are used during cleaning or repairing operations, they shall be of a type approved for Class I locations, and all exposed metal parts shall be effectively grounded.

(e) Electrostatic spraying or detearing equipment shall be installed and used only as provided in Section 516-4.

**516-4. Electrostatic Equipment.** Where electrostatic spraying and detearing equipment is installed, such equipment shall be of approved type, and shall conform to the following requirements.

(a) No transformers, power packs, control apparatus, or other electrical portion of the equipment (except high voltage grids and their connections) shall be installed in any of the hazardous areas defined in Section 516-2 unless of a type approved for the location.

(b) High voltage grids or electrodes shall be located in suitable noncombustible booths or enclosures provided with adequate mechanical ventilation, shall be rigidly supported and of substantial construction, and shall be effectively insulated from ground by means of non-porous noncombustible insulators.

(c) High voltage leads shall be effectively and permanently supported on suitable insulators, shall be effectively guarded against accidental contact or grounding, and shall be provided with automatic means for discharging any residual charge to ground when the supply voltage is interrupted.

(d) Goods being processed shall be supported on conveyors in such a manner that minimum clearance between goods and high voltage grids or conductors cannot be less than twice the sparking distance. A conspicuous sign indicating the sparking distance shall be permanently posted near the equipment.

(e) Approved automatic controls which will operate without time delay to disconnect the power supply and to signal the operator in case of (a) stoppage of ventilating fans or failure of ventilating equipment from any cause, (b) stoppage of the conveyor carrying goods through the high voltage field, (c) occurrence of a ground or of an imminent ground at any point on the high voltage system, or (d) reduction of clearance below that specified in Paragraph 516-4(d).

(f) Adequate fencing, railings or guards which are electrically conducting and effectively grounded shall be provided for safe isolation of the process, and signs shall be permanently posted designating the process zone as dangerous because of high voltage.

#### **516-5. Wiring and Equipment Above Hazardous Areas.**

(a) All fixed wiring above hazardous areas shall be in metallic raceways or shall be Type MI cable. Cellular metal floor raceways may be used only for supplying ceiling outlets or extensions to the area below the floor of a hazardous area, but such raceways shall have no connections leading into or through the hazardous area above the floor unless suitable seals are provided. No electrical conductor shall be installed in any cell, header or duct which contains a pipe for steam, water, air, gas, drainage, or for other service except electrical.

(b) Equipment which may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, motors, or other equipment having make and break or sliding contacts, where installed above a hazardous area or above an area where freshly finished goods are handled, shall be of totally-enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles.

**516-6. Grounding.** All metallic raceways, and all non-current-carrying metallic portions of fixed or portable equipment, regardless of voltage, shall be grounded as provided in Article 250.

## ARTICLE 517 — FLAMMABLE ANESTHETICS

### 517-1. Definitions.

(a) Flammable anesthetics are gases or vapors such as cyclopropane, divinyl ether, ethyl chloride, ethyl ether, and ethylene, which may form flammable or explosive mixtures with air, oxygen, or nitrous oxide.

(b) For the purpose of this Article, anesthetizing locations are areas in hospitals in which flammable anesthetics are or may be administered to patients. Such locations will include operating rooms, delivery rooms and anesthesia rooms, and will also include any corridors, utility rooms or other areas which are or may be used for administering flammable anesthetics to patients. Recovery rooms are not classed as anesthetizing locations unless used for administering flammable anesthetics.

For further information regarding safeguards for hospital operating rooms, see the NFPA Code for the Use of Flammable Anesthetics (No. 56).

### 517-2. Hazardous Areas.

(a) Any room or space in which flammable anesthetics or volatile flammable disinfecting agents are stored shall be considered to be a Class I, Division 1 location throughout.

(b) In an anesthetizing location as defined in Section 517-1, the entire area shall be considered to be a Class I, Division 1 location which shall extend upward to a level 5 feet above the floor.

### 517-3. Wiring and Equipment Within Hazardous Areas.

(a) In hazardous areas as defined in Section 517-2, all fixed wiring and equipment, and all portable equipment, including lamps and appliances, operating at more than 8 volts between conductors, shall conform to the requirements of Sections 501-1 to 501-15 inclusive and of Paragraphs 501-16(a and b) for Class I, Division 1 locations, and all such equipment shall be specifically approved for the hazardous atmospheres involved.

(b) Where a masonry wall or floor constitutes a boundary of a hazardous area, any portion of a raceway embedded in such masonry shall be considered to be within the bound-

ary itself, but any portion of a raceway located in a hollow space in such wall or floor shall be considered to be within the hazardous area.

(c) Where a box, fitting or enclosure is partially but not entirely within a hazardous area, the hazardous area shall be considered to be extended to include the entire box fitting or enclosure.

(d) Flexible cords which are or may be used in hazardous areas for connection to portable equipment, appliances or lamps operating at more than 8 volts between conductors shall be of a type approved for extra hard usage, shall be of ample length, and shall include an additional insulated conductor for grounding. Receptacles and attachment plugs shall be of the type with provision for connection of the grounding conductor, and where located within a hazardous area, shall be approved for Class I locations. A storage device for the flexible cord shall be provided, and shall not subject the cord to bending at a radius of less than 3 inches.

#### **517-4. Wiring and Equipment Above Hazardous Areas.**

(a) Wiring above a hazardous area as defined in Paragraph 517-2(b) shall be installed in metal raceways or shall be Type MI cable.

(b) Equipment which may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting less than 8 feet above the floor, cutouts, switches, receptacles, generators, motors, or other equipment having make and break or sliding contacts, shall be of totally-enclosed type or shall be provided with suitable guards or screens to prevent escape of sparks or hot metal particles.

(c) Ceiling suspended surgical and other lighting fixtures shall conform to Paragraph 501-9(b), except that surface temperature limitations set forth in Paragraph 501-9(b-2) shall not apply, and except that integral or pendent switches which are located above and cannot be lowered into the hazardous area need not be explosion-proof.

**517-5. Sealing.** Approved seals shall be provided in conformance with Section 501-5, and 501-5(a-3) shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas.

#### **517-6. Circuits in Anesthetizing Locations.**

(a) Except as provided in Paragraph 517-6(e), each circuit within or partially within an anesthetizing location as

defined in Paragraph 517-1(b) shall be controlled by a switch having a disconnecting pole in each circuit conductor, and shall be supplied from an ungrounded distribution system which shall be isolated from any distribution system supplying areas other than anesthetizing locations. Such isolation may be obtained by means of one or more transformers having no electrical connection between primary and secondary windings, by means of motor generator sets, or by means of suitably isolated batteries.

(b) Circuits supplying primaries of isolating transformers shall operate at not more than 300 volts between conductors, and shall be provided with proper overcurrent protection. Secondary voltage of such transformers shall not exceed 300 volts between conductors, and all circuits supplied from such secondaries shall be ungrounded and shall have an approved overcurrent device of proper rating in each conductor. Circuits supplied from batteries or from generators or motor-generator sets shall be ungrounded, and shall be protected against overcurrent in the same manner as transformer secondary circuits.

(c) Transformers, motor-generator sets, batteries and battery chargers, together with their overcurrent devices shall be installed in non-hazardous locations, and shall conform to the requirements of this Code for such locations.

(d) In addition to the usual control and protective devices, the ungrounded system shall be provided with an approved ground contact indicator so arranged that a green signal lamp conspicuously visible to persons in the anesthetizing location remains lighted while the system is isolated from ground. An adjacent red signal lamp and an audible warning signal shall be energized when any conductor of the system becomes grounded through a resistance or a capacitive reactance of any value up to at least 60,000 ohms. The current through the ground indicator to the ground shall not exceed 2 milliamperes. The indicator and associated signals shall not be installed within a hazardous area.

The proper functioning of the indicator should be tested at intervals of not more than one week by grounding successively each conductor of the energized distribution system through a suitable meter or resistor. Such tests should be made only while the location is not being used and when entirely free from combustible gases or vapors. A permanent record should be kept of the results of such tests.

(e) In an anesthetizing location, lighting fixtures for fixed lighting (except ceiling suspended or ceiling mounted surgical fixtures) or permanently installed X-ray transformers and associated equipment, may be supplied from a grounded distribution system provided (1) wiring for grounded and ungrounded circuits does not occupy the same raceways, (2) the lighting fixtures and the X-ray equipment (except the enclosed X-ray tube and the metal-enclosed high voltage leads to the tube) be located at least 8 feet above the floor, and (3) switches for the grounded circuits be located outside of the anesthetizing location except that remote control stations for remote control switches may be in the anesthetizing location where the remote control circuit is energized from the ungrounded distribution system.

#### 517-7. Low Voltage Equipment and Instruments.

(a) Electrical apparatus and equipment used within a hazardous area, and which has exposed current-carrying elements or which is frequently in contact with the bodies of persons, shall be designed to operate at 8 volts or less unless it is entirely surrounded by a metallic casing or sheath. Power supply shall be ungrounded, and shall be electrically isolated from all circuits of higher voltage.

(b) Where a low voltage unit receives current from an individual transformer located within a hazardous area, the flexible cord shall conform to Paragraph 517-3(d), the core and case of the transformer shall be effectively grounded, and the transformer shall be approved for Class I locations.

(c) Where low voltage units within a hazardous area are supplied with current from a common source, such as a transformer, motor-generator set, or storage battery, such common source shall be installed in a non-hazardous location. Where located or used within a hazardous area, receptacles and attachment plugs shall be approved for Class I locations. Plugs shall be so designed that they cannot be inserted into receptacles for higher voltage. Flexible cords shall be of adequate length and current-carrying capacity, and shall be approved for extra hard usage. An extra conductor for grounding is not required.

(d) Low voltage equipment and wiring (including flexible cords) shall be protected from dangerous overcurrents by suitable overcurrent devices or by inherent current limiting characteristics of the source of supply. Overcurrent devices shall not be installed in a hazardous area.

(e) Resistance or impedance devices may be used to control low voltage units but shall not be used to limit maximum input voltage. Where a low voltage unit includes a switch or other make and break or sliding contact, or where it includes a resistor or resistance device which may under any operating condition reach a surface temperature exceeding eighty per cent (80%) of the lowest ignition temperature in degrees Centigrade (as determined by A.S.T.M. test procedure — Designation D286-30) of the gases or vapors that may be present, the unit shall be of a type approved for Class I locations.

#### **517-8. Other Equipment.**

(a) Suction, pressure, or insufflation equipment involving electrical elements, and located or used within a hazardous area shall be approved for Class I locations.

(b) X-ray equipment installed or operated in an anesthetizing location as defined in Paragraph 517-1(b) shall be provided with approved means for preventing accumulation of electrostatic charges. All control devices, switches, relays, meters, and transformers shall be totally enclosed, and where installed or operated within a hazardous area, shall be approved for Class I locations. High voltage wiring shall be effectively insulated from ground and adequately guarded against accidental contact.

(c) Equipment for generating high frequency currents or voltages used in electrocautery, diathermy, television, etc., where installed or used in an anesthetizing location, shall conform to Sections 517-3 and 517-4.

**517-9. Grounding.** In any hazardous area, all metallic raceways, and all non-current-carrying metallic portions of fixed or portable equipment (except equipment operating at not more than 8 volts between conductors) shall be grounded as provided in Paragraphs 501-16(a and b).

## ARTICLE 520—THEATERS AND ASSEMBLY HALLS

### A. General

**520-1. Scope.** The requirements of this Article shall apply to all buildings, or part of a building, designed, intended, or used for dramatic, operatic, motion-picture or other shows, and night clubs, dance halls, armories, sporting arenas, bowling alleys, public auditoriums, television studios and like buildings used for public assembly.

**520-2. Motion-Picture Projectors.** Motion-picture equipment and its installation and use shall comply with Article 540.

**520-3. Sound Reproduction.** Sound-reproducing equipment and its installation shall comply with Article 640.

**520-4. Wiring Method.** The wiring method shall be metal raceways or Type MI cable except as follows:

*Exception No. 1. As provided in Articles 640, Sound Reproduction, and 800, Communication Circuits.*

*Exception No. 2. Where the auditorium has a capacity of less than 200 persons, armored cable as provided in Article 334 may be used, or for concealed work, concealed knob-and-tube work or non-metallic sheathed cable as provided in Articles 324 and 326 may also be used.*

For recommendations for determination of population capacity, refer to NFPA Building Exits Code (No. 101).

*Exception No. 3. Portable cables may be used only where fixed wiring methods are impracticable.*

**520-5. Number of Conductors in Raceway.** The number of conductors permitted in any metal conduit or electrical metallic tubing for border or stage pocket circuits or for remote control conductors shall not exceed that shown in Table 1 of Chapter 9. In the case of auxiliary gutters or wireways, the sum of the cross-sectional areas of all contained conductors at any cross-section shall not exceed 40 per cent of the interior cross-sectional area of the gutter or wireway.

**520-6. Enclosing and Guarding Live Parts.** Live parts shall be enclosed or guarded to prevent accidental contact by persons and objects. All switches shall be of the externally operable type. Rheostats shall be placed in approved cases or cabinets which enclose all live parts, having only the operating handles exposed.

### **B. Fixed Stage Switchboard**

**520-21. Dead Front.** Stage switchboards shall be of the dead-front type.

**520-22. Guarding Back of Switchboard.** Stage switchboards having exposed live parts on the back of such boards shall be enclosed by the building walls, wire mesh grills, or by other approved methods. The entrance to this enclosure shall be by means of a self-closing door.

**520-23. Control and Overcurrent Protection of Receptacle Circuits.** Means shall be provided at the stage switchboard for the control and individual overcurrent protection of branch circuits to stage and gallery receptacles used for portable stage equipment.

**520-24. Metal Hood.** A stage switchboard that is not completely enclosed dead-front and dead-rear or recessed into a wall shall be provided with a metal hood extending the full length of the board to protect all equipment on the board from falling objects.

**520-25. Dimmers.** Dimmers shall conform to the following:

(a) **Disconnection and Overcurrent Protection.** Where dimmers are installed in ungrounded conductors, each dimmer shall have overcurrent protection not greater than 125 per cent of the dimmer rating, and shall be disconnected from all ungrounded conductors when the master or individual switch or circuit-breaker supplying such dimmer is in the open position.

(b) **Resistance or Reactor Type Dimmers.** Resistance or series reactor type dimmers may be placed in either the grounded or the ungrounded conductor of the circuit. Where designed to open either the supply circuit to the dimmer or the circuit controlled by it, the dimmer shall then comply with Section 380-1.

It is recommended that resistance or reactor type dimmers be placed in the grounded neutral conductor of the circuit provided they do not open the circuit.

(c) **Auto-Transformer Type Dimmers.** The circuit supplying an auto-transformer type dimmer shall not exceed 150 volts between conductors. The grounded conductor shall be common to the input and output circuits. See Section 200-4.

### C. Stage Equipment — Fixed

**520-41. Circuit Loads.** Footlights, border lights, and proscenium side lights shall be so arranged that no branch circuit supplying such equipment will carry a load exceeding 20 amperes; provided that where heavy-duty lampholders only are used, such circuits may conform to the provisions of Article 210 for circuits supplying heavy-duty lampholders.

**520-42. Conductor Insulation.** Foot, border, proscenium, or portable strip light fixtures shall be wired with conductors having insulation suitable for the temperatures at which the conductors will be operated and not less than 125°C (257°F). See Table 310-2(a).

#### **520-43. Footlights.**

(a) Where metal trough construction is employed for footlights, the trough containing the circuit conductors shall be made of sheet metal not lighter than No. 20 USS gauge (.0359 inch in thickness) treated to prevent oxidation. Lampholder terminals shall be kept at least 1/2 inch from the metal of the trough. The circuit conductors shall be soldered to the lampholder terminals.

(b) Where the metal trough construction specified in Paragraph 520-43(a) is not used, footlights shall consist of individual outlets with lampholders, wired with rigid or flexible metal conduit or Type MI cable. The circuit conductors shall be soldered to the lampholder terminals. Disappearing footlights shall be so arranged that the current supply shall be automatically disconnected when the footlights are replaced in the recess designed therefor.

#### **520-44. Borders and Proscenium Sidelights.**

(a) Borders and proscenium sidelights shall be constructed as prescribed in Section 520-43, shall be suitably stayed and supported, and shall be so designed that the flanges of the reflectors or other adequate guards will pro-

tect the lamps from mechanical injury and from accidental contact with scenery or other combustible material.

(b) **Cables for Border Lights.** Cables for supply to border lights shall be types K, S, SO, or ST flexible cord. See Table 400-11. The cables shall be suitably supported. Such cables shall be employed only where flexible conductors are necessary.

**520-45. Receptacles.** Receptacles intended for the supply of arc lamps shall have not less than 35 amperes capacity and shall be supplied by conductors not smaller than No. 6. Receptacles intended for the supply of incandescent lamps shall have not less than 15 amperes capacity and shall be supplied by conductors not smaller than No. 12. Plugs for arc and incandescent receptacles shall not be interchangeable.

**520-46. Stage Pockets.** Receptacles intended for the connection of portable stage lighting equipment shall be mounted in suitable pockets or enclosures, and shall comply with the requirements of Section 520-45.

**520-47. Lamps in Scene Docks.** Lamps installed in scene docks shall be so located and guarded as to be free from mechanical injury and provide an air space of not less than 2 inches between such lamps and any combustible material.

**520-48. Curtain Motors.** Curtain motors having brushes or sliding contacts shall comply with one of the following conditions:

(a) Be of the totally-enclosed, enclosed-fan-cooled, or enclosed-pipe-ventilated types.

(b) Be enclosed in separate rooms or housings built of non-combustible materials so constructed as to exclude flyings or lint, and properly ventilated from a source of clean air.

(c) Have brush or sliding-contact end of motor enclosed by solid metal covers.

(d) Have brushes or sliding contacts enclosed in substantial, tight, metal housings.

(e) Have the upper half of brush or sliding-contact end of the motor enclosed by a wire screen or perforated metal and the lower half enclosed by solid metal covers.

(f) Have wire screens or perforated metal placed at the commutator or brush ends. No dimension of any opening

in the wire screen or perforated metal shall exceed .05 inch, regardless of the shape of the opening and of the material used.

**520-49. Flue-Damper Control.** Where stage flue dampers are released by an electrical device, the circuit operating the latter shall be normally closed and shall be controlled by at least two externally-operable switches, one switch being placed at the electrician's station and the other where designated by the inspection authority. The device shall be designed for the full voltage of the circuit to which it is connected, no resistance being inserted. The device shall be located in the loft above the scenery and shall be enclosed in a suitable iron box having a tight, self-closing door.

### **D. Portable Switchboards on Stage**

**520-51. Supply.** Portable switchboards shall be supplied only from outlets especially provided for this purpose. Such outlets shall include externally operable, enclosed fused switches or circuit-breakers mounted on the stage wall or at the switchboard in locations readily accessible from the stage floor.

**520-52. Overcurrent Protection.** Circuits from portable switchboards directly supplying equipment containing incandescent lamps of not over 300 watts shall be protected by overcurrent devices having a rating or setting of not more than 20 amperes. Circuits for lampholders over 300 watts may be used where overcurrent protection conforms to the provisions of Article 210. Other circuits shall be provided with overcurrent devices with a rating or setting not higher than the current required for the connected load.

**520-53. Construction.** Portable switchboards for use on stages shall comply with the following:

(a) **Enclosure.** Portable switchboards shall be placed within an enclosure of substantial construction which may be so arranged that the enclosure is open during operation. Enclosures of wood shall be completely lined with sheet metal of not less than No. 24 USS gauge (.0239 inch), and shall be well galvanized, enamelled, or otherwise properly coated to prevent corrosion or be of a corrosion-resistant material.

(b) **Live Parts.** Except as provided for dimmer face plates in Paragraph 520-53(e), there shall be no exposed live parts within the enclosure.

(c) **Switches and Circuit-Breakers.** All switches and circuit-breakers shall be of the externally-operable, enclosed type.

(d) **Circuit Protection.** Overcurrent devices shall be provided in each ungrounded conductor of every circuit supplied through the switchboard. Enclosures shall be provided for all overcurrent devices in addition to the switchboard enclosure.

(e) **Dimmers.** The terminals of dimmers shall be provided with enclosures, and dimmer face plates shall be so arranged that accidental contact cannot be readily made with the face-plate contacts.

(f) **Interior Conductors.** All conductors within the switchboard enclosure shall be stranded and, except for cables feeding to or from the switchboard, shall be asbestos-covered type AA or other types approved for a maximum operating temperature of 200°C (392°F). Each conductor shall have a current-carrying capacity at least equal to the rating of the circuit-breaker, switch or fuse which it supplies, except for conductors for incandescent lamp circuits having overcurrent protection not exceeding 20 amperes. Conductors shall be enclosed in metal troughs or securely fastened in position and shall be bushed where they pass through metal.

(g) **Pilot Light.** A pilot light shall be provided within the enclosure and shall be so connected to the circuit supplying the board that the opening of the master switch will not cut off the supply to the lamp. This lamp shall be on an independent circuit having overcurrent protection of a rating or setting of not more than 15 amperes.

(h) **Supply Connections.** The supply to a portable switchboard shall be by means of flexible cord (types K, S, SO or ST) terminating within the switchboard enclosure or in an externally-operable fused master switch or circuit-breaker. The supply cable shall have sufficient current-carrying capacity to carry the total load on the switchboard and shall be protected by overcurrent devices.

(i) **Cable Arrangement.** Cables shall be protected by bushings where they pass through enclosures and shall be

so arranged that tension on the cable will not be transmitted to the connections.

(j) **Terminals.** Terminals to which stage cables are connected shall be so located as to permit convenient access to the terminals. At terminals not provided with approved pressure connectors the following construction shall be employed:

(1) For conductors of No. 10 or larger, solder lugs shall be used.

(2) For conductors smaller than No. 10, the strands shall be soldered together where connected to clamps or binding screws not specifically approved as pressure connectors.

### **E. Stage Equipment — Portable**

**520-61. Arc Lamps.** Arc lamps shall comply with the following:

(a) **Installation.** Arc-lamp frames and standards shall be so installed and guarded as to prevent their becoming grounded.

(b) **General Construction.** Portable arc lamps shall be substantially constructed entirely of metal not less than No. 20 USS gauge (.0359 inch), except where approved insulating material is necessary.

(c) **Design.** The design shall be such as to provide proper ventilation while retaining sparks, and to prevent carbons or other live parts of lamp from making contact with metal of hood.

(d) **Hoods.** Hoods for other than lens lamps shall have the front opening equipped with a self-closing hinged door frame carrying either wire gauze or glass. Hoods for lens lamps may have a stationary front, and a solid door on either back or side.

(e) **Insulation.** Mica shall be used for the insulation of the lamp frame.

(f) **Switch.** The switch on the standard shall be of such design that accidental contact with any live part will be impossible.

(g) **Rheostats.** Rheostats shall be enclosed in a substantial, properly ventilated metal case affording a clearance of at least 1 inch between case and resistance element.

Where the rheostat is mounted on the standard, a clearance of 3 inches above the floor shall be maintained. Abestos-covered type AA conductors shall be used between the rheostat and the lamp.

(h) **Terminals.** Stranded conductors shall be connected to lamp, rheostat and switch terminals by means of approved lugs or connectors; but only approved pressure connectors shall be used at arc lamp terminals.

**520-62. Portable Plugging Boxes.** Portable plugging boxes shall conform to the following:

(a) **Enclosure.** The construction shall be such that no current-carrying part will be exposed.

(b) **Receptacles and Overcurrent Protection.** Each receptacle shall have a rating of not less than 30 amperes, and shall have overcurrent protection which shall be installed in an enclosure equipped with self-closing doors.

(c) **Busbars and Terminals.** Busbars shall have a current-carrying capacity equal to the sum of the ampere ratings of all the receptacles. Lugs shall be provided for the connection of the master cable.

**520-63. Lights on Scenery.**

(a) Brackets on scenery shall be wired internally and the fixture stem shall be carried through to the back of the scenery where a bushing shall be placed on the end of the stem, except that externally wired brackets or other fixtures may be used when wired with Type P or other cords designed for hard usage which shall extend through scenery and without joint or splice in canopy of fixture back and terminate in an approved type stage connector located within 18 inches of the fixture.

(b) Fixtures shall be securely fastened in place.

**520-64. Portable Strips.** Portable strips shall be constructed in accordance with the requirements for border lights and proscenium side lights in Paragraph 520-44(a). The supply cable shall be protected by bushings where it passes through metal and shall be so arranged that tension on the cable will not be transmitted to the connections. See Section 520-42 for wiring of portable strips.

**520-65. Festoons.** Joints in festoon wiring shall be staggered where practicable. Lamps enclosed in lanterns or

similar devices of combustible material shall be equipped with approved guards.

**520-66. Special Effects.** Electrical devices used for simulating lightning, waterfalls, and the like, shall be so constructed and located that flames, sparks, or hot particles cannot come in contact with combustible material.

**520-67. Cable Connectors.** Cable connectors for flexible conductors shall be so constructed that tension on the cord or cable will not be transmitted to the connections. See Section 400-9. The female half of the connector shall be attached to the line end of the cord or cable.

**520-68. Conductors for Portables.** Flexible conductors used to supply portable stage equipment shall be Types K, S, SO or ST, except that reinforced cord may be used to supply stand lamps where the cord is not liable to severe physical damage and is protected by an overcurrent protection rated at not over 20 amperes.

## **F. Dressing Rooms**

**520-71. Pendent Lampholders.** Pendent lampholders shall not be installed in dressing rooms.

**520-72. Lamp Guards.** All incandescent lamps in dressing rooms, where less than 8 feet from the floor, shall be equipped with open-end guards riveted to the outlet box cover or otherwise sealed or locked in place.

**520-73. Switches Required.** All lights and receptacles in dressing rooms shall be controlled by wall switches installed in the dressing rooms. Each switch controlling receptacles shall be provided with a pilot light to indicate when the receptacle or receptacles are energized.

## **G. Grounding**

**520-81. Grounding.** All metal raceways shall be grounded. The metal frames and enclosures of equipment including border lights shall be grounded, except the frames and enclosures of portable equipment on grounded circuits operating at not over 150 volts to ground. Grounding, when employed, shall be done in the manner specified in Article 250.

## ARTICLE 530 — MOTION PICTURE STUDIOS AND SIMILAR LOCATIONS

### A. General

**530-1. Scope.** The requirements of this Article shall apply to motion picture studios, exchange, factory, laboratory, stage, or a portion of the building in which motion picture films more than  $\frac{7}{8}$  inch in width are manufactured, exposed, developed, printed, cut, edited, rewound, repaired or stored.

For recommendations for protection against cellulose nitrate film hazards refer to NFPA Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film (No. 40).

### B. Stage or Set

**530-11. Permanent Wiring.** The permanent wiring shall be in approved metal raceways or Type MI cable.

*Exception. Communication circuits, and sound recording and reproducing equipment may be wired as permitted by the articles covering those installations. (See Articles 640 and 800.)*

**530-12. Portable Wiring.** The wiring for stage set lighting and stage effects, and other wiring which is not fixed as to location, shall be done with approved portable cables and approved flexible cords. This requirement shall not apply to portable lamps or other electrical equipment used as properties in a motion picture set, on a studio stage or lot, or on location.

**530-13. Stage Lighting and Effects Control.** Switches used for studio stage set lighting and effects (on the stages and lots and on location) shall be of the externally operable type. When contactors are used as the disconnecting means for fuses, an individual externally operable type switch (such as a tumbler switch) for the control of each contactor, shall be located at a distance of not more than six feet from the contactor, in addition to remote control switches.

*Exception. A single externally operable switch may be used to simultaneously disconnect all the contactors on any one location board, where located at a distance of not more than 6 feet from the location board.*

**530-14. Plugging Boxes.** Each receptacle of plugging boxes shall have a current-carrying capacity of not less than 30 amperes.

**530-15. Enclosing and Guarding Live Parts.**

(a) Live parts shall be enclosed or guarded to prevent accidental contact by persons and objects.

(b) All switches shall be of the externally operable type.

(c) Rheostats shall be placed in approved cases or cabinets which enclose all live parts, having only the operating handles exposed.

(d) Current-carrying parts of "bull-switches," "location boards," "spiders," and plugging boxes shall be so enclosed, guarded, or located that persons cannot accidentally come into contact with them or bring conducting materials into contact with them.

**530-16. Portable Lamps.** Portable lamps and work lights shall be equipped with approved portable cords, approved composition or metal-sheathed porcelain sockets and substantial guards.

*Exception: The requirements of this Section shall not apply to portable lamps used as properties in a motion picture set, on a studio stage or lot, or on location.*

**530-17. Portable Arc Lamps.** Portable arc lamps shall be substantially constructed. The arc shall be provided with an enclosure designed to retain sparks and carbons and to prevent persons or materials from coming into contact with the arc or bare live parts. The enclosures shall be ventilated. All switches shall be of the externally operable type.

**530-18. Overcurrent Protection — Short Time Rating.\***

(a) **General.** Automatic overcurrent protective devices (circuit breakers or fuses) for feeders, and subfeeders for moving-picture studio stage set lighting and the stage cables for such stage set lighting, shall be rated or set to operate at not more than 400 per cent of the values given in Table 310-12 and Table 400-9.

\*Special consideration is given to motion picture studios because filming periods are of only a few minutes duration and are rarely longer than 10 minutes.

(b) **Feeders.** The feeders from the substations to the stages shall be protected by means of overcurrent devices

having suitable current-carrying capacity (generally located in the substation). The overcurrent devices may be double-pole, or two single-pole devices may be used. There need be no pole or overcurrent coil in the neutral conductor. The overcurrent device setting for each feeder shall not exceed 400 per cent of the carrying capacity of the feeder, as given in Table 310-12 for the kind of insulation used.

(c) "Location Boards." Overcurrent protection (fuses or circuit breakers) shall be provided at the "location boards." The fuses in the "location boards" shall be not larger in rating than 400 per cent of the carrying capacity of the cables between the "location boards" and the plugging boxes.

(d) **Plugging Boxes.** Where plugging boxes are not provided with overcurrent protective devices, each cable or cord smaller than No. 8 supplied through a plugging box shall be attached to the plugging box by means of a plug containing two cartridge fuses or a circuit breaker. The rating of the fuses or the setting of the circuit breaker shall be not more than 400 per cent of the safe carrying capacity of the cables or cords as given in Tables 310-12, 310-13 and 400-8 for the kind of insulation used.

(e) **Lighting.** Work-lights, stand-lamps, and fixtures shall be connected to plugging boxes by means of plugs containing two cartridge fuses not larger than 20 amperes, or they may be connected to special outlets on circuits protected by fuses or circuit-breaker settings of not more than 20 amperes. Plug fuses shall not be used unless they are on the load side of the fuse or circuit-breakers on the "location boards."

**530-19. Grounding.** Conduit, armored cable or metal raceways, and all noncurrent-carrying metal parts of appliances, devices and equipment shall be grounded as prescribed in Article 250. This shall not apply to pendent and portable lamps, nor to stage lighting and stage sound equipment, nor to other portable or semiportable special stage equipment, operating at not more than 150 volts to ground.

### C. Dressing Rooms

**530-31. Dressing Rooms.** Fixed wiring in dressing rooms shall be installed in accordance with wiring methods covered in Chapter 3. Wiring for portable dressing rooms shall be of an approved type.

### **D. Viewing, Cutting and Patching Tables**

**530-41. Lamps at Tables.** Only approved composition or metal-sheathed porcelain keyless lampholders, equipped with suitable means to guard lamps from physical damage and from film and film scrap, shall be used at patching, viewing and cutting tables.

### **E. Film Storage Vaults**

**530-51. Lamps in Film Storage Vaults.** Lamps in film storage vaults shall be rigid fixtures of the glass enclosed and gasketed type. Lamps shall be controlled by a switch having a pole in each ungrounded conductor. This switch shall be located outside of the vault and provided with a pilot light to indicate whether the switch is on or off. This switch shall disconnect from all sources of supply all ungrounded conductors terminating in any outlet in the vault.

**530-52. Motors and Other Electrical Equipment in Film Storage Vaults.** No electric motors, heaters, portable lights, or other portable electric equipment shall be located in the film storage vaults.

### **F. Substations**

**530-61. Substations.** Wiring and equipment above 600 volts shall conform to Article 710.

**530-62. Low-Voltage Switchboards.** On 600 volts or less switchboards shall conform to Article 384.

**530-63. Overcurrent Protection of DC Generators.** Three-wire DC generators shall have protection consisting of overcurrent devices having current ratings or settings in accordance with the generator rating. The overcurrent protective devices may be single-pole or two-pole and need not have a pole or over-current coil in the neutral lead (whether it is grounded or ungrounded).

**530-64. Working Space and Guarding.** Working space and guarding in permanent fixed substations shall conform to Sections 110-15 and 110-16. For guarding of live parts on motors and generators, see Section 430-11 and 430-14. Switchboards for voltage of not more than 250 volts DC between conductors when located in substations or switchboard rooms accessible to qualified persons only need not be dead-front.

**530-65. Portable Substations.** Wiring and equipment in portable substations shall conform to the sections applying to installations in permanent fixed substations, but, due to the limited space available, the working spaces may be reduced, provided that the equipment shall be so arranged that the operator may do his work safely, and so that other persons in the vicinity cannot accidentally come into contact with current-carrying parts or bring conducting objects into contact with them while they are energized.

**530-66. Grounding at Substations.** Noncurrent-carrying metal parts shall be grounded except the frames of DC circuit breakers installed on switchboards.

## ARTICLE 540 — MOTION PICTURE PROJECTORS

### A. General

**540-1. Scope.** This Article applies to motion picture projectors and associated equipment of the Professional and Non-Professional Types.

### B. Equipment and Projectors of the Professional Type

**540-10. Professional Projector — Definition.** The professional projector employs a 35-millimeter film which is  $1\frac{3}{8}$  inch wide and has on each edge 5.4 perforations per inch.

**540-11. Enclosure.** The professional type of projector, such as is commonly used in theatres and motion picture houses, shall be located in an approved enclosure. Such enclosure shall not be considered as a hazardous location as defined in Article 500.

**540-12. Motor-Driven Projectors.** Motor-driven projectors shall be approved for the purpose as an assembly or shall comply with all of the following conditions:

- (a) An approved projector shall be used.
- (b) An approved projector lamp shall be used.
- (c) Motors shall be so designed or guarded as to prevent ignition of film by sparks or arcs.
- (d) Projectors shall be in charge of a qualified operator.

**540-13. Branch Circuit Conductors.** Conductors supplying outlets for projectors of the professional type shall not be smaller than No. 8 and shall be of sufficient size for the projector employed.

**540-14. Conductors on Lamps and Hot Equipment.** Asbestos covered conductors type AA or other types of insulated conductors having a maximum operating temperature of 200°C (392°F) shall be used on all lamps or other equipment where the ambient temperature at the conductors as installed will exceed 50°C (122°F).

**540-15. Flexible Cords.** Cords approved for hard service in Table 400-11 shall be used on portable equipment.

**540-16. Lamp Guards.** Incandescent lamps in projection rooms or booths shall be provided with an approved lamp guard unless otherwise protected by noncombustible shades or other enclosures.

**540-17. Location of Equipment.** Motor-generator sets, transformers, rectifiers, rheostats, and similar equipment, for the supply or control of current to arc lamps on projectors shall, if practicable, be located in separate rooms. Where placed in the projector room, they shall be so located or guarded that arcs or sparks cannot come in contact with film, and motor-generator sets shall have the commutator end or ends protected as provided in Section 520-48.

**540-18. Construction and Ventilation.** It is recommended that the authority having jurisdiction over the construction and ventilation of rooms for professional type projectors refer to the NFPA Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film (NFPA No. 40).

**540-19. Equipment Prohibited.** Switches, overcurrent devices, or other equipment not normally required or used for projectors, sound reproduction, flood, or other special effect lamps or other equipment shall not be installed in such booths or rooms.

*Exception. Remote-control switches for the control of auditorium lights or a switch for the motor operating the curtain at the motion-picture screen.*

**540-20. Approval.** Projectors and enclosures for arc or incandescent lamps, rectifiers, transformers, rheostats, and similar equipment, shall be of an approved type.

**540-21. Marking.** Projectors and other equipment as set forth in Section 540-20 shall be marked with the name or trademark of the maker and with the voltage and current for which they are designed.

**540-22. Rewinding, Examination and Storage of Extra Films.** It is recommended that the authority having jurisdiction refer to the NFPA Standard for the Storage and

## Handling of Cellulose Nitrate Motion Picture Film (NFPA No. 40).

See Article 530, Sections 530-51 and 530-52. Also see 530-41 for viewing tables.

### C. Non-Professional Type Projectors

**540-30. Definition.** The non-professional projector employs film other than that used on professional type projectors.

**540-31. Booth Not Required.** Projectors of the non-professional or miniature type, when employing only approved slow-burning (cellulose acetate or equivalent) film, may be operated without a booth.

**540-32. Approval.** Projectors, lamp enclosures, and current-controlling devices and similar devices shall be approved as component parts of the projector equipment.

**540-33. Source of Illumination.** The source of illumination shall be a lamp of a type approved for stereopticon use or for motion-picture projection.

**540-34. Marking.** Projectors shall be marked with name or trademark of the maker, with the current and voltage for which they are designed, and for projectors of this type using the standard 35-millimeter film, with the wording "For use with slow-burning films only."

**540-35. Non-Professional Film Marking.** The slow-burning (cellulose acetate or equivalent) film shall have a permanent distinctive marker for its entire length identifying the manufacturer and the slow-burning character of the film stock.

### D. Sound Recording and Reproduction

**540-50. Sound Recording and Reproduction.** Sound recording and reproduction equipment shall comply with Article 640.

## Chapter 6. Special Equipment

### ARTICLE 600 — ELECTRIC SIGNS AND OUTLINE LIGHTING

#### A. General

**600-1. Scope.** The provisions of this Article shall apply to the installation of conductors and equipment for electric signs and outline lighting as defined in Article 100.

**600-2. Disconnect Required.** Each outline lighting installation, and each sign of other than the portable type, shall be controlled by an externally-operable switch or breaker which will open all ungrounded conductors and shall be suitable for conditions of installation, such as exposure to the weather.

(a) **In Sight of Sign.** The switch or breaker required by Section 600-2 shall be within sight of the sign or outline lighting which it controls or may be located elsewhere when capable of being locked in the open position.

(b) **Control Switch Rating.** Switches, flashers, and similar devices controlling transformers shall be either of a type approved for the purpose, or have a current rating not less than twice the current rating of the transformers. 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 switch. See Section 380-14.

#### **600-5. Grounding.**

(a) Signs, troughs, tube terminal boxes and other metal frames shall be grounded in the manner specified in Article 250 of this Code, unless they are insulated from ground and from other conducting surfaces and are inaccessible to unauthorized persons.

(b) Isolated non-current-carrying metal parts of outline lighting may be bonded by No. 14 conductors and grounded in accordance with Article 250.

(c) Signs of the portable incandescent or fluorescent-lamp type in which the open circuit voltage does not exceed 150 volts to ground are not required to be grounded.

**600-6. Load of Branch Circuit.** Circuits shall be so arranged that the number of outlets, lamps, and transformers connected to them, shall in no case place more than 15 amperes on a branch circuit.

**600-7. Marking.**

(a) Signs shall be marked with the maker's name, and for incandescent-lamp signs with the number of lampholders, and for electric discharge signs with input amperes at full load and input voltage. The marking of the sign shall be visible for inspection after installation.

(b) Transformers shall be marked with the maker's name, and transformers for electric discharge signs shall be marked with the input rating in amperes or volt-amperes, the input voltage and the open-circuit high-tension voltage.

**600-8. Enclosures.** Enclosures for signs and outline lighting shall conform to the following:

(a) **Conductors and Terminals.** Conductors and terminals in sign boxes, cabinets, and outline troughs shall be enclosed, except the supply leads.

(b) **Cutouts, Flashers, Etc.** Cutouts, flashers, and similar devices shall be enclosed in metal boxes the doors of which shall be arranged so that they can be opened without removing obstructions or finished parts of the enclosure.

(c) **Strength.** Enclosures shall have ample strength and rigidity.

(d) **Material.** Except for portable signs of the indoor type, signs and outline lighting shall be constructed of metal or other noncombustible material. Wood may be used for external decoration if placed not less than 2 inches from the nearest lampholder or current-carrying part.

(e) **Minimum Thickness — Enclosure Metal.** Sheet copper shall be at least 20 ounce (0.028 inch). Sheet steel may be of No. 28 USS gauge (.0149 inch) except that for outline lighting and for electric discharge signs sheet steel shall be of No. 24 USS gauge (.0239 inch), unless ribbed, corrugated or embossed over its entire surface, when it may be of No. 26 USS gauge (.0179 inch).

(f) **Protection of Metal.** All steel parts of enclosures shall be galvanized or otherwise protected from corrosion.

(g) **Enclosures Exposed to the Weather.** Enclosures for outside use shall be weatherproof and shall have an ample number of drain holes, each not larger than  $\frac{1}{2}$  inch or smaller than  $\frac{1}{4}$  inch. Wiring connections shall not be made through the bottoms of enclosures exposed to the weather unless the enclosures are of the raintight type.

## **B. Signs and Outline Lighting — 600 Volts or Less**

**600-21. Installation of Conductors.** Conductors shall be installed as follows:

(a) **Wiring Method.** Conductors shall be installed as open conductors on insulators, in rigid metal conduit, flexible metal conduit, electrical metallic tubing, armored cable, metal troughing or Type MI cable.

(b) **Insulation and Size.** Conductors shall be of a type approved for general use and, except in portable signs and for short leads permanently attached to lampholders or ballasts, shall be not smaller than No. 14.

(c) **Exposed to the Weather.** Conductors in raceways, armored cable or enclosures exposed to the weather, shall be of the lead-covered type or other type specially approved for the conditions, except where rigid conduit, electrical metallic tubing or enclosures are made raintight and arranged to drain.

(d) **Number of Conductors in Raceway.** Number of conductors in raceway for sign flashers may be in accordance with Table 1 of Chapter 9.

(e) **Open Conductors.** Open conductors on insulators shall comply with the provisions of Sections 300-2 to 300-22 inclusive, and, if outdoors, Article 730, except that the separation between conductors need be only 2 inches.

*Exception: Open conductors may be supported by lampholders located not more than 1 foot apart.*

(f) **Conductors Soldered to Terminals.** Where the conductors are fastened to lampholders other than of the pin type, they shall be soldered to the terminals and the exposed parts of conductors and terminals shall be treated to prevent corrosion. Where the conductors are fastened to pin-type lampholders which protect the terminals from the entrance of water, and which have been found acceptable for sign use, the conductors shall be of the stranded type but need not be soldered to the terminals.

**600-22. Lampholders.** Lampholders shall be of the unswitched type having bodies of suitable insulating material and shall be so constructed and installed as to prevent turning. Miniature lampholders shall not be employed for outdoor signs and outline lighting.

### **C. Signs and Outline Lighting — Exceeding 600 Volts**

**600-31. Installation of Conductors.** Conductors shall be installed as follows:

(a) **Wiring Method.** Conductors shall be installed as open work, as concealed conductors on insulators, in rigid or flexible metal conduit, or in electrical metallic tubing.

(b) **Insulation and Size.** Conductors shall be of a type approved for the purpose and for the voltage of the circuit, and shall be not smaller than No. 14.

(c) **Bends in Conductors.** Sharp bends in the conductors shall be avoided.

(d) **Open Conductors—Indoors.** Open conductors indoors shall be mounted on noncombustible, nonabsorptive insulators. Insulators of porcelain shall be glazed on all exposed surfaces. A separation of at least  $1\frac{1}{2}$  inches shall be maintained between conductors and between conductors and other objects. Conductors shall not be located where subject to physical damage.

(e) **Concealed Conductors on Insulators — Indoors.** Concealed conductors on insulators shall be separated from each other and from all objects other than the insulators on which they are mounted by a spacing of not less than  $1\frac{1}{2}$  inches for voltages above 10,000 volts, and not less than 1 inch for voltages of 10,000 or less. They shall be installed in channels lined with noncombustible material and used for no other purpose, except that the primary circuit conductors may be in the same channel. The insulators shall be of noncombustible, nonabsorptive material.

(f) **Conductors in Raceways.** Where the conductors are covered with lead or other metal sheathing, the covering shall extend beyond the end of the raceway, and the surface of the cable shall not be injured where the covering terminates.

(1) In damp or wet locations, the insulation on all conductors shall extend beyond the metal covering or raceway

at least 4 inches for voltages over 10,000, 3 inches for voltages over 5,000 but not exceeding 10,000, and 2 inches for voltages of 5,000 or less.

(2) In dry locations the insulation shall extend beyond the end of the metal covering or raceways not less than  $2\frac{1}{2}$  inches for voltages over 10,000, 2 inches for voltages over 5,000 but not exceeding 10,000, and  $1\frac{1}{2}$  inches for voltages of 5,000 or less.

(3) For conductors at grounded midpoint terminals, no spacing is required.

(4) Not more than 20 feet of cable from a single transformer shall be run in metal raceway where the potential between the cable and the raceway is more than 5,000 volts.

**(g) Open Conductors — Outdoors.** Open conductors outdoors shall be mounted on noncombustible, nonabsorptive insulators. Insulators of porcelain shall be glazed on all exposed surfaces. A separation of at least two inches shall be maintained between conductors, and between conductors and other objects.

Where subject to physical damage, or where within reach from ground, roof, or window, conductors shall be enclosed in raceways or suitably guarded. Where guarded, a spacing of not less than  $1\frac{1}{2}$  inches shall be maintained between conductors and the enclosure unless the enclosure is nonconducting and noncombustible.

**(h) Show-Windows and Similar Locations.** Conductors that hang freely in the air, away from combustible material, and where not subject to physical damage, as in some show-window displays, need not be otherwise protected.

**(i)** Conductors may be run from the ends of tubing to the grounded midpoint of transformers specifically designed for the purpose and provided with terminals at the midpoint. Where such connections are made to the transformer grounded midpoint, the connections between the high-voltage terminals of the transformer and the line ends of the tubing shall be as short as possible.

**600-32. Transformers.** Transformers shall comply with the following:

**(a) Voltage.** The transformer secondary open-circuit voltage shall not exceed 15,000 volts with an allowance on test of 1000 volts additional. In end-grounded transformers

the secondary, open-circuit voltage shall not exceed 7,500 volts with an allowance on test of 500 volts additional.

(b) **Type.** Transformers shall be of a type approved for the purpose and shall be limited in rating to a maximum of 4,500 volt-amperes.

Open core-and-coil type transformers shall be limited to 5,000 volts with an allowance on test of 500 volts, and to indoor applications in small portable signs.

Transformers for outline lighting installations shall have secondary current ratings not in excess of 30 milliamperes except where they and all wiring connected to them are installed in accordance with the provisions of Article 410 for electric discharge lighting of the same voltage.

(c) **Exposed to Weather.** Transformers used outdoors shall be of the weatherproof type or shall be protected from the weather by enclosure in the sign body or in a separate metal box.

(d) **Transformer Secondary Connections.** The high-voltage windings of transformers shall not be connected in parallel; and shall not be connected in series, except that two transformers each having one end of its high-voltage winding connected to the metal enclosure may have their high-voltage windings connected in series to form the equivalent of a midpoint grounded transformer. The grounded ends shall be connected by insulated conductors not smaller than No. 14.

(e) **Accessibility.** Transformers shall be accessible.

**600-33. Electric Discharge Tubing.** Electric discharge tubing shall conform to the following:

(a) **Design.** The tubing shall be of such length and design as not to cause a continuous over-voltage on the transformer.

(b) **Support.** Tubing shall be adequately supported on noncombustible, nonabsorptive supports. Tubing supports should, where practicable, be adjustable.

(c) **Contact with Flammable Material and Other Surfaces.** The tubing shall be free from contact with flammable material and shall be located where not normally exposed to physical damage. Where operating in excess of 7,500 volts, the tubing shall be supported on noncombustible, non-absorptive, insulating supports which maintain a spacing

of not less than  $\frac{1}{4}$  inch between the tubing and the nearest surface.

**600-34. Terminals and Electrode Receptacles for Electric Discharge Tubing.** Terminals and electrode receptacles for electric discharge tubing shall comply with the following:

(a) **Terminals.** Terminals of the tubing shall be inaccessible to unqualified persons and isolated from combustible material and grounded metal or shall be enclosed. Where enclosed they shall be separated from grounded metal and combustible material by noncombustible, nonabsorptive, insulating material approved for the purpose or by  $1\frac{1}{2}$  inches of air. Terminals shall be relieved from stress by the independent support of the tubing.

(b) **Tube Connections Other Than With Receptacles.** Where tubes do not terminate in receptacles designed for the purpose, all live parts of tube terminals and conductors shall be so supported as to maintain a separation of at least  $1\frac{1}{2}$  inches between conductors or between conductors and any grounded metal.

(c) **Receptacles.** Electrode receptacles for the tubing shall be of noncombustible, nonabsorptive insulating material approved for the purpose.

(d) **Bushings.** Where electrodes enter the enclosure of outdoor signs or of an indoor sign operating at a voltage in excess of 7,500 volts, bushings shall be used unless receptacles are provided or the sign is wired with bare wire mounted on approved supports which maintain the tubing in proper position. Bushings shall be of noncombustible, nonabsorptive material. Where bare wiring is used, the conductor shall be not less than No. 14 solid copper, shall be supported so as to prevent sagging and lessening of the spacing required elsewhere in this Article, and electrode terminal assemblies shall be of an approved type and supported not more than 6 inches from the electrode terminals.

(e) **Show-Windows.** In the exposed type of show-window signs, terminals shall be (1) enclosed by receptacles approved for the purpose or (2) where hanging in air, free from grounded surfaces, enclosed in sleeves of vulcanized fiber, phenolic composition, or other suitable material which overlaps all live parts by at least  $\frac{1}{2}$  inch.

**(f) Receptacles and Bushing Seals.** A flexible, non-conducting seal may be used to close the opening between the tubing and the receptacle or bushing against the entrance of dust or moisture. This seal shall not be in contact with grounded conductive material and shall not be depended upon for the insulation of the tubing.

**(g) Enclosures of Metal.** Enclosures of metal for electrodes shall be of not less than No. 24 USS gauge (.0239 inch) sheet metal.

**(h) Enclosures of Insulating Material.** Enclosures of insulating material shall be noncombustible, nonabsorptive and approved for the voltage of the circuit.

**600-35. Switches on Doors.** Doors or covers giving access to uninsulated parts of indoor signs or outline lighting exceeding 600 volts and accessible to the general public, shall either be provided with interlock switches which on the opening of the doors or covers disconnect the primary circuit, or shall be so fastened that the use of other than ordinary tools will be necessary to open them.

## ARTICLE 610 — CRANES AND HOISTS

### A. Scope and Use

**610-1. Scope.** The provisions of this Article shall apply to the installation of cranes, crane runways, hoists, and mono-rails.

For definitions of various kinds of cranes and hoists see American Standard Safety Code for Cranes, Derricks, and Hoists, ASA B30.2—1943.

### 610-2. Particular Locations.

(a) **Ignitable Material Hazards.** Installations in hazardous locations shall comply with the provisions of Section 503-13.

(b) **Combustible Materials.** Where a crane operates over readily combustible material, the resistors shall be placed in a well-ventilated cabinet composed of noncombustible material so constructed that it will not emit flames or molten metal.

*Exception: Resistors may be located in a cage or cab constructed of noncombustible material which encloses the sides of the cage or cab from the floor to a point at least 6 inches above the top of the resistors.*

### B. Wiring

**610-11. Wiring Method.** Conductors shall be enclosed in raceways or be Type MI cable.

*Exception No. 1. Bare Conductors.* Bare conductors used as contact conductors.

*Exception No. 2. Open Conductors.* Short lengths of open conductors at resistors, collectors, and other equipment.

*Exception No. 3. Flexible Connections.* Where flexible connections are necessary to motors and similar equipment, flexible metal conduit, armored cable, multiple conductor rubber-covered cable or an approved non-metallic enclosure may be employed.

*Exception No. 4. Pendent Push-Button Stations.* Where multiple conductor cable is used with a suspended push-button station, the station must be supported in some satisfactory manner that will protect the electrical conductors against strain.

**610-12. Raceway Terminal Fittings.** Conductors leaving raceways shall comply with the provisions of Section 300-16.

**610-13. Types of Conductors.** Conductors shall be of the rubber-covered or the thermoplastic type except:

*Exception No. 1. Contact Conductors.* Contact conductors along runways, crane bridges and monorails may be bare and may be of hard drawn copper, or aluminum, or steel in the form of tees, angles, tee rails, or other stiff shapes.

*Exception No. 2. Flexible Conductors.* Flexible conductors may be used to convey current and where practicable, cable reels or take-up devices may be employed.

*Exception No. 3. Varnished Cambric Conductors.* Varnished-cambric conductors (Type V) or asbestos varnished cambric (Types AVA and AVB) may be used in dry locations.

*Exception No. 4. Type MI Cable.* Type MI cable may be used in wet or dry locations within its specified temperature ratings.

*Exception No. 5. Exposed to High Temperatures.* Conductors exposed to external heat or connected to resistors shall have an insulation approved for the temperature and location as specified in Section 310-2. Where conductors not having a flame-resistant outer covering are grouped together, the group shall be covered with a flame-resistant tape.

**610-14. Conductors**

(a) **Current-Carrying Capacity.** The allowable current-carrying capacity of conductors shall be as shown in Table 610-14(a). For the carrying capacity of conductors between controllers and resistors, see Section 430-23.

(b) **Minimum.** Conductors shall not be smaller than No. 14.

*Exception: No. 16 may be used for crane and hoist motor and control circuits only when the application meets Section 610-14(a) current carrying capacity, and provided the conductors are protected against physical damage.*

**Table 610-14(a)**  
**Current-Carrying Capacity in Amperes of Insulated Conductors in Raceway or Cable**  
**Used with Short Time Rated Crane and Hoist Motors**

Max. Oper- ating Temp.	60° C		75° C		90° C		110° C	
	Type R, RW, T, TW		Type RH, RHW		Type TA, AVB RHH, SA		Type AVA	
	60 min	30 min	60 min	30 min	60 min	30 min.	60 min	30 min
16	10	10	10	12	31	32	38	40
14	20	20	25	26	36	40	45	50
12	25	25	30	33	49	52	60	65
10	35	35	40	43	63	69	73	80
8	45	50	55	60				
6	57	70	76	86	83	94	93	105
5	65	80	85	95	95	106	109	121
4	77	95	100	117	111	130	126	147
3	90	115	120	141	131	153	145	168
2	107	130	137	160	148	173	163	190
1	130	150	143	175	158	192	177	215
0	160	180	190	233	211	259	239	294
00	195	225	222	267	245	294	275	331
000	245	280	280	341	305	372	339	413
0000	295	350	300	369	319	399	352	440
250	350	375	364	420	400	461	447	516
300	410	475	455	582	497	636	554	707
350	460	550	486	646	542	716	616	809
400	515	580	538	688	593	760	666	856
450	565	640	600	765	660	836	740	930
500	620	700	660	847	726	914	815	1004

Other insulations shown in Section 310-2 and approved for the temperatures and location may be substituted for those shown in Table 610-14(a). The allowable current-carrying capacity of conductors used with 15-minute motors shall be the 30-minute ratings increased by 12 per cent.

**(c) Contact Conductors.** The size of contact wires shall be not less than the following:

<u>Distance between end strain insulators</u>	<u>Size of wire</u>
0-30 feet	No. 6
31-60 feet	No. 4
over 60 feet	No. 2

**610-15. Common Return.** Where a crane or hoist is operated by more than one motor, a common-return conductor of proper current-carrying capacity may be used.

### **C. Contact Conductors**

**610-21. Installation of Contact Conductors.** Bare contact conductors shall conform to the following:

**(a) Contact Wires.** Wires that are used as contact conductors shall be secured at the ends by means of approved strain insulators and shall be so mounted on approved insulators that the extreme limit of displacement of the wire will not bring the latter within less than  $1\frac{1}{2}$  inches from the surface wired over.

**(b) Supports Along Runways.** Main contact conductors carried along runways shall be supported on insulating supports placed at intervals not exceeding 20 feet, and these supports shall be insulating except for grounded rail conductors as provided in Paragraph 610-21(e). Such conductors shall be separated not less than 6 inches except for monorail hoists where a spacing of not less than 3 inches may be used. Where necessary, intervals between insulating supports may be increased up to 40 feet, the separation between conductors being increased proportionately.

**(c) Supports on Bridges.** Bridge contact conductors shall be kept at least  $2\frac{1}{2}$  inches apart and, where the span exceeds 80 feet, insulating saddles shall be placed at intervals not exceeding 50 feet.

It is recommended that the distance between wires be greater than  $2\frac{1}{2}$  inches where practicable.

**(d) Supports for Rigid Conductors.** Conductors along runways and crane bridges, which are of the rigid type

specified in Section 610-13 Exception No. 1, shall be carried on insulating supports spaced at intervals of not more than 80 times the vertical dimension of the conductor, but in no case greater than 15 feet, and spaced apart sufficiently to give a clear electrical separation of conductors or adjacent collectors of not less than 1 inch.

**(e) Track as Circuit Conductor.** Monorail, tramrail or crane-runway tracks may be used as a conductor of current for one phase of a three-phase alternating-current system furnishing power to the carrier, crane or trolley, provided all of the following conditions are fulfilled:

(1) The conductors for supplying the other two phases of the power supply shall be insulated.

(2) The power for all phases shall be obtained from an insulating transformer.

(3) The voltage shall not exceed 300 volts.

(4) The rail serving as a conductor shall be effectively grounded at the transformer and may also be grounded by the fittings used for the suspension or attachment of the rail to a building or structure.

**(f) Electrical Continuity of Contact Conductors.** All sections of bare rigid contact conductors shall be mechanically joined to provide a continuous electrical connection.

**(g) Not to Supply Other Equipment.** Contact conductors shall not be used as feeders for any equipment other than the crane or cranes which they are primarily designed to serve.

**(h) Isolating or Guarding Contact Conductors.** Except in locations to which only qualified persons are admitted, contact conductors shall be so isolated by elevation or be provided with suitable guards so arranged that persons cannot inadvertently touch the current-carrying parts while in contact with the ground or with conducting material connected to the ground.

**610-22. Collectors.** Collectors shall be so designed as to reduce to a minimum sparking between them and the contact conductor, and when operated in rooms used for the storage of easily ignitable combustible fibers and materials the requirements of Section 503-13 shall be complied with.

### D. Control

**610-31. Runway Conductor Disconnecting Means.** A disconnecting means shall be provided between the runway contact conductors and the power supply. Such disconnecting means shall consist of a motor-circuit switch or circuit-breaker, except that a general-use switch may be used when the disconnecting means is provided in accordance with Section 610-32. This disconnecting means shall be readily accessible and operable from the ground, shall be arranged to be locked in the open position, shall open all ungrounded conductors simultaneously, and shall be placed within sight of the crane or hoist and the runway contact conductors.

**610-32. Disconnecting Means for Crane.** Where a crane is operated from a cage or cab, a motor-circuit switch or circuit-breaker shall be provided in the leads from the runway contact conductors. The switch or circuit-breaker shall be in the cage or cab or mounted on the bridge and operable from the cage or cab when the trolley is at one end of the bridge.

**610-33. Rating of Disconnecting Means for Crane.** On both alternating-current and direct-current crane protective panels, the continuous ampere rating of the switch or circuit-breaker required by Section 610-32, and mainline contactors, shall be not less than 50 per cent of the combined short-time ampere ratings of the motors, nor less than 75 per cent of the sum of the short-time ampere ratings of the motors required for any single crane motion.

**610-34. Limit Switch.** A limit switch shall be provided for upper limit of travel of crane hoists.

### E. Overcurrent Protection

**610-41. Contact Conductors.** The main contact conductors shall be protected by an overcurrent device.

**610-42. Crane Motors.** Where more than one motor is employed on a crane, each motor shall have individual overcurrent protection as provided in Article 430, except that where two motors operate a single hoist, carriage, truck, or bridge, and are controlled as a unit by one controller, the pair of motors with their leads may be protected by a single

overcurrent device which shall be located in the cage or cab where there is one.

### F. Grounding

**610-51. Grounding.** Motor frames, tracks, the entire frame of a crane or hoist, and cases of controllers shall be grounded in the manner specified in Article 250. Small portable hoists shall be grounded where required by Section 250-45.

## **ARTICLE 620—ELEVATORS, DUMBWAITERS, AND ESCALATORS**

### **A. Scope and General**

**620-1. Scope.** This Article shall apply to electrical equipment and wiring used in connection with elevators, dumbwaiters, and escalators.

**620-2. Voltage Limitations.** The nominal voltage used for elevator, dumbwaiter or escalator operating control and signal circuits, operating equipment, driving machine motors, machine brakes, and motor-generator sets shall not exceed the following:

(a) For operating control and signal circuits and related equipment including door operator motors: 300 volts except that higher potentials may be used for frequencies of 25 through 60 cycles alternating current or for direct current provided the current in the system cannot, under any conditions, exceed 8 milliamperes for alternating current or 30 milliamperes for direct current.

(b) Driving machine motors, machine brakes, and motor-generator sets: 600 volts, except that higher potentials may be used for driving motors of motor-generator sets.

**620-3. Live Parts Enclosed.** All live parts of electrical apparatus in the hoistways, at the landings, or in or on the cars of elevators and dumbwaiters or in the wellways or the landings of escalators shall be enclosed to protect against accidental contact.

### **B. Conductors**

**620-11. Insulation of Conductors.** The insulation of conductors installed in connection with elevators, dumbwaiters or escalators shall comply with the following:

(a) **Control Panel Wiring.** Conductors from panels to main circuit resistors shall be flame-retardant and suitable

for a temperature of not less than 90°C. (194°F.). All other wiring on control panels shall be flame-retardant, moisture-resistant.

(b) **Traveling Cables.** Traveling cables used as flexible connections between the elevator or dumbwaiter car and the raceway shall be Type E, EO, or ET elevator cable or other approved types and shall have a flame-retardant, moisture-resistant outer covering.

(c) **Other Wiring.** All conductors in the raceways and in or on the cars of elevators and dumbwaiters and in the wellways of escalators and in the machine room of elevators, dumbwaiters, and escalators shall have flame-retardant and moisture-resistant insulation.

(d) **Thickness of Insulation.** The thickness of the insulation of all conductors shall be suitable for the voltage to which the conductors are subjected.

**620-12. Minimum Size of Conductors.** The minimum size of conductors used for elevator, dumbwaiter and escalator wiring, except for conductors which form an integral part of control equipment, shall be as follows:

(a) **Traveling Cables.**

(1) For lighting circuits: No. 14, except that No. 20 or larger conductors may be used in parallel provided the carrying capacity is equivalent to at least that of No. 14 wire.

(2) Operating control and signal circuits: No. 20.

(b) **Other Wiring.** All operating control and signal circuits: No. 20.

### C. Wiring

**620-21. Wiring Methods.** Conductors located in hoistways and escalator wellways, in or on cars and machine and control rooms, not including the traveling cables connecting the car and hoistway wiring, shall be installed in rigid conduit, electrical metallic tubing, metal wireways, or Type MI cable subject to the following exceptions:

*Exception No. 1. Flexible conduit or armored cable may be used in hoistways and in escalator wellways between*

*risers and limit switches, interlocks, operating buttons, and similar devices.*

*Exception No. 2. Short runs of flexible conduit or armored cable may be used on cars where so located as to be free from oil and if securely fastened in place.*

*Exception No. 3. Types S, SO, and ST cords may be used as flexible connections between the fixed wiring on the car and the switches on car doors or gates.*

*Exception No. 4. Conductors between control panels and machine motors, machine brakes, and motor generator sets, not exceeding six feet in length, may be grouped together and taped or cored without being installed in a raceway provided the taping or cording is painted with an insulating paint. Such cable groups shall be supported at intervals of not more than three feet and so located as to be free from physical damage.*

*Where motor generators and machine motors are located adjacent to or underneath control equipment, and are provided with extra length terminal leads not exceeding six feet in length, such leads may be extended to connect directly to controller terminal studs without regard to the carrying capacity requirements of Articles 430 and 445. Auxiliary gutters may be used in machine and control rooms between controllers, starters and similar apparatus.*

#### **D. Installation of Conductors**

**620-31. Raceway Terminal Fittings.** Conductors leaving raceways shall comply with the provisions of Section 300-16. In no case shall the raceway terminate less than 6 inches from the floor.

**620-32. Metal Wireways.** Section 362-5 shall not apply to wireways. The sum of the cross sectional area of the individual conductors in a metallic raceway shall not be more than 50 per cent of the interior cross sectional area of the wireway.

**620-33. Number of Conductors in Other Raceways.** The number of operating and control circuit conductors in other raceways may be in accordance with Table 1 of Chapter 9.

**620-34. Supports.** Supports for conductor raceways in the hoistway or escalator wellway shall be securely fastened to the guide rail or to the hoistway or wellway construction.

**620-35. Auxiliary Gutters (Wiring Troughs).** Auxiliary gutters shall not be subject to the restrictions of Section 374-2 as to length or of Section 374-5 as to number of conductors.

**620-36. Different Systems in One Raceway or Traveling Cable.** Conductors for operating, control, power, signal, and light circuits of 600 volts or less may be run in the same traveling cable or raceway system provided that all conductors are insulated for the maximum voltage found in the cables or raceway system and all live parts of the equipment are insulated from ground for this maximum voltage. Such a traveling cable or raceway may also include a pair of telephone conductors for the car telephone provided such conductors are insulated for the maximum voltage found in the cable or raceway system.

**620-37. Foreign Wires.** Main feeders for supplying power to elevators and dumbwaiters shall be installed outside the hoistway, except in existing structures subject to special permission of the enforcing authority. Only such electrical wiring, conduit and cable used directly in connection with the elevator or dumbwaiter, including wiring for signals, for communication with the car, for lighting and ventilating the car and wiring for low voltage fire detecting systems for the hoistways, may be installed inside the hoistway.

### **E. Traveling Cables**

**620-41. Suspension.** Traveling cables shall be so suspended at the car and hoistway end as to reduce the strain on the individual copper conductors to a minimum.

Cables exceeding 100 feet in length and which have steel supporting fillers shall be suspended directly by the steel supporting fillers.

Where non-metallic fillers are used, the cables shall be suspended by looping the cables around the supports.

**620-42. Hazardous Locations.** In hazardous locations, traveling cables shall be Type EO and shall be secured to explosion proof cabinets by heavy-duty rubber-bushed threaded connector bushings sealed off at the enclosure as provided in Section 501-5.

**620-43. Location of and Protection for Cables.** Traveling cable supports shall be so located as to reduce to a minimum