NFPA No.
70

ASA C1-1953
UDC 614.825
Aug. 7, 1953

National Electrical Code

1953

One Dollar

NATIONAL FIRE PROTECTION ASSOCIATION
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NATIONAL FIRE PROTECTION ASSOCIATION

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The National Fire Protection Association is a clearing house for information that is authoritative on the subject of fire protection and fire prevention. Non-commercial and non-profit, the Association is supported by the dues of its members. Membership now includes over one-hundred-and-seventy national and regional organizations, and fifteen thousand individuals, firms and corporations. Membership is open to any individual or organization interested in the protection of life and property against loss by fire and full information on membership benefits will be supplied upon request.

The Association has two functions: one, to provide standards under the guidance of which fire waste may be checked; the other, to educate the public so that loss of life and injury from fire will be reduced and the needless fire destruction of property will be halted. The National Electrical Code indicates the character of the technical standards issued by the Association.

ELECTRICAL SECTION

1953 National Electrical Code Corrections

Wireways in Hoistways. Section 6206, covering wiring methods for elevators, dumbwaiters and escalators specifically permits metal wireways in elevator shafts and escalator wellways. Section 3622 prohibits wireways in hoistways, which was an editorial error in correlation. The Electrical Correlating Committee now advises that the intent is to permit this wiring method in hoistways. Section 3622 should accordingly be corrected by deletion of item 2, "in hoistways." This change is to be made in future printings of the 1953 Code.

Sealing of Conduit in Hazardous Locations. In the 1951 National Electrical Code, Section 5015 (a), there was a requirement for seals "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." In the official text of the 1953 Code this wording was inadvertently deleted owing to a misunderstanding of the intent of the Panel responsible. The Correlating Committee now states that this wording should be inserted in the 1953 Code, following Par. 5015 (a) 1 and before the fine print note. The Electrical Correlating Committee is being asked to consider action to formalize this correction through the release of an interim amendment.

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Aug. 7, 1953

National Electrical Code

1953 Edition

42ND ANNIVERSARY

UNDER NFPA SPONSORSHIP

NATIONAL FIRE PROTECTION ASSOCIATION
INTERNATIONAL
60 Batterymarch Street, Boston 10, Mass.

Printed in U. S. A.

The National Electrical Code

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, including the Underwriters' National Electric Association.

The National Conference was disbanded in 1911. For the past 42 years the National Fire Protection Association has acted as sponsor. For the Rules of Procedure under which this 1953 Edition was prepared, see the Appendix, pages 444-448.

The 1953 Edition of the National Electrical Code, presented herewith, incorporates Tentative Interim Amendment No. 98 (see page 248) and completely replaces the 1951 Code and all other previous editions and supplements to previous editions.

This 1953 Edition of the National Electrical Code was formally adopted by the National Fire Protection Association by action at its Annual Meeting held May 18-22, 1953 as recorded in the published Proceedings of this meeting, and by its Board of Directors, June 29, 1953. Pages 9 to 443 constitute the official 1953 National Electrical Code.

The National Fire Protection Association has printed a cloth bound edition of the 1953 National Electrical Code (size 9 x 6 in.) which includes a 128 page appendix of excerpts of the electrical provisions of 62 other NFPA standards. This is available from the Association for $3.00 per copy. (See back inside cover.) The National Board of Fire Underwriters is publishing a pocket size, paper covered edition of the 1953 Code similar to this volume.

This 1953 Edition of the Code has been submitted to the American Standards Association by its sponsor, the National Fire Protection Association, and as of Aug. 7, 1953, the 1953 Edition was adopted by the ASA as an American Standard. The ASA designation given to this Code is printed on the cover of this edition.

The Association wishes to extend its appreciation, in the name of its 15,000 members, to the National Electrical Code Committee, to its Chairman, Mr. Merwin M. Brandon, and to its Secretary, Mr. Charles L. Smith, for their devoted services in the interest of electrical safety. The Committee membership is printed on the following two pages.

NATIONAL FIRE PROTECTION ASSOCIATION

Aug. 31, 1953

National Fire Protection Association

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NATIONAL ELECTRICAL CODE

INTRODUCTION

Purpose and Scope. 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. 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 sub-stations; also the conductors that connect the installations to a supply of electricity, and other outside conductors adjacent to the premises.

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.

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

Wiring Layout. It is recommended that architects 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.

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 architects and others provide similar restrictions wherever practicable, to the end that the effects of break-downs from short-circuits or grounds, even though resulting fire and similar damage is confined to wires, their insulation and enclosures, may not involve entire services to premises nor interruptions of essential and independent services.

Enforcement and Interpretation. This Code is intended to be suitable not only for the use of insurance inspectors but also for mandatory application by governmental bodies exercising legal jurisdiction over electrical installations. 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.

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 page 447 for procedure for securing official interpretations of the Code).

It is customary to revise this Code periodically to conform with developments in the art and the results of experience, and the latest edition of the Code should always be used.

With reference to the approval of specific items of equipment and materials contemplated by the Code, it is pointed out that in order to avoid the necessity for repetition of examinations by different examiners, frequently with inadequate facilities for such work, and to avoid the confusion which would result from conflicting reports as to the suitability of devices and materials examined for a given purpose, it is necessary that such examinations 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.

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.

Definitions. Article 100 contains definitions of a number of terms used in this Code which will facilitate their correct interpretation and application. For definitions of terms not so listed, reference may be made to the American Standard Definitions of Electrical Terms. (ASA C42).

Code Arrangement. The first four chapters 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. Chapter 9 covers construction specifications. The larger tables, examples and the diagrams are collected in Chapter 10.

CHAPTER 1. GENERAL

ARTICLE 100—DEFINITIONS

Definitions which duplicate those in the American Standard Definitions of Electrical Terms, C42, are marked with an asterisk (*) Those not so marked either differ from or are not found in the 1941 edition of the American Standard.

***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.

***Accessible:** (As applied to equipment). Admitting close approach because not guarded by locked doors, elevation or other effective means. (See also "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 non-flammable insulating liquid which, when decomposed by the electric arc, evolves only non-explosive gases.

Branch Circuit: 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.

Building: A structure which stands alone or which is cut off from adjoining structures by unpierced fire walls.

***Cabinet:** An enclosure designed either for surface or flush mounting, and provided with a frame, matt or trim in which swinging doors are hung. (See cutout box.)

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, district messenger, fire and burglar alarms, watchmen, 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.

Connector, Pressure (Solderless): A pressure connector is a connector in which contact between the conductor and the connector is obtained without the use of solder by means of mechanically applied pressure.

***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.

***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 consume electrical energy.

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

***Dustproof:** So constructed or protected that an accumulation of 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 operation at loads, and for intervals of time, both of which may be subject to wide variation.

See table in section 4312 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 the specified gas or vapor surrounding the enclosure by sparks, flashes or explosions of the gas or vapor within.

Exposed: (As applied to live parts). Exposed means that a live part can be inadvertently touched or approached nearer than a safe distance by any person. It is applied to parts not suitably guarded or isolated.

***Exposed:** (As applied to wiring methods). Accessible; 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: Any conductors of a wiring system between the service equipment, or the generator switchboard of an isolated plant, and the branch circuit over-current 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.

***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 Location: See Article 500.

Hoistway: A hoistway is any shaftway, hatchway, well-hole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

***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 the weather, wash rooms 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 raceway, designed to hold conductors and plug receptacles, assembled in the field or at the factory.

***Outlet:** A point on the wiring system at which current is taken to supply fixtures, lamps, heaters, motors and current-consuming equipment generally.

***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.

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 overcurrent protective devices for the control of light, heat, or power circuits of small individual as well as aggregate 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 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, busways and auxiliary gutters.

***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 inspection, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc.

***Receptacle Outlet:** An outlet equipped with one or more receptacles, not of the screw-shell type, or provided with one or more points of attachment within one foot or less, intended to receive attachment plug caps.

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 for 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.

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 cable.

Service Conductors: That portion of the supply conductors which extends from the street main or duct or from transformers to the service equipment of the premises supplied. For overhead conductors this includes the conductors between the last pole or other aerial support and the service equipment.

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

Service-Entrance Conductors: That portion of service conductors between the terminals of service equipment and a point outside the building, clear of building walls, where joined by tap or splice to the service drop or to street mains or other source of supply.

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 Raceway: The rigid metal conduit, electrical metallic tubing, or other raceway, that encloses 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 displaying 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.

Signal Circuit: Any electrical circuit which supplies energy to a device 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 authorities 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.

*__Isolating Switch:__ A switch intended for isolating an electric circuit from the 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 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: A thermal cutout is 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-circuits.

Vaportight: So enclosed as to resist the passage of vapor, as by the use of a gasket.

*__Ventilated:__ Provided with a means to permit circulation of the air sufficiently 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.

ARTICLE 110 — GENERAL

1101. Approval. The conductors and equipment required or permitted by this code shall be acceptable only if approved. See definition of "Approved" in Article 100.

1102. Wiring Methods. Only wiring methods recognized as suitable are included in this code. Special types of wiring may be used only where recognized as suitable under this and other articles of this code. The recognized methods of wiring may be installed in any type of building or occupancy except as otherwise provided in this code.

1103. 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.

1104. Special Chapters Amendatory of General Rules. The provisions of Chapters 5, 6 and 7 of this code are supplementary to, or amendatory of, the general provisions of Chapters 1 to 4, inclusive, and the latter apply under such circumstances except as so amended for particular condition.

1105. Mechanical Execution of Work. Electrical equipment shall be installed in a neat and workmanlike manner.

1106. 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.

1107. 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, or rectifier.

1108. Conductor Gauges. Conductor sizes are given in American Wire Gauge (AWG)

1109. 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. If other materials are used, the size shall be changed accordingly. See section 3106.

1110. Deteriorating Agencies: Unless approved for the purpose, no conductors or equipment shall be located in a 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.

1111. 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.

1112. 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.

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 a, and may be used in lieu thereof.

1113. 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 4432.

1114. Enclosure of 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 Article 500. For motors see sections 4308 and 4310.

1115. 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.

1116. General Plan of Investigation. 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, sizes, voltages, current capacities, and specific uses:

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 liable to arise in service.

e. Arcing effects.

1117. 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 either soldered, brazed or welded, 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, solders, and fluxes, employed where making connections, should be suitable for the material of the conductor.

1118. Splices. Conductors shall be so spliced or joined as to be mechanically and electrically secure without solder and, unless an approved splicing device is used, shall then be soldered with a fusible metal or alloy or brazed or welded. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that on the conductors.

1119. 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:

1. 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 1 and 2 of Chapter 10 of this code, 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

2. The above values shall be determined with all switchboards, panelboards, fuseholders, switches and overcurrent devices in place.

3. If lampholders, receptacles, fixtures, or appliances are also connected, the minimum resistance permitted for branch circuits supplying same shall be one-half the value specified in paragraph 1.

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

1120. 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 — POLARITY IDENTIFICATION OF SYSTEMS AND CIRCUITS

2001. General. All interior wiring systems, except as provided in sections 2007, 2512, 2514, 2515, 2516, 2517 and 5083 shall have a grounded conductor which is continuously identified throughout the system, except as permitted by paragraph b of section 2005.

2002. 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.

2003. 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.

2004. Connections to Screw-Shells. An identified conductor, if run to a lampholder, shall be connected to the screw-shell.

2005. Means of Identification of Conductors. Identification for conductors shall be secured as follows:

a. Insulated conductors of No. 6 or smaller, except conductors of weather-proof and Type MI cable type, shall have an outer identification as specified in paragraph (d) of section 93101. All 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, and weatherproof conductors of all sizes if used indoors, shall have an outer identification as specified in paragraph d of section 93101, or shall be identified by distinctive marking at terminals during process of installation.

c. Flexible cords shall be identified as provided in section 94002.

d. If, 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 identified by painting or other effective means at any point where a connection is to be made if the neutral conductor is present.

2006. Identified Conductor in Identified Circuits Only. Conductors having white or natural gray covering shall not be used other than as conductors for which identification is required by section 2001, except under the following conditions, and then only if they are, in other respects, suitable for use as ungrounded conductors in the circuit:

a. 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 if the identified conductor of the two-wire cable is rendered permanently unidentified at terminals.

b. Cable containing an identified conductor may be used for single-pole, three-way or four-way switch loops if 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.

c. A flexible cord, for connecting a portable appliance, having one conductor identified as required by section 94002 may be used even though there is no grounded conductor in the circuit supplying the outlet to which it is connected.

2007. Unidentified Circuits. Two-wire branch circuits and multi-wire A. C. 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 4384 and for heating equipment in section 4277. Polyphase circuits need not have one conductor grounded and identified, except as required by section 2514, but if one conductor is grounded it shall be identified. Other unidentified ungrounded systems or circuits may be used only by special permission.

2008. **Identification of 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, unless specifically excepted, a pair of connecting terminals properly marked for identification, unless the electrical connection of a terminal intended to be connected to the grounded conductor is clearly evident.

a. **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 paragraphs e and f of this section for polarized receptacles for attachment plugs and polarized attachment-plug caps.

b. **Utilization Appliances.** The terminals of utilization appliances need not be marked to indicate the proper connection to the grounded conductor. If the terminals of utilization appliances, of which single-pole switches form an integral part, are marked for identification, the terminal connected to the switch shall be the unidentified terminal.

c. **Portable Appliances.** The terminals of portable appliances need not be marked for identification.

d. **Single-pole Devices.** Devices, to the terminals of which only one side of the line is connected, need not have terminals marked for identification.

e. **Two-wire Receptacles and Caps.** Two-wire attachment-plug receptacles without screw shells, and two-wire attachment plug caps, unless of the polarity type, need not have their terminals marked for identification. Two-wire polarized receptacles for attachment plugs and polarized attachment-plug caps shall have the terminal intended for connection to the grounded conductor marked for identification.

f. **Three-wire Receptacles and Caps.** Three-wire attachment-plug receptacles and three-wire attachment-plug caps, one terminal of which may be used for the connection of a grounding conductor, shall have such terminal identified in a manner differing from that specified in section 2009. The other terminals need not be marked for identification.

g. **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.

h. 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 indicate the grounded conductor.

2009. Means of Identification of Terminals. The marking of terminals shall be done 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.

ARTICLE 210 - BRANCH CIRCUITS

2101. Scope. The provisions of this article shall apply to branch circuits supplying lighting or appliance loads or combinations of such loads. If 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 if branch circuit supplies only motor loads.

2102. Other Article Provisions. 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:

	Section
Busways	3647
Cranes and Hoists	6142
Elevators, Dumbwaiters and Escalators	6251
Infra-red Industrial Heating Equipment	4237
Induction and Dielectric Heat Generating Equipment	Article 665
Instruments	93843
Motors and Motor Controllers	Article 430
Organs	6506
Remote-Control, Low-Energy Power, Low Voltage Power and Signal Circuits	Article 725
Signs and Outline Lighting	6006
Sound Recording and Reproduction	6406
Systems over 600 Volts	Article 710
Systems under 50 Volts	Article 720
Theatres and Assembly Halls	5241, 5286, 5292
Motion Picture Studios and Similar Locations	Article 530
Welders	Article 630

2103. Classification. 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.

General Provisions

2111. 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.

2112. Color Code. If 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. If 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.

2113. Voltage. Branch circuits supplying lampholders, fixtures, or receptacles of the standard 15-ampere or less rating shall not exceed 150 volts to ground, except (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 application, mounted not less than eight feet from the floor, which do not have switch control as an integral part of the fixture, may exceed 150 volts to ground but shall not exceed 300 volts to ground; (2) in industrial establishments, office buildings, large schools and stores, 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, may exceed 150 volts to ground, but shall not exceed 300 volts to ground; (3) in railway properties as described in section 1111; (4) for infra-red industrial heating appliances as described in section 4237. In dwelling occupancies, the voltage between conductors supplying lampholders of the screw-shell type, receptacles, or appliances, shall not exceed 150 volts, except that the voltage between conductors supplying only, (a) permanently connected appliances, or (b) portable appliances of more than 1,380 watts, or (c) portable motor-operated appliances of ¼ horsepower or greater rating may exceed 150 volts.

2114. Heavy-Duty Lampholders. Heavy-duty lampholders as referred to in this article shall include Edison-base lampholders of the mogul type, and other lampholding devices required for lamps exceeding the maximum rating of the medium-base lamp as provided in section 94103.

2115. 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 b, branch circuits shall be provided for a computed load not less than that determined by section 2116.

The number of circuits shall be not less than that determined from the total computed load and the capacity of circuits to be used, but in every case the number shall be sufficient for the actual load to be served.

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.

If lighting units to be installed operate at other than 100 per cent power factor, see paragraph b of section 2125 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 circuit called for in paragraph b, below.

See Examples No. 1, 2, 3 and 4, Chapter 10.

b. Receptacle Circuits (Dwelling Occupancies). For the small appliance load in kitchen, laundry, pantry, dining-room and breakfast-room of dwelling occupancies, one or more 20 ampere branch circuits 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.

Where a grounding receptacle is required as in sections 2124.b. and 2559 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 shall be acceptable as a grounding conductor.

c. Other Circuits. For specific loads not otherwise provided for in paragraphs a or b, branch circuits shall be as required by other sections of the code.

2116. Calculation of Load. The branch circuit load for lighting and appliances 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 in order that the wiring system may have sufficient branch circuit and feeder capacity to insure safe operation.

a. General Lighting. For general illumination:

1. In Listed Occupancies. In the occupancies listed in the table in section 2203, a load of not less than the unit load of Column A 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.

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 b of section 2115) may be considered as outlets for general illumination, and no additional load need be included for such outlets. The provisions of paragraph b of this section shall apply to all other receptacle outlets.

Demand factors in column B of Section 2203.a. do not apply to branch circuit calculations.

2. In Other Occupancies: In other occupancies, a load of not less than the unit load specified in paragraph b of this section 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 4314 and 4316.

‡This provision not applicable to receptacle outlets connected to the circuits specified in paragraph b of section 2115 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 b shall be modified as follows:

1. Ranges. For household electric ranges, the branch circuit load may be computed in accordance with Table 29, Chapter 10.

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.

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.

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 a or b of this section; 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 a of this section.

2. **Other Than Dwelling Occupancies.** When adding new circuits or extensions to existing circuits in other than dwelling occupancies, the provisions of paragraphs a or b of this section shall apply.

Specific Requirements

2121. 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 be not smaller than No. 8 for ranges of 8¾ kw or more rating, nor smaller than No. 14 for other loads.

See paragraph b of Section 2115.

c. **Exceptions:**

1. **Range Loads.** See Note 5 of Table 29, Chapter 10. Where the maximum demand of a range of 8¾ kw or more rating is computed according to Column A of Table 29, Chapter 10, the neutral conductor of a three-wire branch circuit supplying a household electric range 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.

2. **Taps.** Tap conductors supplying
(a) Individual lampholders or fixtures, or;
(b) Individual outlets with taps not over eighteen inches long, or;
(c) Infra-red lamp industrial heating appliances, 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 the rating is not less than 20 amperes for 50 ampere circuits or 15 amperes for other circuits.

3. **Fixture Wires and Cords.** Fixture wires and cords may be of smaller size, but not less than the size specified in paragraph d of section 2403.

See Table 3, Chapter 10, for the carrying capacity of fixture wires and cords.

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 a and b of section 2123.

2122. 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.

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

c. **Exceptions:**

1. **Taps and Fixture Wires.** Taps, fixture wires and cords as permitted in paragraph c of section 2121 may be considered as protected by the circuit overcurrent device.

2123. Outlet Devices. Outlet devices shall conform to the following:

a. **Lampholders.** Lampholders shall have a rating of not less than the load to be served; and when connected to circuits having a rating of over 20 amperes shall be of the heavy-duty type.

b. **Receptacles.** Receptacles shall have a rating of not less than the load to be served; and when connected to circuits having two or more outlets shall conform to the following:

15-amp. circuits	Not over 15-amp. rating
20-amp. circuits	15 or 20-amp. rating
30-amp. circuits	20 or 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 plug caps used on such circuits are not interchangeable. Grounding receptacles installed in circuits of less than 150 volts between conductors shall be approved for use only on potentials less than 150 volts.

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

c. **Exceptions:**

1. **Range Loads.** See Note 5 of Table 29, Chapter 10.

2124. 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, one receptacle outlet shall be provided for every 20 linear feet or major fraction thereof of the total (gros[illegible] di[illegible]e around the room as measured horizontally [illegible]l at the floor line. The receptacle o[illegible] as practicable, be spaced equal dist[illegible] [illegible]east one receptacle outlet shall be install[illegible] r the connection of laundry appliances. This receptacle shall be of a 3-pole type designed for grounding. Receptacle outlets in floor shall not be counted as part of the required number of receptacle outlets unless located close to the wall.

See Examples 1 and 4, Chapter 10.

2125. 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. If 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.

c. Exceptions:

1. **Range Loads.** See Note 5 of Table 29, Chapter 10.

2126. 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 if lighting units or portable appliances are also supplied.

b. 30-Ampere Branch Circuits. Fixed lighting units 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 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.

2127. Table of Requirements. The requirements for circuits having two or more outlets (other than the receptacle circuits of paragraph b of section 2115) as specifically provided for above are summarized in the following table:

Branch Circuit Requirements

(Type R, RH, RW, RU, RUW, T, and TW 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 2403.d.			
OVERCURRENT PROTECTION	15 Amp.	20 Amp.	30 Amp.	50 Amp.
OUTLET DEVICES:				
Lampholders Permitted	Any Type	Any Type	Heavy Duty	Heavy Duty
Receptacle Rating	Max. 15 Amp.	15 or 20 Amp.	20 or 30 Amp.	50 Amp.
MAXIMUM LOAD	15 Amp.	20 Amp.	30 Amp.	50 Amp.
PERMISSIBLE LOAD	Sec. 2126 a	Sec. 2126 a	Sec. 2126 b	Sec. 2126 c

ARTICLE 220—FEEDERS

2201. **Feeder Size.** Feeder conductors shall have a current rating not smaller than the feeder load as determined by Section 2203. 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. If 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.

If 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 10.

2202. **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 2203 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.

2203. **Calculation of Load.** 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 2116, subject to the following provisions:

a. **General Lighting.** The demand factors specified in this paragraph may be applied to the computed branch circuit load for general illumination. It is not intended that these demand factors be applied in determining the carrying capacities of branch circuits for general illumination supplied by the feeders.

See paragraph c.

Unit Loads and Feeder Demand Factors

The unit values and the demand factors 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.

Type of Occupancy	COL. A Unit Load Per Sq. Ft. (Watts)	COL. B Load to which Demand Factor Applies (Watts)	Demand Factor
Armories and Auditoriums	1	Total Wattage	100%
Banks	2	Total Wattage	100%
Barber Shops and Beauty Parlors	3	Total Wattage	100%
Churches	1	Total Wattage	100%
Clubs	2*	Total Wattage	100%
Court Rooms	2	Total Wattage	100%
Dwellings—(Other Than Hotels)	3*	3,000 or less Next 117,000 Over 120,000	100% 35% 25%
Garages—Commercial (storage)	½	Total Wattage	100%
Hospitals	2	50,000 or less Over 50,000	40%† 20%
Hotels, including apartment houses without provisions for cooking by tenants	2*	20,000 or less Next 80,000 Over 100,000	50%† 40% 30%
Industrial Commercial (Loft) Buildings	2	Total Wattage	100%
Lodge Rooms	1½	Total Wattage	100%
Office Buildings	3	30,000 or less Over 30,000	100% 70%
Restaurants	2	Total Wattage	100%
Schools	3	Total Wattage	100%
Stores	3	Total Wattage	100%
Warehouses Storage	¼	12,500 or less Over 12,500	100% 50%
In any of above occupancies except single-family dwellings and individual apartments of multi-family dwellings:			
Assembly Halls and Auditoriums	1	Total Wattage as specified for the specific occupancy	
Halls, Corridors, Closets	½		
Storage spaces	¼		

*See paragraph c of this section.

†For sub-feeders to areas in hospitals and hotels where entire lighting is likely to be used at one time; as in operating rooms, ballrooms, dining rooms, etc., a demand factor of 100 per cent shall be used.

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

c. Small Appliances. The small appliance load specified in sub-paragraph c-1, and the computed branch circuit load for receptacle outlets in other than dwelling occupancies, for which the allowance is not more than 1½ amperes per outlet, may be included with the general lighting load and subject to the demand factors in paragraph a of this section.

1. 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 1,500 watts shall be included for small appliances (portable appliances supplied from receptacles of 15-ampere or less rating) in dining room, kitchen and laundry. If the load is subdivided through two or more feeders, the computed load for each shall include not less than 1,500 watts for small appliances.

d. Electric Ranges. The feeder load for household electric ranges and other cooking appliances, individually rated more than 1¾ kw, may be calculated in accordance with Table 29, Chapter 10.

In order to provide for possible future installation of ranges of higher ratings, it is recommended that where ranges of less than 8¾ kw ratings are to be installed, the feeder capacity be not less than the maximum demand value specified in Column A of Table 29, Chapter 10.

Where a number of 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 No. 7, Chapter 10.

e. Fixed Appliances (Other than Ranges and Space Heating Equipment). Where four or more fixed appliances in addition to electric ranges and space heating equipment are connected to the same feeder in a single or multi-family dwelling, a demand factor of 75% may be applied to the fixed appliance load, but not including electric ranges or space heating equipment.

f. Motors. For motors, a load computed according to the provisions of sections 4314, 4315 and 4316 shall be included.

g. Neutral Feeder Load. The neutral feeder load shall be the maximum unbalance of the load determined by section 2203. 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, the maximum unbalanced load shall be considered as 70 per cent of the load on the ungrounded conductors, as determined in accordance with Column A of Table 29, Chapter 10. For 3-wire d-c or single-phase a-c, 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.

See Examples 1, 2, 3, 4 and 5 Chapter 10.

h. 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, except that 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%, provided the conductors are of sufficient capacity for the load so determined.

2204. 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 3018.

2205. 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 230—SERVICES

General Requirements

2301. One Set of Service Conductors Only. In general, a building shall be supplied through only one set of service conductors, except:

a. Where more than one service drop is permitted by section 2321.

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 Sections 2351-b and 2371-a-4.)

c. Where additional services are required for different classes of use.

Different classes of use could be because of needs for different voltage, frequency, or phase, or because of rate schedules as in the case of controlled water heater service.

2302. Service from One Building Through Another. No overhead service, no underground service, and no service from an isolated plant shall supply one building through another, unless such buildings are under single occupancy or management. 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.

2303. 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.

a. **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.

b. **Underground.** Except as provided in paragraph a, underground service conductors up to the point of attachment to service equipment shall be covered with rubber, cambric, thermoplastic, paper or other approved insulating material. 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.

c. Service Drops. Except as provided in paragraph a, service drop conductors in multiple-conductor cables shall be rubber-covered or thermoplastic-covered. All open individual conductors shall be rubber-covered, thermoplastic-covered, or weather-proof (type WP).

d. On Exterior of or Entering Buildings. Except as provided in paragraph a, service 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. Open individual conductors which enter the building shall be rubber-covered or thermoplastic-covered; but where on the exterior of the building only may be weatherproof (type WP).

2304. 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.

a. Service-Entrance Conductors. Service entrance conductors, including underground services, shall have a current-carrying capacity sufficient to carry the load as determined by section 2203 and in accordance with Tables 1 and 2 of Chapter 10. Service entrance conductors shall not be smaller than No. 6 except:

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

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

3. 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.

4. The neutral conductor which shall have a current-carrying capacity in conformity with section 2203-g, but shall not be smaller than the ungrounded conductors when these are No. 8 or smaller.

b. Service Drops. Conductors in service drops shall be not smaller than No. 10 if of soft copper, or No. 12 if 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.

2305. **Service-Entrance Conductors without Splice.** Service-entrance conductors shall be without splice except as follows:

a. Clamped or bolted connections in a meter enclosure are permitted.

b. Taps to main service conductors are permitted as provided in paragraph b of section 2301, or to individual sets of service equipment as provided in paragraph a of section 2351.

c. A connection is permitted, if 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.

d. 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.

2306. Conductors in Service Raceway. Conductors other than service conductors, grounding conductors, or control conductors from time switches having over-current protection, shall not be installed in the service raceway.

Underground Services

2311. Mechanical Protection. Underground service conductors shall be protected against mechanical injury by being installed in duct, conduit, in cable of one or more conductors approved for the purpose, or by other approved means. See section 3102-b.

2312. Protection on Poles. If 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.

2313. Protection Where Entering Building. Where underground service conductors enter a building, they 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.

2314. Sealing End of Raceway. 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.

Service-Drop Conductors

2321. Number of Drops. No building shall be supplied from the same transformer, or from the same secondary distribution system, through more than one service drop, except as follows:

a. Fire Pumps. If a separate service is required for fire pumps.

b. Emergency Lighting. If a separate service is required for emergency lighting purposes.

c. Capacity Requirements. If capacity requirements make multiple services desirable.

d. Buildings of Large Area. By special permission, if more than one service drop is necessary due to the area over which a single building extends.

e. Multiple-Occupancy Buildings. By special permission, in multiple-occupancy buildings where there is no available space for service equipment accessible to all the occupants.

f. Different Voltages or Characteristics. Where additional service of different voltages or other characteristics are required for different classes of use, see Section 2301-c.

2322. Clearance of Service Drop. Service drops shall not be readily accessible and 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 7323.

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.

See fine print note following section 2333.

2323. Supports Independent of Building. Where practicable, conductors passing over a building shall be supported on structures which are independent of the building. If necessary to attach conductors to roof they shall be supported on substantial structures.

2324. Point of Attachment to Building. In general, the point of attachment of a service drop to a building shall be not less than 10 feet above ground 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 the form of the building will not permit the above clearances, the attachment may be less than 10 feet provided at least 12 feet clearance is obtained over residential garage driveways, and all other clearances are obtained and all ungrounded conductors and connections within 8 feet of the ground are properly insulated with rubber or equivalent insulation.

2325. Means of Attachment. Multiple-conductor cables used for service drops shall be attached to buildings by fittings approved for the purpose.

Service Conductors on or in Buildings

2331. Wiring Methods. Service 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 automatic over-current protection at their outer end.

2332. 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 mechanical injury. Service-entrance cables, if liable to contact with awnings, shutters, swinging signs, installed in exposed places in driveways, near coal chutes or otherwise exposed to mechanical injury, shall be of the protected type or be protected by conduit, electrical metallic tubing or other approved means.

2333. **Individual Conductors Exposed to Weather.** Individual open conductors, if 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 if supports are placed at intervals not exceeding 4½ feet and conductors are not less than 2 inches from the surface wired over. Weatherproof conductors (type WP) on exterior of buildings shall have a clearance from the ground of not less than 8 feet, and a clearance from windows, doors, porches, etc., of not less than 3 feet.

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

2334. **Individual 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 4½ feet and maintaining the conductors at least one inch from the surface wired over and a separation of at least 2½ inches between conductors.

2335. **Individual Wires Entering Buildings.** Individual conductors entering buildings shall pass inward and upward through slanting non-combustible, non-absorptive 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.

2336. **Service Cables.** Service cables of a type not approved for mounting in contact with the wall 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.

2337. **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 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 not be connected to the service-drop conductors at a point above the level of the service head or the termination of service-entrance cable sheaths. If service heads are used, conductors of opposite polarity shall be brought out through separately bushed holes.

2338. **Enclosing Raceways Made Raintight.** If rigid metal raceways are installed where exposed to weather the raceways shall be made raintight and arranged to drain.

2339. **Terminating Raceway at Service Equipment.** If 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 if 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.

Disconnecting Means

2351. **General.** Each set of service-entrance conductors shall be provided with a readily accessible means of disconnecting all conductors from the source of supply.

a. **Switch and Circuit-Breaker.** The disconnecting means shall be manually operable. It may consist of not more than six switches or six circuit-breakers in a common enclosure, or in a group of separate enclosures, located at a readily accessible point nearest to the entrance of the conductors, either inside or outside the building wall. Two or three single pole switches or breakers, capable of individual operation, may be grouped on multi-wire circuits (where applicable, see section 2353) as one multi-pole disconnect, provided they are equipped with "handle ties," "handles within 1/16 inch proximity," a "master handle," or "other means," making it practical to disconnect all conductors of the service with no more than six operations of the hand. The disconnecting means shall be of a type approved for service equipment and for prevailing conditions.

b. 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 2301-b and each such service may have not more than six switches or circuit-breakers.

c. Disconnection of Grounded Conductor. If 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.

d. 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.

e. Safeguarding Emergency Supply. If an emergency supply is provided to feed the conductors controlled by the service disconnecting means, the disconnector 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.

2352. 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, lightning arresters and circuits for emergency systems, fire pump equipment and for fire alarms as provided in section 2375, 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 2331 and disconnecting means shall be installed as required in section 2351.

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

2353. **Simultaneous Opening.** The disconnecting means shall simultaneously disconnect all ungrounded conductors, except for 3-wire direct-current or single-phase circuits or multi-wire lighting circuits.

2354. **Types Permitted.** The disconnecting means for ungrounded conductors may be a manually-operable switch or circuit-breaker of the air-break or oil-immersed type, equipped with a handle or lever for mechanical operation by the hand.

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

2355. **Indicating.** The disconnecting means shall plainly indicate whether it is in the open or closed position.

2356. **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.

2357. **Rating of Service Switch.** A service switch shall have a rating not less than the load to be carried determined in accordance with section 2203. In general the service disconnecting means shall have a rating of not less than 60 amperes if a switch is used, and not less than 50 amperes if a circuit-breaker is used; however for installations consisting of not more than two 2-wire branch circuits a switch or circuit-breaker of 30-ampere minimum rating may be used. Where multiple switches or circuit breakers are used in accordance with 2371-a-3, the ratings of the service equipment shall not be less than the minimum specified in this Section.

2358. **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.

2359. **Hazardous Locations.** Service equipment installed in hazardous locations shall comply with the requirements of Article 500.

2360. **Service Equipment Grouped.** If 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 sections 2301-b, 2301-c and 2321, shall be grouped and each set of equipment marked to identify it.

Overcurrent Protection

2371. **Where Required.** Each ungrounded service-entrance conductor shall have overcurrent protection.

a. **In 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:

1. For motor-starting currents, ratings in conformity with sections 4342, 4362, or 4363 may be used.

2. Circuit-breakers may have a setting in conformity with paragraphs b and c of section 2403.

3. Not more than six circuit-breakers or six sets of fuses may serve as the overcurrent device.

4. In a multiple occupancy building each occupant shall have access to his over-current 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 2301-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.

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 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.

2372. 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 service raceway.

2373. Location of Branch-Circuit Overcurrent Devices. If 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.

2374. Protection of Special Circuits. If necessary to prevent tampering, an automatic overcurrent device protecting service conductors supplying only a special load such as a water heater, may be locked or sealed if located so as to be accessible.

2375. 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, that may be connected and installed on the supply side of the service disconnecting means as permitted in section 2352.

c. Circuits for emergency lighting, and supply conductors for time switches may be connected on the supply side of the service overcurrent device if 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 if 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 2561) or to a common system and equipment ground electrode (see section 2554); or meters for alternating current service not containing a grounded service conductor and not in excess of 300 volts.

Grounding and Guarding

2381. **Enclosure.** 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 ignitible material. Such an enclosure shall be provided with means for locking or sealing doors giving access to live parts.

2382. **Grounding.** 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 if containing lead-sheathed cable bonded to a continuous underground lead-sheathed cable system.

c. Flexible Conduit. If 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 No. 8, using clamps or other approved means. The conductor and bonding devices shall be protected from mechanical injury. If the flexible conduit runs to the service cabinet, similar bonding shall be installed between the cabinet and the rigid raceway.

Services Exceeding 600 Volts

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 4541 to 4548, 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.

2386. General. Service conductors and equipment used on circuits exceeding 600 volts between conductors shall comply with sections 2301 to 2325 inclusive, sections 2335, 2381 and 2382, and also the following sections 2387 to 2392 inclusive.

2387. 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. If the voltage exceeds 15,000 volts between conductors they shall enter a transformer vault conforming to the requirements of sections 4541 to 4548. Conductors in conduit or duct and enclosed by concrete or brick not less than 2 inches thick shall be considered outside of the building. 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.

a. 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 2500 not less than 3 inches.

b. **Service Cable.** Where cable conductors emerge from a metal sheath or raceway, the insulation of the conductors shall be protected from moisture and mechanical injury by a pothead or other approved means.

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

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.

2388. **Disconnecting Means.** The circuit-breaker or the alternatives for it specified in section 2389 will constitute the disconnecting means required by section 2351.

2389. **Overcurrent Protection.** Overcurrent devices shall be provided in accordance with the following:

a. **In Vault or Consisting of Metal-Enclosed Switchgear.** If the service equipment is installed in a transformer vault meeting the provisions of sections 4541 to 4548, 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. If the voltage is 25,000 or less, a non-automatic switch 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 1 and 2. If these limitations are exceeded, an automatic-trip circuit-breaker shall be installed in compliance with the requirements of paragraph b.

4. If 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. Metal-enclosed switchgear referred to in this section shall consist of switchgear having 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. If installed over a wood floor, suitable protection thereto shall be provided.

b. Not in Vault or Metal Enclosure. If the service equipment is not in a vault or metal enclosure, the overcurrent device shall consist of 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. A circuit-breaker used as service equipment 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 paragraph **a** shall have an interrupting rating at least equal to the maximum short-circuit current possible in the circuit.

d. Circuit-Breakers. Provision shall be made so that the circuit-breaker is 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.

2390. 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, if 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 2389-a are of a type that may be operated as a disconnect switch, they may serve as the isolating switch if 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.

2391. Lightning Arrester. A lightning arrester complying with the requirements of Article 280 shall be placed on each ungrounded overhead service conductor on the supply side of the service equipment, if called for by the authority enforcing this code.

2392. Equipment in Secondaries. If 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 various paragraphs of this article.

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

ARTICLE 240—OVERCURRENT PROTECTION

Installation

2401. General Requirement. Overcurrent protection for conductors 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. A grounded conductor is considered to be protected from overcurrent if a protective device of a suitable rating or setting is provided in each ungrounded conductor of the same circuit.

2402. Overcurrent Protection of Equipment. Equipment shall be protected against overcurrent as specified in the references in the following table:

Branch Circuits	Article 210
Capacitors	Sections 4607-b and 4608
Cranes and Hoists	Sections 6141 and 6142
Elevators, Dumbwaiters and Escalators	Article 620
Generators	Section 4454
Induction and Dielectric Heat Generating Equipment	Section 6654
Motion Picture Studios and Similar Locations	Article 530
Motors	Article 430
Over 600 Volts	Article 710
Remote-Control, Low Energy Power, Low Voltage Power and Signal Circuits	Article 725
Services	Sections 2371 to 2375
Signs and Outline Lighting	Section 6006
Sound Equipment	Section 6406
Switchboards and Panelboards	Sections 3857 and 3882
Theaters and Assembly Halls	Article 520
Transformers	Article 450

2403. Overcurrent Protection of Conductors. Conductors shall be protected in accordance with their current-carrying capacities, as given in Tables 1 and 2, Chapter 10, except as follows:

a. Fuses. 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 but in no case shall the size or rating of the fuse exceed 150 per cent of the allowable current-carrying capacity of the conductor. 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. Plug fuses installed in residential occupancies should be of the time-delay type. The screw shell of plug type fuseholders shall be connected to the load side of the circuit.

Ampere ratings for fuses are 15, 20, 25, 30, 35, 40, 50, 60, 70, 80, 100, 125, 150, 200, 250, 300, 400, 500, and 600. Fuses of a size other than the standard sizes listed may be used if they are of a size smaller than those included in the standard list.

b. Non-Adjustable-Trip Circuit-Breakers. **Non-adjustable-trip circuit-breakers, except as otherwise permitted in sub-paragraph 9 of Tables 1 and 2 of Chapter 10, shall be rated in accordance with the current-carrying capacity** of the conductor. Circuit-breakers of the 0 to 30 ampere class should be of the time-delay type.

Ampere ratings for molded case circuit breakers are 15, 20, 30, 40, 50, 70, 100, 125, 150, 175, 200, 225, 250, 300, 350, 400, 500 and 600.

c. 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 150 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.

d. 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 6251. Fixture wires of the sizes permitted for taps in paragraph c.2 of section 2121 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 over-current 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.

e. **Motor Circuits.** The conductors supplying motors and motor-operated appliances shall be considered as protected by the overcurrent protective devices specified in sections 4322, 4324, 4342, 4343 and 4362.

f. **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 2121 and 2122.

g. **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 1 and 2 of Chapter 10.

h. **Taps.** A conductor tapped from a feeder shall be considered as properly protected from overcurrent if installed in accordance with sections 2434, 3647 and 4348.

2404. **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 4330.

2405. **Ungrounded Conductors.** An overcurrent device (fuse or overcurrent trip unit of a circuit-breaker) shall be placed in each ungrounded conductor. Circuit-breakers shall open all ungrounded conductors of the circuit. The number and position of the overcurrent units such as trip coils or relays shall be as given in Table 28, Chapter 10. 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 operating at more than 150 volts to ground.

2406. Services. For services the number of overcurrent units shall be as specified in section 2371.

2407. Motors. For motor-running protection the number of overcurrent units shall be as specified in sections 4326, 4327 and 4328.

2408. 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.

2409. Grounded Conductor. No overcurrent device shall be placed in any permanently grounded conductor, except as follows:

a. **Simultaneous Opening.** If the overcurrent device simultaneously opens all conductors of the circuit.

b. **Conductors of Branch Circuits.** In locations where the conditions of grounding or the likelihood of reversal of connection warrants, the authority enforcing this code may require, on systems having a grounded neutral or having one side grounded, that the conductors of 2-wire branch circuits shall have an overcurrent device in each conductor.

c. For motor-running protection as provided in sections 4326 and 4327.

2410. 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.

2411. Fuses in Multiple. For the protection of conductors, except the conductors of motor-branch circuits, having allowable carrying capacities exceeding the rated capacity of the largest approved cartridge type fuse, 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.

Location

2434. **Location in Circuit.** Overcurrent devices shall be located at the point where the conductor to be protected receives its supply, except as follows:

a. **Service Conductors.** An overcurrent protective device for service conductors may be located as specified in section 2372.

b. **Smaller Conductor Protected.** If the overcurrent device protecting the larger conductors also protects the smaller conductors in accordance with Tables 1 and 2 of Chapter 10.

c. **Taps Not Over 5 Feet Long.** If (1) the smaller conductors have 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, (2) the tap is not over 5 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 open wires on insulators, is enclosed in conduit, electrical metallic tubing, or in metal gutters when not a part of the switchboard or panelboard.

d. **Taps Not Over 25 Feet Long.** If the smaller conductors have a current-carrying capacity at least one-third that of the conductor from which they are supplied, and provided the tap is suitably protected from mechanical injury, 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 1 and 2, Chapter 10. Beyond this point the conductors may supply any number of circuit-breakers or sets of fuses.

2435. **Location in Premises.** Overcurrent devices shall be located where they will be:

a. Readily accessible, except as provided in section 2372 for service equipment and section 3650 for busways.

b. Not exposed to mechanical injury.

c. Not in the vicinity of easily ignitible material.

Enclosures

2436. 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 ignitible material and dampness. The operating handle of a circuit-breaker may be accessible without opening a door or cover.

2437. 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.

2438. Vertical Position. Enclosures for overcurrent devices shall be mounted in a vertical position unless in individual instances this is shown to be impracticable.

2439. Rosettes. Fuses shall not be mounted in rosettes.

2440. 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, if 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 2352 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 4410.

2441. 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.

Construction and Use of Overcurrent Devices

2451. 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. 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.

2452. Holders for Plug Fuses. Holders for plug fuses of 30 amperes or less shall not be installed unless they comply with section 2453 or are made to comply with section 2453 by the insertion of an adapter.

Note: The Board of Directors of the National Fire Protection Association voted on July 15, 1946, to suspend the mandatory provisions of the above paragraph pending the completion of investigation of branch circuit protection and further action by the Board or by the Association.

2453. **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. Live Parts. Fuses and fuseholders when installed and assembled together shall have no live parts exposed.

f. Adapters to be Non-Removable. Fuse adapters shall be so designed that when once inserted in a fuseholder they cannot be removed, except that adapters without the locking device may be used in installations existing before the effective date of this code.

g. 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.

h. Plug Type. Fuses and fuseholders shall be of the plug type.

i. Ampere Rating. Each fuse, fuseholder and adapter shall be marked with its ampere rating.

j. 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.

2461. Cartridge Fuses and Fuseholders. Cartridge fuses and fuseholders shall conform to the following:

a. Classification. 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

b. Non-Interchangeable. 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.

c. Marking. Each fuse shall be marked with its ampere and voltage ratings.

2471. Link Fuses and Fuseholders. Link fuses shall be mounted on approved fuseholders.

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

2481. 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. Injury to Operator. Circuit-breakers shall be arranged and mounted so that their operation is not likely to injure the operator.

c. Indication. Circuit-breakers shall indicate whether they are in the open or closed position.

d. 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.

e. Marking. Circuit-breakers shall be marked with their rating in such a manner that the marking will be visible after installation.

ARTICLE 250—GROUNDING

2501. Scope. This article treats of protection of electric installations by grounding. Insulation, isolation, and guarding are suitable alternatives under certain conditions.

Systems and Circuits

2511. 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.

For instrument transformer grounding, see section 2621.

2512. 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 if 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 if the voltage to ground of either conductor would exceed 300 volts after grounding.

2513. Three-Wire Direct-Current Systems. The neutral conductor of all 3-wire direct-current systems supplying interior wiring shall be grounded.

2514. Alternating-Current Systems. Secondary alternating-current systems supplying interior wiring, and interior alternating-current wiring systems, shall be grounded if 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 2303, paragraph a, the system shall be grounded.

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

2515. Furnace Circuits. Electric furnace circuits need not be grounded.

2516. Electric Crane Circuits. Circuits for electric cranes operating over combustible fibers in Class III hazardous locations shall not be grounded. See section 5083.

2517. Circuits of Less Than 50 Volts. Circuits of less than 50 volts need not be grounded, except as follows:

a. If supplied by transformers from systems of more than 150 volts to ground, except as provided in paragraph c of section 2545.

b. If supplied by transformers from ungrounded systems.

c. If run overhead outside of buildings.

Location of Grounding Connections

2521. Current Over Grounding Conductors. The grounding of wiring systems, circuits, equipment, 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. If 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.

2522. 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.

2523. 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 2521. 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 2524.

2524. Two or More Buildings Served by a Single Service. If more than one building is served 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 utilizing two or more branch circuits supplied from such service, and in the case of a building housing live stock, shall be so connected.

2525. 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.

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

2526. Isolated Systems. For an interior wiring system or circuit which is required to be grounded and which is not 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.

Conductor Enclosures

2531. Exposed Metal. Exposed conductive materials enclosing electric conductors are grounded for the purpose of preventing a potential above ground on the enclosures.

2532. **Service Conductor Enclosures.** Service raceways, service cable sheaths or armoring, if of metal, shall be grounded.

2533. **Other Conductor Enclosures.** Metal enclosures for conductors shall be grounded, except 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, if within reach from grounded surfaces, are guarded against contact by persons.

2534. **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.

Equipment

2541. **Exposed Metal.** 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.

2542. **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. If equipment is supplied by means of metal-clad wiring;

b. If equipment is located in a wet location and is not isolated;

c. If equipment is located within reach of a person who can make contact with any grounded surface or object;

d. If equipment is located within reach of a person standing on the ground;

e. If equipment is in a hazardous location; see Article 500;

f. If equipment is in electrical contact with metal or metal lath;

g. If 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.

2543. 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 4436;

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 lamps 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 if effectively insulated;

i. X-ray tubes used in therapy. For exceptions see section 6633.

For instruments, meters and relays, see sections 2622 to 2624.

2544. 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.

2545. Portable Equipment. Under any of the following conditions, exposed non-current-carrying metal parts of portable equipment shall be grounded:

a. In hazardous locations;

b. If operated at more than 150 volts to ground, except:

1. Motors, if guarded;

2. Metal frames of electrically-heated appliances exempted by section 4238;

3. Enclosures for X-ray tubes used in therapy exempted by section 6633.

c. In other than residential occupancies, (1) exposed metal parts of 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 and not protected by insulated handles and enclosures, 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, if 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.

2546. Spacing from Lightning Rods. Metal frames and cases 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.

Methods of Grounding

2551. Effective Grounding. The path to ground from circuits, equipment, or conductor enclosures shall be permanent and continuous and shall have ample carrying capacity to conduct safely any currents liable to be imposed on it, and shall have impedance sufficiently low to limit the potential above ground, and to facilitate the operation of the overcurrent devices in the circuit.

2552. Grounding Conductor to Circuit. 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.

2553. **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.

2554. **Common Grounding Electrode.** Where the alternating-current system is connected to a grounding electrode in or at a building as specified in sections 2523 and 2524, the same electrode shall be used to ground wire enclosures and equipment in or on that building.

2555. **Underground Service.** 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 sheath cable bonded to the underground system, need not be grounded at the building and may be insulated from the interior conduit or piping.

2556. **Short Sections of Raceway.** Isolated sections of metal raceway or cable armor, if required to be grounded, shall preferably be grounded by connecting to other grounded raceway or armor, but may be grounded in accordance with section 2557.

2557. **Fixed Equipment.** Metal boxes, cabinets and fittings, or non-current-carrying metal parts of other fixed equipment, if metallically connected to grounded cable armor or metal raceway, are considered to be grounded by such connection. If not so connected they may be grounded in one of the following ways:

a. By a grounding conductor run with circuit conductors; this conductor may be uninsulated, but if it is provided with an individual covering, the covering shall be finished to show a green color.

b. By a separate grounding conductor installed the same as a grounding conductor for conduit and the like;

c. By special permission, other means for grounding fixed equipment may be used.

2558. **Equipment on Structural Metal.** Electric equipment secured to and in contact with the grounded structural metal frame of a building, shall be deemed to be grounded. 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 if the machine is grounded in accordance with this code.

2559. **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;

See note following section 4010.

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 if an individual covering is provided for such conductors it shall be finished to show a green color;

See note following section 4010.

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

2560. **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 2557 and 2559 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.

2561. **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 c of section 2557; and in section 2560.

Bonding

2571. **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 2572:

a. The service raceways or service cable armor or sheath, except as provided in section 2382. b. and section 2555;

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.

2572. **Means of Assuring Continuity.** 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 2613.

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 otherwise formed so as to impair the electrical connection to ground.

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

2573. **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.

2574. **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.

2575. **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 b, c, d and e of section 2572, 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.

2576. **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.

2577. **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 b, c, d and e of section 2572.

2578. **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 2613; where used between grounding electrodes or around water meters and the like, they shall be attached in a manner provided for in section 2614.

Grounding Electrodes

2581. **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. If 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 2582 and 2583.

2582. **Other Available Electrodes.** Where a water system as described in section 2581 is not available, the grounding connection may be made to any of the following:

a. The metal frame of the building, if effectively grounded;

b. A continuous metallic underground gas piping system.

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

2583. **Made Electrodes.** Where electrodes described in sections 2581 and 2582 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 ¼ 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 3/4-inch trade size and, if 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 ⅝ inch in diameter. Approved rods of non-ferrous materials or their approved equivalent used for electrodes shall be not less than ½ 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 if pipes or rods are used as the electrode they shall comply with paragraphs b and c of this section 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.

2584. **Resistance.** Made electrodes shall, if practicable, have a resistance to ground not to exceed 25 ohms. If 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.

2585. **Railway Tracks.** Rails or other grounded conductors of electric railway circuits shall not be used as a ground for other than railway lightning arresters and railway equipment, conduit, armored cable, metal raceway, and the like, if other effective grounds are available; and 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.

2586. **Use of Lightning Rods.** Lightning rod conductors and driven pipes, rods or other made electrodes used for grounding lightning rods, shall not be used in lieu of the made grounding electrodes required by this Article for grounding wiring systems and equipment. The foregoing provision shall not be taken to forbid the bonding together of the several made electrodes that are respectively provided for electric wiring systems and equipment, for communication systems, and for lightning protection. (See section 8041-b-5.)

Grounding Conductors

2591. **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 cr 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. If 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.

2592. **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 mechanical injury. A No. 6 grounding conductor, which is free from exposure to mechanical injury, may be run along the surface of the building construction without metal covering or protection, if 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 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 Section 2592.a. except that where smaller than No. 6, as permitted by Section 2595, it need not be armored or installed in a raceway if run through the hollow spaces of a wall or partition or otherwise run so as to be not subject to mechanical injury.

2593. **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 c of section 4454, 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.

2594. **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 the following table, except that where connected to made electrodes (as in section 2583) the conductor need not be larger than No. 6 copper wire or its equivalent in carrying capacity.

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

b. If 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 the following table, except that where connected to made electrodes (as in section 2583) the conductor need not be larger than No. 6 copper or its equivalent in carrying capacity.

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	½	½
1 or 0	6	½	1
00 or 000	4	¾	1¼
Over 000 to 350,000 c.m.	2	¾	1¼
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

2595. **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 the following table, except that where connected to electrodes as described in section 2583, the grounding conductor need not be larger than No. 6 copper or its equivalent:

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*	½	½
30	14	½	½
40	12	½	½
60	10	½	½
100	8	½	½
200	6	½	1
400	4	¾	1¼
600	2	¾	1¼
800	0	1	2
1000	00	1	2
1200	000	1	2

*Permissible only when part of an approved cable assembly.

2596. **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 grounding portable equipment shall be part of an approved flexible cord assembly. For grounding portable or pendent equipment protected at more than 20 amperes, the table in section 2595 shall be followed.

2597. **Outline Lighting.** Isolated non-current-carrying metal parts of outline lighting systems may be bonded together by a No. 14 conductor protected from mechanical injury, if a conductor complying with section 2595 is used to ground the group.

2598. **Common Raceway.** A grounding conductor may be run in the same metal raceway with other conductors of the system to which it is connected.

2599. **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.

Grounding Conductor Connections

2611. **Grounding Conductor to Raceway.** 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 2595.

2612. **Grounding Conductor 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. If 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. If 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 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 2582 and 2583 at a point which will assure a permanent ground. Where practicable the point of attachment shall be accessible.

2613. 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.

2614. 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.

2615. 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 mechanical injury to pipe.

2616. Protection of Attachment. Ground clamps or other fittings, unless approved for general use without protection, shall be protected from ordinary mechanical injury (1) by being placed where they are not liable to be damaged or (2) by being enclosed in metal, wood, or equivalent protective covering.

2617. Clean Surfaces. If 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.

Instrument Transformers, Relays, Etc.

2621. Instrument Transformer Circuits. The secondary circuits of current and potential instrument transformers shall be grounded if the primary windings are connected to circuits of 300 volts or more to ground, and, if 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.

2622. 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.

2623. 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 if the voltage to ground exceeds 150.

2624. **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.

2625. **Instrument Grounding Conductor.** The grounding conductor for secondary circuits of instrument transformers and for instrument cases shall not be smaller than No. 12, if of copper, or, if 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.

Lightning Arresters

2631. **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, or (4) a separate grounding conductor. The bonding or grounding conductor shall be of copper not smaller than No. 14 or of equivalent corrosion-resistant material.

2632. 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 (a) above, but is otherwise grounded as in sections 2582 and 2583, such interconnection, if 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 at least 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

Industrial Stations

2801. **Where Required.** Lightning arresters shall be provided in industrial stations in locations where thunder storms are frequent and adequate protection against lightning is not otherwise provided.

For lightning arresters in hazardous locations, see Article 500.

2802. **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 if means are provided to protect circuits that may remain disconnected from the bus.

2803. **Where Connected.** The arrester shall be connected on the line side of all connected station apparatus.

Other Occupancies

2811. **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 if the operating voltage of the circuit exceeds 750 volts between conductors they shall be inaccessible to unqualified persons.

General

2821. **Location — Indoors.** Arresters installed indoors shall be located well away from other equipment, passageways and combustible parts of buildings, and if containing oil shall be separated from other equipment by walls meeting the requirements of section 4542.

2822. **Location—Outdoors.** If 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.

2823. **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 2631, 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.

2824. **Insulation.** Lightning-protection accessories such as gap electrodes, and choke coils if used, shall have an insulation from ground or from other conductors at least equal to the insulation required at other points of the circuit.

2825. **Isolating Switch.** If 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.

2826. **Grounding.** Lightning arresters shall be grounded in the manner prescribed in Article 250.

CHAPTER 3. WIRING METHODS AND MATERIALS

ARTICLE 300 — GENERAL REQUIREMENTS FOR WIRING METHODS

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

3001. Scope. The provisions of sections 3002 to 3020 inclusive, shall apply to all wiring installations, except for remote-control, low-energy power and signal systems as provided in Article 725, and communication systems as provided in Article 800.

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.

3002. 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, and may be used for voltages over 600 where specifically permitted elsewhere in this code.

3003. Protection Against Corrosion and Mechanical Injury. Conductors and equipment shall be protected against corrosion and mechanical injury in accordance with the following:

a. 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; except that 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.

See section 3462 for conduit, and section 3482 for electrical metallic tubing.

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.

b. Mechanical Injury. If subject to mechanical injury, conductors shall be adequately protected.

3004. Secured in Place. Raceways, cable assemblies, boxes, cabinets and fittings shall, unless otherwise provided, be securely fastened in place. Raceways and cable assemblies shall be mechanically secured to boxes, fittings, cabinets and other enclosures, except as provided for non-metallic boxes in section 3710.

3005. Runs Continuous. Raceways and cable assemblies shall be continuous from outlet to outlet and from fitting to fitting. Conductors shall be continuous from outlet to outlet and, except as permitted for auxiliary gutters in section 3748, and for wireways in section 3625, there shall be no splice or tap within the raceway itself.

3006. Free Length of Conductors at Outlets. At least six inches of free conductor shall be left at each outlet and switch point for the making up of joints or the connection of fixtures or devices, except where conductors are intended to loop without joints through lampholders, receptacles and similar devices.

3007. Boxes at Outlets. Except as permitted in sections 3369 and 4179, 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.

3008. Boxes and Fittings Where Conductors Are Brought Out. Except as provided in section 3009, 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.

3009. Bushing in Lieu of Box or Fitting. 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.

3010. Through Studs, Joists and Rafters. When, in exposed or concealed work, conductors in insulating tubes or cables are run through bored holes in studs, joists or similar wood members, holes shall be bored at the approximate centers of wood members, or at least two inches from the nearest edge. Where 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 if 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.

3011. Conductors of Different Systems. 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 6217; for sound recording in section 6405; for remote-control, low-energy power and signal circuits in sections 7266 and 7292; and communication system in sections 8012 and 8031. Secondary wiring to electric discharge lamps of 1,000 volts or less may occupy the same enclosure as the branch circuit conductors. 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 if all conductors are insulated for the maximum voltage of any conductor within the enclosure. 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. Control, relay and ammeter conductors used in connection with any motor or starter may occupy the same enclosure as the motor circuit conductors.

3012. 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 3466; electrical metallic tubing, 3486; surface metal raceways, 3524; underfloor raceways, 3545; cellular metal floor raceways, 3564; wireways, 3624; auxiliary gutters, 3745; theatres, 5212; signs, 6021-d; elevators, 6213; and sound recording, 6403 and 6404.

3013. Inserting Conductors in Raceways. Raceways, except those used for exposed work and having a removable cover or capping, shall first be installed as a complete raceway system without the conductors. Conductors shall not be inserted until all mechanical work on the building which is liable to injure the conductors has been completed, as far as possible. Pull wires, if used, shall not be installed until the raceway system is in place. Graphite, talc, or an approved compound may be used as a lubricant in inserting conductors in raceways. Cleaning agents or lubricants having a deleterious effect on conductor covings shall not be used.

3014. Supporting Vertical Conductors in Raceways. 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

The following methods of supporting cables are recommended:

a. 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.

b. 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.

c. 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.

3015. Raceways Exposed to Different Temperatures. If 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.

3016. Electrical Continuity of Metal Raceways and Enclosures. Interior 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.

3017. Grounding Metal Enclosures. Metal raceways, cable armor and fittings shall be grounded if and as prescribed in Article 250.

3018. Alternating-Current Systems in Metal Enclosures. Where run 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. If 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 providing each phase conductor of the circuit and the neutral conductor, if one is used, are installed in each enclosure. The conductors of such an installation can conform to the provisions of Section 3105 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 3441 to 3444 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 eliminated by cutting slots in the metal between the individual holes through which the conductors of the circuit pass, or by 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.

3019. Underground Runs. Conductors run underground shall comply with the provisions of sections 2311, 2312 and 2313 as far as mechanical protection is concerned.

3020. Wiring in Ventilating Ducts. 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. No wiring system of any type shall be installed in ducts for dust, loose stock or vapor removal. 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.

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

ARTICLE 310 — CONDUCTORS

3101. General. The intent and purpose of the following rules is to provide that conductors shall have mechanical strength, insulation, and carrying capacity adequate for the particular conditions under which they are to be used.

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.

3102. Conductor Insulation. Conductors shall be insulated, except when uninsulated conductors are specifically permitted in this code. Conductor insulations as specified in the following table may be used for any of the wiring methods recognized in this chapter, except as otherwise provided for in the table or the notes following, or as otherwise specified in this code. They are suitable for 600 volts unless otherwise specified.

Trade Name	Type Letter	Max. Operating Temp.	Special Provisions
Rubber-Covered Fixture Wire Solid or 7-Strand	RF-1	60 C 140 F	Fixture wiring. Limited to 300 V.
	RF-2	60 C 140 F	Fixture wiring, and as permitted in Section 3103.
Rubber-Covered Fixture Wire Flexible Stranding	FF-1	60 C 140 F	Fixture wiring. Limited to 300 V.
	FF-2	60 C 140 F	Fixture wiring, and as permitted in Section 3103.
Heat-Resistant Rubber-Covered Fixture Wire Solid or 7-Strand	RFH-1	75 C 167 F	Fixture wiring. Limited to 300 V.
	RFH-2	75 C 167 F	Fixture wiring, and as permitted in Section 3103.
Heat-Resistant Rubber-Covered Fixture Wire Flexible Stranding	FFH-1	75 C 167 F	Fixture wiring. Limited to 300 V.
	FFH-2	75 C 167 F	Fixture wiring, and as permitted in Section 3103.
Thermoplastic-Covered Fixture Wire—Solid or Stranded	TF	60 C 140 F	Fixture wiring, and as permitted in section 3103.

Trade Name	Type Letter	Max. Operating Temp.	Special Provisions
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.
Code Rubber	R	60 C 140 F	General use.
Heat-Resistant Rubber	RH	75 C 167 F	General use.
Moisture-Resistant Rubber	RW	60 C 140 F	General use and wet locations.
Moisture and Heat Resistant Rubber	RH, RW	60 C 140 F 75 C 167 F	General use and wet locations. General use.
Moisture and Heat resistant Rubber	RHW	75 C 167 F	General Use and Wet Locations.
Latex Rubber	RU	60 C 140 F	General use.
Heat Resistant Latex Rubber	RUH	75 C	General use.
Moisture Resistant Latex Rubber	RUW	60 C 140 F	General use and wet locations.
Thermoplastic	T	60 C 140 F	General use

Trade Name	Type Letter	Max. Operating Temp.	Special Provisions
Moisture-Resistant Thermoplastic	TW	60 C 140 F	General use and wet locations.
Mineral Insulation (Metal Sheathed)	MI	85 C 185 F	General Use and Wet Locations with Type O termination fittings. Maximum operating temperature for special applications 250° C.
Thermoplastic and Asbestos	TA	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	Wet locations.
Asbestos and Varnished Cambric	AVB	90 C 194 F	Dry locations only.
Asbestos	A	200 C 392 F	Dry locations only. Not for general use. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AA	200 C 392 F	Dry locations only. Open wiring. Not for general use. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AI	125 C 257 F	Dry locations only. Not for general use. In raceways, only for leads to or within apparatus. Limited to 300 V.
Asbestos	AIA	125 C 257 F	Dry locations only. Open wiring. Not for general use. In raceways, only for leads to or within apparatus.

Trade Name	Type Letter	Max. Operating Temp.	Special Provisions
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.
Slow-Burning Weatherproof	SBW	90 C 194 F	Dry locations only. Open wiring only.
Weatherproof	WP	80 C 176 F	Open wiring by special permission where other insulations are not suitable for existing conditions.

The rubber insulations include those made from natural and synthetic rubber, neoprene and other vulcanizable 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 3736-b.

For size of conductors recognized for the various insulating coverings, and for construction details, see section 93101.

a. **Temperature Limitations.** No conductor shall be used under such conditions that its temperature, even when carrying current, will exceed the temperature specified in the table for the type of insulation involved.

b. **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-resistant, thermoplastic-covered (Type TW); 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.

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. If single conductor cables are installed, all conductors of each service, feeder, subfeeder 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.

c. **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.

3103. **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 4006; for fixture wire in section 4142; for fractional horsepower motors in section 4312; for cranes and hoists in section 6112; for elevator control and signal circuits in section 6205; for machine tools in section 6721; and for remote-control, low-energy power, low-voltage power and signal circuits in section 7263.

3104. **Stranded Conductors.** Except when used as bus bars or in Type MI Cable, conductors No. 6 and larger, installed in raceways, shall be stranded.

3105. **Conductors in Multiple.** Conductors in sizes 1/0 to 500,000 c.m., inclusive, 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.

3106. **Current-Carrying Capacity.** The maximum, continuous, current-carrying capacities of copper conductors are given in Tables 1, 2 and 3 of Chapter 10. The current-carrying capacities of aluminum conductors shall be taken as 84 per cent of those given for the same sizes of copper conductors with the same kind of insulation.

ARTICLE 320 — OPEN WIRING ON INSULATORS

3201. **Scope.** Open wiring on insulators shall comply with the provisions of sections 3001 to 3020 inclusive, Article 730 and shall also comply with the provisions of the following sections 3202 to 3215 inclusive.

3202. **Use.** Open wiring on insulators may be used for both exposed and concealed 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 b of section 5073.

3203. **Types of Conductors.** The type of conductors shall conform to Article 310. Only single conductors shall be used.

3204. **Supports.** Conductors shall be supported in accordance with the following:

a. Open conductors shall be rigidly supported on non-combustible, non-absorptive insulating material, except as provided in section 3206.

b. Rigid supporting requires, under ordinary circumstances, if wiring over flat surfaces, supports at least every 4½ feet, this interval being shortened if the conductors are liable to be disturbed. Conductors shall be supported by means of a knob or cleat within 6 inches of a tap. In buildings of mill construction, mains not smaller than No. 8, where not liable to be disturbed, may be separated about 6 inches and run direct from timber to timber, being supported from each timber only. If circuits of No. 8 or larger are run across open spaces where not liable to be disturbed, they may be supported at distances not greater than 15 feet if approved non-combustible, non-absorptive insulating separators providing not less than 2½ inch separation between conductors are installed at intervals of not over 4½ feet.

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.

3205. Spacing. Open conductors in dry places and for voltages not exceeding 300 volts shall be separated 2½ inches from each other and ½ inch from the surface wired over; and, except as provided in paragraph b of section 3204, for voltages from 301 to 600 volts shall be separated 4 inches from each other and 1 inch from the surface wired over. In damp or wet locations a separation of at least 1 inch from the surface wired over shall be maintained for all voltages.

3206. Flexible Tubing. In dry locations, where not exposed to severe mechanical injury, 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.

3207. Dead Ends. Open conductors shall not be dead-ended at a rosette, lampholder or receptacle unless the last support is within 12 inches of the same.

3208. Tie Wires. No. 8 or larger conductors supported on solid knobs shall be securely tied thereto. If conductors are used for tying, they shall have an insulation equivalent to the conductors which they confine.

3209. 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 non-combustible, non-absorptive insulating material. If 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 porcelain tube or sleeve.

3210. Separation from Metal Work. Open conductors shall be separated at least 2 inches from metallic conduit, piping, or other conducting material, or from any exposed lighting, power or signal conductor, unless separated therefrom by a continuous and firmly fixed non-conductor additional to the insulation of the conductor. If any insulating tube is used, it shall be secured at the ends. Deviation from this requirement may, if necessary, be allowed by the authority enforcing this code.

3211. 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 run over, rather than under, pipes upon which moisture is likely to gather or which may leak.

3212. Protection from Mechanical Injury. Where open conductors cross ceiling joists and wall studs, and are exposed to mechanical injury, they shall be protected by one of the following methods. Conductors within 7 feet from the floor shall be considered exposed to mechanical injury

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 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 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 conduit, in which case the rules for conduit shall be followed, or by metal piping in which case the conductors shall be encased in continuous lengths of approved flexible tubing. The conductors passing through conduit or piping shall be so grouped that current in both directions is approximately equal.

3213. In Accessible Attics. Conductors in unfinished accessible attics or roof spaces shall be installed in accordance with the requirements of section 3247.

3214. In Concealed Spaces. Conductors shall not be in contact with any object other than their insulating supports. If run in concealed spaces they shall be installed as required for concealed knob-and-tube work in accordance with the provisions of sections 3241 to 3248, inclusive.

3215. 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 non-combustible, non-absorptive insulating tubes.

ARTICLE 324 — CONCEALED KNOB-AND-TUBE WORK

3241. Scope. Concealed knob-and-tube work shall comply with the provisions of sections 3001 to 3020, inclusive, and shall also comply with the provisions of the following sections 3242 to 3248, inclusive.

3242. 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 5211, (3) in motion-picture studios, nor (4) in hazardous locations.

3243. Type of Conductor. The type of conductors shall conform to Article 310. Only single conductors shall be used.

3244. Supports. Conductors shall be supported at intervals not exceeding 4½ feet by knobs and tubes. There shall be a knob within 6 inches from each tap. Tie wires shall comply with section 3208. If such support is impracticable and the conductors are in a dry location, they may be fished if separately enclosed in flexible tubing extending in continuous lengths from one support to the next or to an outlet box, or from one outlet box to another. Otherwise, conduit, armored cable, electrical metallic tubing or non-metallic sheathed cable shall be used.

3245. Conductor Separation. Conductors shall be separated at least 3 inches and maintained at least 1 inch from the surface wired over. 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. Where practicable, conductors shall be run singly on separate timbers or studding.

3246. 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 3209, 3210, 3211, and 3215 shall be complied with.

b. Conductors passing through cross timbers in plastered partitions shall be protected by an additional tube extending at least 3 inches above the timber.

3247. **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. If 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. If carried along the sides of rafters, studs or floor joists, neither running boards nor guard strips will be required.

3248. **Boxes of Insulating Material.** Non-metallic outlet boxes may be used as provided in section 3703.

ARTICLE 328—BARE-CONDUCTOR FEEDERS

3281. **Use.** By special permission, bare conductors installed in accordance with the provisions of sections 3001 to 3020 inclusive and in accordance with the provisions of the following sections 3282 to 3287 inclusive may be used for feeders only. Such bare conductors may be installed only in a chase, channel or shaft of non-combustible material in a building of fire-resistive construction; and only if 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 4807.

3282. **Size and Capacity of 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.

3283. **Branch Taps.** Branch taps from bare-conductor feeders may be installed as specified in section 2434; provided that the mechanical protection specified by subparagraphs c or d of section 2434 shall not be required for that portion of the conductor located in the chase, channel or shaft.

3284. **Accessibility.** The conductors shall not be accessible to other than qualified persons.

3285. **Supports.** Conductors shall be supported as follows:

a. Conductors shall be supported on non-combustible 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 93847 will be maintained under all conditions of operation.

3286. **Fire Cut-Offs.** If floors are pierced, suitable cut-offs against vertical travel of fire shall be provided.

3287 **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

3301. **Scope.** Installation of mineral insulated-metal sheathed cable (Type MI) shall comply with the provisions of sections 3001 to 3020 inclusive and in addition shall comply with the following sections 3302 to 3309. For the purpose of this article, mineral insulated-metal sheathed 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.

3302. **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; 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.

3303. **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.

3304. **Through Studs, Joists and Rafters.** Except for exposed work, Section 3010 shall apply.

3305. **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.

3306. **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.

3307. **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 and in addition, the conductors extending beyond the sheath shall be insulated with an approved insulating material.

3308. **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 3018.

3309. **Insulation Resistance.** The completed wiring system shall be tested for insulation resistance in accordance with Section 1119.

ARTICLE 334—ARMORED CABLE

3341. **Scope.** Installations of armored cable shall comply with the provisions of sections 3001 to 3020 inclusive, and in addition shall comply with the provisions of the following sections 3342 to 3348 inclusive.

3342. **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 (Type ACV) may be used only for exposed work in dry locations in buildings occupied for industrial purposes, and shall not be smaller than No. 4, except where approved for over 600 volts under sections 7105 and 7121. 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 5211; (2) in motion-picture studios; (3) in any hazardous locations; (4) where exposed to corrosive fumes or vapors; (5) in storage-battery rooms; (6) on cranes or hoists, except as provided in sub-paragraph 6113-c; nor (7) in hoistways or on elevators, except as provided in section 6206.

3343. **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 4½ feet and within 12 inches from every outlet box or fitting, except where cable is fished and except lengths of not over 24 inches at terminals where flexibility is necessary.

3344. **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 3346.

c. On the underside of floor joists in basements where supported at each joist and so located as not to be subject to mechanical injury.

3345. **Through Studs, Joists and Rafters.** See section 3010.

3346. **In Accessible Attics.** Cable in accessible attics or roof spaces shall be installed as follows:

a. If run across the top floor joists, or within 7 feet of floor or floor joist across the face of rafters or studding, the cable shall be protected by substantial guard strips which are at least as high as the cable. If the attic 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. If carried along the sides of rafters, studs or floor joists, neither guard strips nor running boards shall be required.

3347. **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 will not be required with lead-covered cables which shall be so installed that the lead sheath will be visible for inspection.

3348. **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.

ARTICLE 336—NON-METALLIC SHEATHED CABLE

Type NM and NMC

3361. Scope. Installations of non-metallic sheathed cable shall comply with the provisions of sections 3001 to 3020 inclusive, and shall also comply with the provisions of the following sections 3362 to 3370 inclusive.

3362. Use. Non-metallic sheathed cable may be used for both exposed and concealed work as follows:

a. **Type NM.** This type of non-metallic sheathed cable may be used for both exposed and concealed work in normally dry locations. It may be run 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 used for both exposed and concealed work in dry, moist, damp or corrosive locations, and in outside and inside walls of masonry block or tile. If 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 ¾ 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 5211, (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.

3363. 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 outlet box or fitting, except that in concealed work in finished buildings where such supporting is impracticable, the cable may be fished from outlet to outlet.

3364. Exposed Work—General. In exposed work, except as provided in sections 3366 and 3367, 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 mechanical injury where necessary, by conduit, pipe, guard strips or other means. If passing through a floor the cable shall be enclosed in rigid conduit or pipe extending at least 6 inches above the floor.

3365. Through Studs, Joists and Rafters. See section 3010.

3366. In Unfinished Basements. If 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.

3367. In Accessible Attics. Cable in accessible attics or roof spaces shall be installed as follows:

a. If run across the top of floor joists, or within 7 feet of floor or floor joists, across the face of rafters or studding, the cable shall be protected by substantial guard strips at least as high as the cable. If the attic 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. If carried along the sides of rafters, studs or floor joists, neither guard strips nor running boards shall be required.

3368. **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.

3369. **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. If connections to conductors are by binding-screw terminals, there shall be available as many screws as conductors, unless cables are clamped within the structure, or unless terminals are of a type approved for the purpose.

3370. Boxes of Insulating Material. Non-metallic outlet boxes approved for the purpose may be used as provided in section 3703.

ARTICLE 338—SERVICE-ENTRANCE CABLE

Types ASE, SE and USE

3381. Scope. Service-entrance cable used as service-entrance conductors shall comply with the provisions of Article 230. Service-entrance cable used for interior wiring shall comply with the provisions of sections 3001 to 3020 inclusive. Cable with metal interlocking armor shall be installed in accordance with the applicable provisions of Article 334. Unarmored cable shall be installed in accordance with the applicable provisions of Article 336. Service-entrance cable shall also comply with the provisions of sections 3382 and 3383.

3382. Use. Approved service-entrance cables may be used in interior wiring systems if all the conductors of the cable are of the rubber-covered or thermoplastic type; but if without individual insulation on the grounded conductor may be used only for range, clothes dryer and domestic water-heater circuits, or as feeders from a service cabinet to supply other buildings; or as service-entrance conductors for such other buildings, if the following conditions are met:

a. The cable has a final non-metallic outer covering.

b. The supply is alternating current not exceeding 150 volts to ground.

c. No domestic water-heater is supplied through a conductor without individual insulation.

3383. Through Studs, Joists and Rafters. See section 3010.

ARTICLE 339—UNDERGROUND FEEDER AND BRANCH CIRCUIT CABLE

Type UF

3391. **Scope.** Installations of underground feeder and branch circuit cable (Type UF) shall comply with the provisions of Sections 3001 and 3020 inclusive, paragraph b of Section 3102, and in addition shall conform with provisions of Section 3392.

3392. **Use.** Underground feeder and branch circuit cable may be used underground, including direct burial in the earth, as feeder or branch circuit cable when provided with overcurrent protection not in excess of the rated current carrying capacity of the individual conductors. If 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. If 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. Multiple conductor Type UF cable may also be used for interior wiring when complying with the provisions of Article 336, and may be used in wet locations.

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 5211, (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.

ARTICLE 340—NON-METALLIC WATERPROOF WIRING

3401. Scope. Installations of non-metallic waterproof wiring shall comply with the requirements of sections 3001 to 3020, and in addition the following sections 3402 to 3409 inclusive.

3402. Use. Subject to the approval of the authority enforcing this code, non-metallic waterproof wiring may be used for exposed work in breweries, ice plants, cold storage warehouses or similar wet locations where subject to mildly corrosive fumes and vapors, if the voltage does not exceed 300 volts between conductors or 150 volts to ground.

3403. Conductors. Rubber-sheathed multiple-conductor cable approved for the purpose shall be used. The individual conductors of the cable shall not be smaller than No. 12, except that the cable may contain an approved size of conductor, with or without individual insulation, to be used for equipment grounding purposes only. See paragraph a of section 2557.

3404. Supports. The cable shall be supported on insulators approved for the purpose and spaced at intervals not exceeding 3 feet.

3405. Attachment to Fittings. The cable shall be securely fastened to all outlet boxes, fittings and cabinets. A moisture-proof seal shall be provided between the cable and all outlet boxes, fittings and cabinets.

3406. Passing Through Walls. The cable shall be enclosed in rigid conduit, electrical metallic tubing, or approved insulating tubing, where passing through walls, and where so enclosed, the enclosure shall be sealed with a suitable fitting.

3407. Protection. Where exposed to mechanical injury the cable shall be protected.

3408. Boxes and Fittings. Boxes and fittings shall conform to the following:

a. Outlet boxes, fittings and cabinets shall be constructed of cast metal, insulating material or other material approved for the purpose.

b. Switch plates, fixtures, and similar parts shall be of insulating material when mounted on boxes, fittings, and cabinets of insulating material.

3409. Grounding. Metal boxes, fittings, or cabinets if used shall be grounded in accordance with Article 250.

ARTICLE 342—NON-METALLIC SURFACE EXTENSIONS

3421. Scope. Installations of non-metallic surface extensions shall comply with the provisions of sections 3001 to 3020 inclusive, and in addition shall comply with the provisions of the following sections 3422 to 3429 inclusive.

3422. Use. Non-metallic surface extensions may be used only if all of the following conditions are met:

a. The extensions are from existing outlets on branch circuits.

b. The extensions are run exposed in dry locations.

c. The building is occupied for residential or office purposes.

d. The extensions are not in unfinished basements, attics, or roof spaces.

e. The voltage does not exceed 150 volts between conductors.

f. The extensions are not subject to corrosive vapors.

3423. 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.

3424. Not to Run Outside Room. An extension shall not be run through a floor or partition, nor outside the room in which it originates.

3425. **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. 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.

3426. **Supports.** Non-metallic surface extensions shall be secured in place by approved means at intervals not exceeding 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.

3427. **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 if fittings completely covering the tap connections are used.

3428. **Bends.** A bend in an assembly which reduces the normal spacing between the conductors shall be covered with a cap to protect the assembly from mechanical injury.

3429. **Fittings.** Each run of an assembly 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

3441. **Use.** Underplaster extensions, installed as permitted by sections 3441 to 3444 inclusive, may be used only for extensions of existing branch circuits, if laid on the face of masonry or other material and buried in the plaster finish of ceilings or walls, in buildings of fire-resistive construction.

3442. **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 single conductors 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.

3443. **Limit of Run.** No such extension shall extend beyond the floor on which it originates unless standard sizes of rigid conduit, electrical metallic tubing or armored cable are employed.

3444. **Methods of Installation.** The methods of installation for such extensions shall be as specified elsewhere in this code for the particular type of material used, except that when alternating current is to be employed, all of the conductors of a circuit need not be contained in a single raceway or cable.

ARTICLE 346—RIGID METAL CONDUIT

3461. **Scope.** Installations of rigid metal conduit shall comply with the provisions of sections 3001 to 3020 inclusive and in addition shall comply with the provisions of the following sections 3462 to 3471 inclusive.

3462. **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.

If practicable, the use of dissimilar metals throughout 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.

3463. 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.

3464. 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.

3465. Minimum Size. No conduit smaller than ½ 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 section 4439, paragraph b.

3466. 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 4, 5 and 9 of Chapter 10.

2. Where conductors are of various sizes to be used in combination, use Tables 11 and 12 of Chapter 10 and the dimensions of rubber-covered conductors from Table 13.

b. **Rewiring existing conduits:** For rewiring existing conduits, the allowable fill may be determined from Tables 11 and 12 of Chapter 10 using the dimensions from Table 13 of wire actually used.

c. **Maximum number of conductors:** One conduit shall not contain more than nine conductors except as noted in Table 9 of Chapter 10.

3467. Reaming. All ends of conduits shall be reamed to remove rough edges.

3468. 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 b of section 3736 for the protection of conductors at bushings.

3469. Couplings. Threadless couplings and connectors used with conduit shall be made tight. If installed in wet places or if buried in masonry, concrete, or fill shall be of a type to prevent water from entering the conduit. Running threads shall not be used on conduit for connection at couplings.

3470. 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 the following table:

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.
1-¼ in.	8 in.	14 in.
1-½ in.	10 in.	16 in.
2 in.	12 in.	21 in.
2-½ in.	15 in.	25 in.
3 in.	18 in.	31 in.
3-½ in.	21 in.	36 in.
4 in.	24 in.	40 in.
5 in.	30 in.	50 in.
6 in.	36 in.	61 in.

3471. 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.

ARTICLE 348—ELECTRICAL METALLIC TUBING

3481. **Scope.** Installations of electrical metallic tubing shall comply with the provisions of Sections 3001-3020 inclusive, Sections 3464, 3471, and in addition, shall comply with the provisions of the following Sections 3482 to 3487 inclusive.

3482. **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 mechanical injury; (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; (3) in any hazardous locations except as otherwise provided in Article 500; (4) where exposed to corrosive vapor except as permitted in section 3483.

3483. **Corrosive Fumes.** If 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. If practicable, the use of dissimilar metals throughout the system shall be avoided to eliminate the possibility of galvanic action.

3484. **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.

3485. **Minimum and Maximum Sizes.** No tubing smaller than ½ 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 b of section 4439. The maximum size of tubing shall be the 2-inch electrical trade size.

3486. **Number of Conductors in Tubing.** One tubing shall not contain more conductors than as provided in section 3466.

3487. **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.

3488. **Couplings and Connectors.** Threadless couplings and connectors used with tubing shall be made up tight, and if to be buried in masonry, concrete, or fill, or if installed in wet places shall be of a type to prevent water from entering the raceway.

3489. **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 the table in section 3470.

3490. **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.

ARTICLE 350—FLEXIBLE METAL CONDUIT

3501. Scope. Installations of flexible metal conduit shall comply with the provisions of section 3001 to 3020, sections 3343, 3344, 3348, and of sections 3465 to 3468 inclusive, and in addition shall comply with the provisions of the following sections 3502 and 3503.

3502. 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 6206; (3) in storage-battery rooms; (4) in any hazardous location except as permitted by sections 5054 and 5073; nor (5) where rubber-covered conductors are exposed to oil, gasoline, or other materials having a deteriorating effect on rubber.

3503. 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 3442; (2) as permitted for motors by paragraph b of section 4439; 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.

Size AWG	Maximum Number of Conductors in 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

3511. Scope. 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.

3512. 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 mechanical injury; (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 (140F); (4) In any hazardous location, except as described in 5014-b, 5054, and 5073 of Article 500, unless it is specially approved for such use.

3514. Maximum Size. The maximum size of liquid-tight flexible metal conduit shall not exceed 1¼ inch electrical trade size.

3515. 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 RACEWAY

3521. **Scope.** Installations of surface metal raceways shall comply with the provisions of sections 3001 to 3020 inclusive and in addition shall comply with the provisions of the following sections 3522 and 3527 inclusive.

3522. **Use.** Surface metal raceway may be used 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 mechanical injury 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; (6) in storage-battery rooms; nor (7) in any hazardous location.

3523. **Size of Conductors.** No conductor larger than No. 6 shall be installed in surface metal raceway.

3524. **Number of Conductors in Raceways.** The number of conductors installed in any raceway shall not be greater than the number for which the raceway is approved, and in no case shall more than 10 conductors be installed in a single raceway compartment.

3525. **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.

3526. **Combination Raceways.** If 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.

ARTICLE 353—MULTI-OUTLET ASSEMBLY

3531. **Scope.** Installations of multi-outlet assembly shall comply with applicable provisions of Sections 3001 to 3020 inclusive and in addition shall comply with the provisions of the following Section 3532.

3532. **Use.** Multi-outlet assembly may be used in dry locations. It shall not be used (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 mechanical injury 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; (6) in storage battery rooms; nor (7) in any hazardous locations. Multi-outlet assembly shall not be extended through walls, partitions or floors.

ARTICLE 354—UNDERFLOOR RACEWAY

3541. **Scope.** Installations of underfloor raceways shall comply with the provisions of sections 3001 to 3020 inclusive and in addition shall comply with the provisions of the following sections 3542 to 3556 inclusive.

3542. **Use.** Underfloor raceways may be used when installed beneath the surface of concrete or other flooring material, or in office occupancies, when laid flush with the concrete floor and covered with linoleum or equivalent floor covering. Open-bottom type of raceways may be used in concrete fill between the rough and the finished floor only. Underfloor raceways shall not be used (1) if subject to corrosive vapors; (2) in any hazardous location; (3) in commercial garages; nor (4) in storage-battery rooms.

3543. **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 ¾ inches of concrete or wood above the raceway.

b. Raceways Over 4 Inches in Width or With Less Than ½ Inch Separation. Flat-top raceways over 4 inches in width or raceways of any width placed less than ½ inch apart, shall be covered with concrete to a depth of not less than 1½ inches.

c. Raceways Flush With Concrete. Approved metal flat-top raceways if not over 4 inches in width may, in office occupancies, be laid flush with the concrete floor surface if covered with substantial linoleum not less than ⅛ inch in thickness or with equivalent floor covering. When 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 ½ inch apart.

3544. 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 No. 0 Awg.

3545. 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 if the raceway contains only armored cable or nonmetallic sheathed cable, these requirements shall not apply.

3546. Splices and Taps. Splices or taps shall be made only in junction boxes.

3547. Discontinued Outlets. When an outlet is discontinued, the conductors supplying the outlet shall be removed from the raceway.

3548. Open-Bottom Raceway—How Laid. Open-bottom raceway 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, except that this thickness may be reduced to ¼ inch where the raceway crosses a run of conduit, and except 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. Raceways shall be mechanically secured to the concrete pad.

3549. 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 made mechanically secure to prevent disturbing this alignment during construction.

3550. **Markers at Ends.** At every end of line of raceway, a fitting shall be installed extending through 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.

3551. **Dead Ends.** Dead ends of raceways shall be closed.

3552. **Low Points.** Where practicable, raceways and their fittings shall be so arranged as to avoid low points that may form traps for water.

3553. **Special Fittings at Angles.** Where raceways are run at other than right angles, special fittings shall be provided, if in the judgment of the authority enforcing this code, these are necessary.

3554. **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.

3555. **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.

3556. **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.

ARTICLE 356—CELLULAR METAL FLOOR RACEWAYS

3561. Scope. Installations of cellular metal floor raceways shall comply with the provisions of sections 3001 to 3020 inclusive, and in addition shall comply with the provisions of the following sections 3562 to 3570. 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.

3562. Use. Conductors shall not be installed in cellular metal floor raceways (1) where subject to corrosive vapor; (2) in any hazardous location; (3) in commercial garages, except for supplying ceiling outlets or extensions to the area below the floor but not above; nor (4) in storage battery rooms. 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.

3563. Size of Conductors. No conductor larger than No. 0 shall be installed, except by special permission.

3564. 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 if the raceway contains only armored cable or non-metallic sheathed cable, these requirements shall not apply.

3565. Splices and Taps. Splices and taps shall be made only in header access units or junction boxes.

3566. Discontinued Outlets. When an outlet is discontinued, the conductors supplying the outlet shall be removed from the raceway.

3567. Markers. A suitable number of markers shall be installed extending through the floor for the future locating of cells and for system identification.

3568. 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.

3569. 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.

3570. 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.

ARTICLE 362—WIREWAYS

3621. Purpose and Scope. Wireways are sheet-metal troughs with hinged or removable covers for housing and protecting electrical wires and cables and in which conductors are laid in place after the wireway has been installed as a complete system. Installations of wireways shall comply with the provisions of sections 3001 to 3020 inclusive and in addition shall comply with the provisions of the following sections 3622 to 3630 inclusive.

3622. Use. Wireways may be used only for exposed work in dry locations. Wireways shall not be used (1) where subject to severe mechanical injury or corrosive vapor; (2) in hoistways; (3) in any hazardous location; nor (4) in storage-battery rooms.

3623. Size of Conductors. No conductor larger than 500,000 c.m. shall be installed in any wireway.

3624. 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 4 of Table 1 of Chapter 10 are not applicable to the foregoing.

3625. Splices and Taps. Splices or taps, made and insulated by approved methods, may be located within the wireway if they are accessible. The conductors, including splices and taps, shall not fill the wireway to more than 75 per cent of its area.

3626. 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.

3627. Extension Through Walls. Wireways may extend transversely through dry walls if in unbroken lengths where passing through.

3628. Dead-Ends. Dead-ends of wireways shall be closed.

3629. Extensions From Wireways. Extensions from wireways shall be made with rigid or flexible metal conduit, electrical metallic tubing, surface metal raceway or armored cable.

3630. Marking. Wireways shall be marked so that their manufacturer's name or trade mark will be visible after installation.

ARTICLE 364—BUSWAYS

3641. **Scope.** Installations of busways shall comply with the provisions of sections 3001 to 3020 inclusive and in addition shall comply with the provisions of the following sections 3642 to 3653 inclusive.

3642. **Use.** Busways may be used only for exposed work. Busways shall not be used (1) where subject to severe mechanical injury or corrosive vapors; (2) in hoistways; (3) in any hazardous location; (4) in storage-battery rooms; nor (5) outdoors or in wet or damp locations unless specially approved for the purpose.

Busways may be used for service-entrance conductors. See section 2331.

3643. **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. If a busway is installed in a vertical position, the supports for the busbars shall be designed for vertical installation.

3644. **Extension Through Walls.** Busways may extend transversely through dry walls if in unbroken lengths where passing through. Busways may extend vertically through dry floors if totally enclosed (unventilated) where passing through and for a minimum distance of six feet above the floor to provide adequate protection from mechanical injury.

3645. **Dead-Ends.** Dead-ends of busways shall be closed.

3646. **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.

3647. **Overcurrent Protection.** Overcurrent protection shall be provided in accordance with sections 3648 to 3652 inclusive.

3648. **Rating of Overcurrent Protection—Feeders and Sub-Feeders.** If 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, but not exceeding 150 per cent of the allowable current rating of the busway.

3649. **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.

3650. **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, except as permitted in section 2434. Where the overcurrent device is not readily accessible, it shall be enclosed or guarded until it is electrically disconnected from the busway.

3651. **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 applying to branch circuits of that rating.

3652. **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.

3653. **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.

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.

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

3701. Scope. The provisions of this article shall apply to the installation of outlet, switch and junction boxes, and fittings as required by section 3007. Installations in hazardous locations shall conform to Article 500.

3702. Use of Round Outlet Boxes. Round outlet 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.

3703. Non-Metallic Outlet Boxes. Non-metallic outlet 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.

3704. Metallic Outlet Boxes. When 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.

3705. 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 4162.

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.

3706. Depth of Boxes for Concealed Work. Outlet boxes for concealed work shall have an internal depth of at least 1½ inches, except that where the installation of such a box will result in injury to the building structure or is impracticable, a box not less than ½ inch internal depth may be installed.

3707. Supports—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.

a. **Concealed Work.** In concealed work, except as prescribed in paragraph b of this section, outlet 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 7/8 inch in thickness. Lath of wood, metal or composition shall not be considered a structural unit. See sections 4131 and 4132 for support of fixtures.

b. **Exposed Work.** In exposed work, and in concealed work in existing buildings where conductors or cables are fished and outlet boxes cannot be secured as provided in paragraph a of this section without disturbing the building finish, the boxes may be mounted directly upon the plaster surface if securely fastened in place.

3708. **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.

3. **Exceptions.** The limitations of sub-paragraphs 1 and 2 of this section 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 ports 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 section 3736 for insulation of conductors at bushings.

3709. Number of Conductors in a Box. Boxes shall be of sufficient size to provide free space for all conductors enclosed in the box.

a. The maximum number of conductors, not counting fixture wires, permitted in outlet and junction boxes shall be as in the following tables with the exceptions noted.

DEEP BOXES

Box Dimensions 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.

SHALLOW BOXES OF LESS THAN 1½″ DEPTH

Box Dimensions 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

The above tables apply where no fittings or devices, such as fixture studs, cable clamps, hickeys, switches or receptacles are contained in the box. Where one or more fixture studs, cable clamps, or hickeys are contained in the box, the number of conductors shall be one less than shown in the tables, with a further deduction of one for each flush device or combination of flush devices mounted on the same strap. A conductor running through the box is counted as one conductor, and each conductor terminating in the box is also counted as one conductor. 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:

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

c. The limitations in paragraphs a and b of this section 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 a and b of section 3709 do not apply to conductors used for rewiring existing raceways as referred to in Table 11, Chapter 10.

3710. Conductors Entering Boxes or Fittings. Conductors entering boxes or fittings shall be protected from abrasion, and shall conform to the following:

a. Openings to be Closed. Openings through which conductors enter shall be adequately closed.

b. Metal Boxes and Fittings. If metal outlet boxes or fittings are used 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 used with metal outlet boxes or fittings, the raceway or cable shall be secured to such boxes and fittings.

c. Non-Metallic Boxes. If 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 if supported within 8 inches of the box.

3711. 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 shall be used with non-metallic outlet boxes.

b. If 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.

3712. 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 shall not be used with non-metallic boxes or fittings unless recessed at least 1/4 inch from the outer surface.

3713. 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.

3714. 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.

3715. Position in Wall. In walls or ceilings of concrete, tile or other non-combustible 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 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.

3716. Repairing Plaster. Except on walls or ceilings of concrete, tile or other non-combustible 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.

3717. Junction Boxes to 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.

3718. 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.

3719. Boxes at Fixture Outlets. Boxes used at outlets for fixtures shall be designed for the purpose. At every outlet used exclusively for lighting, the box shall be so designed or installed that a fixture may be attached.

ARTICLE 373—CABINETS AND CUTOUT BOXES

3731. **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 Article 500.

3732. **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.

3733. **Position in Wall.** In walls of concrete, tile, or other non-combustible material, cabinets shall be so installed that the front edge of the cabinet will not set back of the finished surface more than ¼ inch. In walls constructed of wood or other combustible material, cabinets shall be flush with the finished surface or project therefrom.

3734. **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. If metal plugs or plates are used with non-metallic cabinets or cutout boxes, they shall be recessed at least ¼ inch from the outer surface.

3735. **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.** If metal cabinets or cutout boxes are used 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.

3736. 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:

Conductor Size	Minimum Width of Gutter in Inches
No. 1	3
No. 0 to 200,000 c.m.	4
211,600 to 500,000 c.m.	6
600,000 to 900,000 c.m.	8
1,000,000 to 1,400,000 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. If conduit bushings are constructed wholly of insulating material, a locknut shall be provided both inside and outside the enclosure to which the conduit is attached.

3737. 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.

b. Used as Junction Boxes. Switch enclosures shall not be used as junction boxes, troughs or raceways for conductors feeding through or tapping off to other switches, unless special designs are employed to provide adequate space for this purpose.

3738. 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 c and d of section 93732.

ARTICLE 374—AUXILIARY GUTTERS

3741. **Purpose.** Auxiliary gutters, used to supplement wiring spaces at meter centers, distribution centers, switchboards and similar points of interior wiring systems, may enclose conductors or bus-bars, but shall not be used to enclose switches, overcurrent devices or other appliances or apparatus.

3742. **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.

3743. **Supports.** Gutters shall be supported throughout their entire length at intervals not exceeding 5 feet.

3744. **Covers.** Covers shall be securely fastened to the gutter.

3745. **Number of Conductors in Raceway.** 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.

For elevators see section 6215.

The correction factors specified in Note 4 of Table 1 of Chapter 10 are not applicable to the foregoing.

3746. **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.

3747. **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 spacing 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.

3748. 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 if 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 2434.

3749. Construction. 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 raceway 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:

Maximum Width of the Widest Surface of Gutters	Thickness (USS Sheet Steel Gauge)
Up to and including 6 inches	No. 16—.0598 inch
Over 6 in. and not over 18 in.	No. 14—.0747 inch
Over 18 in. and not over 30 in.	No. 12—.1046 inch
Over 30 inches	No. 10—.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 3736 shall apply.

ARTICLE 380—SWITCHES

3801. **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.

3802. **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, if in metal enclosures, be run with both polarities in the same enclosure.

3803. **Enclosures.** Switches and circuit-breakers, except pendent and surface type snap switches and knife switches mounted on an open face switchboard or panelboard, shall be of the externally operable type enclosed in metal boxes or cabinets.

3804. **Wet Locations.** If a switch or circuit-breaker is in a wet location or outside of a building, it shall be enclosed in a weatherproof enclosure or cabinet installed to conform to section 3732.

3805. **Time Switches, Flashers and Similar Devices.** Time switches, flashers and similar devices, unless mounted on switchboards or control panels, if not in approved individual housing, shall be enclosed in metal boxes or cabinets but need not be of the externally-operable type.

3806. **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 if the throw be vertical a locking device shall be provided which will insure the blades remaining in the open position when so set.

3807. **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.

3808. **Accessibility and Grouping.** Switches and circuit-breakers, so far as practicable, shall be readily accessible and shall be grouped.

3809. **Covers of Flush Snap Switches.** Flush snap switches, if 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, if of metal, shall be not less than 0.04 inch in thickness, and plates of non-conducting, non-combustible material shall be not less than 0.10 inch in thickness.

3810. **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 ½ inch from the surface wired over.

3811. **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.

3812. **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.

3813. **Knife Switches.** 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. 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. Knife switches of lower rating may be used as general-use switches and may be opened under load. Motor-circuit switches (see definition) may be of the knife-switch type.

3814. **Rating of Snap Switches.** Snap switches 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 loads, and for combined tungsten-filament and non-inductive loads, switches shall be "T" rated, except where the three following qualifications are satisfied:

1. If 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 when 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. When 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.

For switches on signs and outline lighting, see sections 6002, 6003 and 6004.

For switches controlling motors, see sections 4383 and 4403.

ARTICLE 384—SWITCHBOARDS AND PANELBOARDS

3841. **Scope.** The requirements of this article shall apply to all switchboards, panelboards, and distribution boards used for the control of light and power circuits, except switchboards in utility company operated central stations and/or sub-stations, which directly control energy derived from generators or transforming devices, and except switchboards or portions thereof used exclusively to control signal circuits operated by batteries. The requirements of this article shall apply to battery-charging panels if current is taken from light or power circuits.

3842. **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, 370, 380 and other articles which apply. Switchboards and panelboards in hazardous locations shall conform to the requirements of Article 500.

3843. **Support of Bus-bars and Conductors.** Conductors and bus-bars on a switchboard, panelboard or control board shall be so located as to be free from mechanical injury and shall be held in such a manner as to be rigid.

Switchboards

3851. **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.

3852. **Wet Locations.** If a switchboard is in a wet location or outside of a building, it shall be enclosed in a weatherproof enclosure or cabinet installed to conform to section 3732.

3853. **Location Relative to Easily Ignitible Material.** Switchboards shall be so placed as to reduce to a minimum the probability of communicating fire to adjacent easily ignitible material.

3854. **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.

3855. **Clearance Back of Switchboard.** If 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. If 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.

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 1112.

3856. **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, and be one of the following types: R, RH, V, AVA, AVB, T, TA or Type MI cable.

3857. **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.

3858. **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.

3859. **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 2621 to 2625.

Panelboards

3880. **General.** All panelboards shall have a rating not less than the minimum feeder capacity required for the load as computed from Article 220.

3881. **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% of its overcurrent devices rated 30 amperes or less, for which neutral connections are provided.

3882. **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.

3883. **Overcurrent Protection.**

a. Except as installed for service as in paragraph a.3. of Section 2371, 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.

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% of the circuit loading, as determined by Articles 210 and 220.

3884. **Panelboards in Damp or Wet Locations.** Panelboards in damp or wet locations shall be installed in conformity to section 3732.

3885. **Enclosure.** Panelboards shall be mounted in cabinets or cutout boxes.

3886. **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 2375.

ARTICLE 390—PREFABRICATED BUILDINGS

3901. 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.

3902. Wiring Methods. Only wiring methods recognized in this code shall be used.

3903. 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

4001. General. Flexible cords shall be suitable for the conditions of use and location.

4002. Types. Cords of the several types shall conform to the descriptions of Table 31 of Chapter 10. Types of flexible cords other than those listed in Table 31, and other uses for types listed in the table, shall be the subject of special investigations and shall not be used before being approved.

4003. 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. Flexible cord shall not be used (a) as a substitute for the fixed wiring of a structure; (b) where run through holes in walls, ceilings, or floors; (c) where run through doorways, windows, or similar openings; (d) where attached to building surfaces; or (e) where concealed behind building walls, ceilings, or floors.

4004. Splices. Flexible cord shall be used only in continuous lengths without splice or tap.

4005. 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 fixtures, and for supplying current to portable lamps and other merchandise for exhibition purposes.

4006. 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.

4007. Insulation—Over 300 Volts. If 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.

4008. 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 2403. Cords shall be not smaller than required by Table 3, Chapter 10, for the rated current of the appliance.

4009. 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.

4010. 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 section 2559-a. and 2559-b. unless excepted elsewhere in this Code.

This requirement becomes effective January 1, 1955.

ARTICLE 410—LIGHTING FIXTURES, LAMPHOLDERS, LAMPS, RECEPTACLES AND ROSETTES

General

4101. 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 sections 4102 to 4216 inclusive, except as otherwise provided in this code.

4102. Application to Other Articles. Equipment for use in hazardous locations shall conform to Article 500.

4103. 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.

Provisions For Fixture Locations

4111. Fixtures in Damp, Wet or Corrosive Locations. Fixtures installed in damp or wet locations shall be of vaportight or other types approved for such locations and shall be so constructed or installed that water cannot enter or accumulate in wireways, lampholders or other electrical parts. Fixtures installed in corrosive locations shall be of a type approved for such locations.

4112. 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 90C (194F).

4113. Fixtures over Combustible Material. Lampholders installed over specially combustible material shall be of the unswitched type and unless individual switches are provided, 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.

4114. Fixtures in Show-Windows. No externally-wired fixture other than of the chain type shall be used in a show-window. For use of cords in show-windows, see section 4005.

4115. Fixtures in Clothes Closets. Fixtures in clothes closets shall be installed on the ceiling or on the wall above the door. Pendants shall not be installed in clothes closets.

4116. Space for Cove Lighting. Coves shall have adequate space and shall be so located that lamps and equipment can be properly installed and maintained.

Provisions at Fixture Outlet Boxes, Canopies and Pans

4121. 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.

4122. Temperature Limit of Conductors in Outlet Boxes. Fixtures shall be of such construction or so installed that the conductors in outlet boxes will not be subjected to temperatures greater than that for which the conductors are approved.

4123. 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.

4124. 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.

4125. 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 mechanical injury.

Fixture Supports

4131. 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.

4132. Means of Support. Where there is an outlet box or a fitting which will provide adequate support, a fixture shall be attached thereto; otherwise a fixture shall be supported as required by section 3707. A fixture which weighs more than 50 lbs. shall be supported independently of the outlet box.

Wiring of Fixtures

4141. Fixture Wiring—General. Wiring on or within fixtures shall be neatly arranged and not exposed to mechanical injury. Excess wiring shall be avoided. Conductors shall be so arranged that they will not be subjected to temperatures above those for which they are approved.

4142. Conductor Size. Fixture conductors shall not be smaller than No. 18.

4143. Conductor Insulation. Fixtures shall be wired with conductors having insulation suitable for the current, voltage, and temperature to which the conductors will be subjected. Where fixtures are installed in damp, wet, or corrosive locations, conductors shall be of a type approved for such locations. For current-carrying capacity of fixture wire, see Table 3, Chapter 10. For maximum operating temperature and voltage limitation of fixture wires, see section 3102.

4144. Conductors for Special Conditions. Fixtures provided with mogul base screw-shell lampholders and operating at not more than 300 volts between conductors shall be wired with Type AF fixture wire. 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 fixture wire or Type AFC, AFPO, or AFPD flexible cord; except that where temperatures do not exceed 90C (194F) Type CF fixture wire or Type CFC, CFPD, or CFPO flexible cord may be used or where temperatures exceed 60°C. but not higher than 75°C. Type RH rubber covered wire, Types RFH-1, RFH-2, FFH-1, and FFH-2 fixture wires may be used. 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 wires 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.

See Section 3102 for fixture wires and conductors; also, Table 31 for flexible cords.

4145. Conductors for Movable Parts. Stranded conductors shall be used on chain fixtures and other movable parts. Conductors shall be so arranged that the weight of the fixture or movable parts will not put a tension on the conductors.

4146. Pendent Conductors for Incandescent Filament Lamps. Pendent lampholders with permanently attached leads, if 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. 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. If the pendent conductors are longer than 3 feet, they shall be twisted together.

4147. Protection of Conductors. Conductors shall be secured in a manner that will not tend to cut or abrade the insulation. Conductors shall be protected from abrasion where they pass through metal. Exposed flexible cord or fixture wire shall not be used to supply permanently installed fixtures in show cases or wall cases.

4148. 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 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 9/32 inch in diameter are suitable for use with plain pendent cord and holes 13/32 inch in diameter with reinforced cord.

4149. Connections, Splices and Taps. 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. Splices and taps shall not be located within fixture arms or stems. No unnecessary splices or taps shall be made within or on a fixture. For approved means of making connections, see section 1118.

4150. 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 (a) an installation of fixtures approved for end to end assembly to form a continuous raceway; or, (b) fixtures which are connected together by approved wiring methods.

4151. 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 2004.

Lampholders

4156. Lampholders, Screw-Shell Type. Lampholders of the screw-shell type shall be installed for use as lampholders only.

4157. 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 2007.

4158. Lampholders in Damp or Wet Locations. Lampholders installed in damp or wet locations shall be of the weatherproof type.

Receptacles

4161. Rating and Type. 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. Face plates, if of metal shall not be less than 0.04 inch in thickness, or plates shall be of non-conducting non-combustible material not less than 0.10 inch in thickness.

4162. Receptacles in Floors. Receptacles located in floors shall be enclosed in floor boxes especially approved for the purpose, except that where such receptacles are located in elevated floors of show-windows or other locations, where the authority enforcing this code judges them to be free from mechanical injury, moisture and dirt, the standard approved type of flush receptacle box may be used.

4163. Receptacles in Damp or Wet Locations. Receptacles installed in damp or wet locations shall be of the weatherproof type.

4164. Receptacles—Grounding Type. Receptacles (1) installed for the attachment of flexible cords that have a grounding conductor, (2) having maximum ratings of 15 amperes and of 150 volts, (3) having two current-carrying contacts 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.

4165. Attachment Plug Caps. Attachment plug caps to be used with Receptacles—Grounding Type, Section 4164, 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.

Rosettes

4166. Approved Types. Fusible rosettes shall not be installed. Separable rosettes which make possible a change in polarity shall not be used. For construction specifications, see section 94104.

4167. Rosettes in Damp and Wet Locations. Rosettes installed in damp or wet locations shall be of the weatherproof type.

Construction

4171. Combustible Shades and Enclosures. Adequate air space shall be provided between lamps and shades or other enclosures of combustible material.

4172. Portable Handlamps. Handlamps of the portable type supplied through flexible cords shall be of the molded composition or other type approved for the purpose. Brass-shell paper-lined lampholders shall not be used. Handlamps shall be equipped with a handle. Where subject to mechanical 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 5105.f.3.

4173. Marking. 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. 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.

Special Provisions for Flush and Recessed Fixtures

4176. Approved Type. Fixtures which are installed in recessed cavities in walls or ceilings shall be of an approved type and shall conform to sections 4177 to 4180 inclusive.

4177. Temperature. Fixtures shall be so constructed or installed that adjacent combustible material will not be subjected to temperatures in excess of 90C (194F). Where a fixture is recessed in fire-resistant material in a building of fire-resistant construction, a temperature higher than 90C (194F), but not higher than 150C (302F) is acceptable if the fixture is plainly marked that it is approved for that service.

4178. Clearance. Recessed portions of enclosures, other than at points of support, shall be spaced at least ½ inch from combustible material.

4179. Wiring. Conductors having insulation suitable for the temperature encountered shall be used. Fixtures having terminal connections which operate at temperatures higher than 60C (140F) shall have circuit conductors as is described, (a) or (b) below:

a. Branch circuit conductors having an insulation suitable for the temperature encountered may be run directly to the fixture.

b. 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 (1) 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.

4180. **Construction.** For the construction of flush and recessed fixtures, see section 94105.

Special Provisions for Electric Discharge Lighting Systems of 1,000 Volts or Less

4181. **General.** 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. In addition to complying with the general requirements for lighting fixtures, such equipment shall conform to sections 4182 to 4187 inclusive. Transformers of the oil-filled type shall not be used. The terminals of an electric discharge lamp shall be considered as alive if any lamp terminal is connected to a potential of more than 300 volts.

4182. **Direct-Current Equipment.** Fixtures shall be installed on alternating-current circuits only, unless the fixtures are equipped with auxiliary equipment and resistors especially designed and approved for direct-current operation and the fixtures are so marked.

4183. **Voltages — Dwelling Occupancies.** Equipment having an open-circuit voltage of more than 1000 volts shall not be installed in dwelling occupancies. 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.

4184. **Fixture Mounting.** Fixtures having exposed ballasts or transformers shall be so installed that such ballasts or transformers shall not be in contact with combustible material.

4185. **Auxiliary Equipment Not Integral with Fixture.** 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. 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.

4186. **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.

4187. **Switches.** Snap switches shall conform to section 3814.

Special Provisions for Electric Discharge Lighting Systems of More Than 1,000 Volts

4191. **General.** 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. In addition to complying with the general requirements for lighting fixtures, such equipment shall conform to section 4191 to section 4203 inclusive. 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.

For signs and outline lighting, see Article 600.

4192. **Control.** Fixtures or lamp installations shall be controlled either singly or in groups by an externally-operable switch or circuit-breaker which will open all ungrounded primary conductors. 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.

4193. **Switches.** Snap switches shall conform to section 3814.

4194. **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.

4195. Transformer Type. Transformers shall be of an approved enclosed type. Transformers of other than the askarel insulated or dry type shall not be used.

4196. Transformer Secondary Connections. 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. The grounded ends shall be connected by an insulated conductor not smaller than No. 14.

4197. Location of Transformers. Transformers shall be accessible after installation. The transformers should be installed as near to the lamps as practicable to keep the secondary conductors as short as possible. Transformers shall be so located that adjacent combustible materials will not be subjected to temperatures in excess of 90C.

4198. 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 6031.

4199. 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.

4200. Lamp Supports. Lamps shall be adequately supported as required in section 6033.

4201. Mechanical Injury. Lamps shall not be located where normally exposed to mechanical injury.

4202. 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.

4203. 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.

Arc Lamps

4205. General. Arc lamps used in theatres shall conform to section 5284, and arc lamps used in projection machines shall conform to section 5431. Arc lamps used on constant-current systems shall conform to the general requirements of Article 710.

Grounding

4211. General. Fixtures and lighting equipment shall be grounded as provided in sections 4212 to 4216 inclusive.

4212. Metallic Wiring Systems. Metal fixtures installed on outlets wired with grounded metal raceway or grounded armored cable shall be grounded.

4213. 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 except as follows:

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 4215.

2. Fixtures not mounted on metal or metal-lath ceilings or walls need not be insulated or grounded. See section 4215.

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.

4214. Equipment of More Than 150 Volts to Ground. Metal fixtures, transformers and transformer enclosures on circuits operating at more than 150 volts to ground shall be grounded. 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.

4215. Fixtures, Lampholders and Receptacle Plates Near Grounded Surfaces. 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. Metal pull chains used at these locations shall be provided with insulating links.

4216. Methods of Grounding. Equipment shall be considered as grounded when mechanically connected in a permanent and effective manner to metal raceway, the armor of armored cable, the grounding conductor in nonmetallic sheathed cable, or a separate grounding conductor not smaller than No. 14, providing that the raceway, armor, or grounding conductor is grounded in a manner specified in Article 250.

ARTICLE 422 — APPLIANCES

4221. Scope. This article shall apply to electric appliances used in any occupancy.

4222. 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 29 of Chapter 10 for the conductors of a household range branch circuit.

Installation of Appliances

4231. Insulation of Cords. Flexible cords used to connect heating appliances shall comply with the following:

a. **Appliances Requiring Heater Cords.** Flexible cords used to connect smoothing irons, or to connect portable electrically-heated appliances rated at more than 50 watts and which produce temperatures in excess of 121C (250F) on surfaces with which the cord is liable to be in contact, shall be one of the types of approved heater cords listed in Table 31, Chapter 10.

b. **Other Heating Appliances.** All other portable electrically-heated appliances shall be connected by one of the approved types of cord listed in Table 31, Chapter 10, selected in accordance with the usage specified in that table.

4232. 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 mechanical injury, it shall be suitably protected.

4233. 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.

4234. **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.

4235. **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.

4236. **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.

4237. **Infra-Red Lamp Industrial Heating Appliances.** 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. Screw-shell lampholders shall not be used with infra-red lamps over 300 watts rating unless the lampholders are especially approved for the purpose. These 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.

4238. **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 2557 and 2560.

Control and Protection of Appliances

4241. Disconnecting Means. Each appliance shall be provided with a means for disconnection from all ungrounded conductors as follows:

a. Portable Appliances. For portable appliances (including household ranges and clothes dryers) a separable connector or an attachment plug and receptacle may serve as the disconnecting means. 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. Attachment plug caps 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.

b. Stationary Appliances. For stationary appliances rated at not over 300 volt amperes or 1/8 horsepower, the branch-circuit overcurrent device may serve as the disconnecting means. For stationary appliances of greater rating the branch-circuit switch or circuit-breaker may, if readily accessible to the user of the appliance, serve as the disconnecting means.

c. Unit Switches. Switches which are a part of an appliance shall not be considered as taking the place of the single disconnecting means required by this section unless there are other means for disconnection as follows:

1. **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.

2. **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.

3. **Single-Family Dwellings.** In single-family dwellings, the service disconnecting means may be used.

4. **Other Occupancies.** In other occupancies, the branch-circuit switch or circuit-breaker, if readily accessible to the user of the appliance, may be used for this purpose.

d. Switch or Circuit-Breaker to Be Indicating. Switches or circuit-breakers used as disconnecting means shall be of the indicating type.

e. Motor-Driven Appliances. A switch or circuit-breaker which serves as the disconnecting means for a stationary motor-driven appliance of more than 1/8 horsepower shall be located within sight of the motor controller or shall be capable of being locked in the open position.

4242. **Overcurrent Protection.** 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. 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 29, Chapter 10, shall have the main circuit subdivided into two or more circuits, each provided with overcurrent protection rated at not more than 50 amperes. Infra-red lamp heating appliances shall have overcurrent protection not exceeding 50 amperes.

4243. **Flatirons.** Except as permitted in Section 4236 electrically heated smoothing irons shall be equipped with an approved temperature limiting device.

4244. **Water Heaters.** It is recommended that permanently-installed electrically heated water heaters be equipped with temperature-limiting means.

Marking of Appliances

4261. 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.

4262. **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.

Special Provisions For Fixed Electrical Space Heating

4271. **General.** Equipment for use with electrical space heating systems shall be of a type approved for such service.

In addition to complying with the general requirements for appliances, such equipment shall comply with sections 4271 to 4286 inclusive.

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.

Electrical space heating systems employing methods of installation other than covered by sections 4271 to 4286 inclusive may be used only by special permission.

4272. **Use.** Space heating systems shall not be used

(1) where exposed to severe mechanical injury unless adequately protected.

(2) in wet or damp locations unless specially approved for the purpose.

See also rules on Corrosive Conditions, Section 3102 b and c.

4273. **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.)

4274. **Appliances to be Complete Units.** Panels and cables shall be installed in their complete sizes or lengths as supplied by the manufacturer. Units which are shortened or from which the marking labels or nameplates are missing shall not be installed. Units shall be suitable for use with approved wiring systems.

4275. **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.

4276. 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.

4277. 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 4241, 4241-b and 4241-d for disconnecting means for stationary appliances.

4278. 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 factor given in Table 1, Chapter 10.

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 factor given in Table 1, Chapter 10.

4279. 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 of Table I, Chapter 10.

4280. **Confinement in One Room.** Panels shall not extend beyond the room in which they originate. 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, except that single runs of cable may pass over partitions where embedded. This requirement shall not prohibit low-temperature heat sources in closets to control relative humidity.

4281. **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.

4282. **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.

4283. **Installations of Heating Cables in Plaster.**

a. Cables shall not be installed in walls.

b. Adjacent runs of cable not exceeding 2¾ watts per foot shall be installed not less than 1½ 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 plaster or of other approved material having a nominal thickness of ½-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. Cables shall be kept free from contact with metal or conducting surfaces.

4284. **Installation of Non-Heating Leads.** 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. 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. The marking of the leads shall be visible in the junction box.

4285. **Installation of Cables in Concrete or Poured Masonry Floors.**

a. Adjacent runs of cable not exceeding 2¾ 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.

4286. **Tests During and After Installation.** 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.

Cable shall be tested for insulation resistance after plastering or the pouring of floors. See Section 1119, Insulation Resistance.

ARTICLE 430—MOTORS AND MOTOR CONTROLLERS

General

4301. **General.** It is intended that the following general provisions shall cover all provisions for motors and controllers which do not properly fall into the other divisions of this article. 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.

4302. **Application of Other Articles.** Motors and controllers shall also comply with the provisions of the following:

Auto-transformers	Section 2003
Capacitors	Section 4608
Cranes and Hoists	Article 610
Elevators	Article 620
Garages, Aircraft Hangars, Dispensing and Service Stations, Bulk Storage Plants, Finishing Processes and Combustible Anesthetics	Article 510
Hazardous Location	Article 500
Machine Tools	Article 670
Motion-picture Projectors	Sections 5411, 5416
Motion-picture Studios	Article 530
Organs	Section 6503
Resistors and Reactors	Article 470
Theaters	Section 5246

4303. **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.

4304. **Identification of Motors**

a. **General Motor Applications.** Except as noted in Paragraph (b) below, a motor shall be provided with a name plate which shall give 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. For a motor rated at 1/8 horsepower or larger the horsepower rating shall be marked, except that the motors of arc welders may be marked in amperes. A motor provided with a protective device integral with the motor (see Section 4322), shall have a marking which will so indicate. For an alternating-current motor rated at 1/2 horsepower or larger, except a polyphase wound-rotor motor, the name plate shall be marked with a code letter to show its input in kilovolt-amperes with locked rotor, selected from the table given in Section 94304, Chapter 9.

The code letter indicating motor input with locked rotor must be in an individual block on the name plate, properly identified. This code letter is to be used for determining branch-circuit overcurrent protection by reference to Table 26, Chapter 10, as provided in Section 4342.

b. Sealed (Hermetic-Type) Refrigeration Compressor Motors. Sealed (hermetic-type) refrigeration compressors shall be provided with a name plate 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 polyphase motors shall also be marked on the name plate. If a protective device integral with a motor is used (see Section 4322), the name plate shall have a marking which will so indicate.

4305. Identification of Controllers. A controller shall be marked with the maker's name or identification symbol, 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 since the necessary data must be on the motor nameplate.

4306. Identification of Terminals. Terminals of motors and controllers shall be suitably identified, as by marking or color, where necessary to indicate the proper connections.

4307. **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.

4308. **Enclosures.** 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.

4309. **Current-Carrying Capacities.** Current-carrying capacities shall be determined as follows:

a. **General Motor Applications.** Except as noted in Paragraph b below, 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 21 to 24 of Chapter 10, including footnotes, shall be used in lieu of actual current rating marked on the motor nameplate. Motor running overcurrent protection shall be based on the motor nameplate current rating. If 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 21 to 24, prorated if necessary.

b. **Sealed (Hermetic-Type) Refrigeration Compressor Motors.** For sealed (hermetic-type) refrigeration compressor motors the current-carrying capacity of the branch-circuit conductors, branch circuit over-current protection and motor running over-current protection shall be selected on the basis of the full-load current marked on the compressor name plate. For motor controllers and disconnecting means, see Sections 4383 (e) and 4403.

4310. **Location of Motors.** 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. 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.

Size of Conductors for Motor Circuits

4311. General. It is the intent of the following provisions to specify sizes of conductors capable of carrying the motor current without overheating under the conditions specified.

4312. Individual Motor. Branch-circuit conductors supplying an individual motor shall have a carrying capacity not less than 125 per cent of the motor full-load current rating; provided, that conductors for motors used for short-time, intermittent, periodic, or varying duty may have a carrying capacity not less than the percentage of the motor name-plate current rating as shown in the following table, unless the authority enforcing the code grants special permission for conductors of smaller size.

Classification of Service	Percentages of Name-Plate Current Rating			
	5-Minute Rating	15-Minute Rating	30 & 60-Minute Rating	Continuous Rating
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
	or lower at the discretion of the authorities enforcing the regulations.			

*This figure also applies for conductors which supply a motor-generator single-operator arc welder which has a 60 per cent duty cycle rating.

Any motor 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.

The size of conductor calculated on the basis of 125 per cent of the motor full-load current for the more usual motor ratings is shown in Table 20, Chapter 10.

For long runs, it may be necessary in order to avoid excessive voltage drop, to use conductors of sizes larger than the minimum sizes given in Table 20, Chapter 10.

See example No. 8, Ch. 10, and Diagram No. 20, Ch. 10.

The conductors between stationary motors, rated 1 H. P. or less, and the separate terminal enclosures permitted in paragraph 4439-b may be smaller than No. 14 but not smaller than No. 18, provided they have current-carrying capacity as specified above.

4313. Wound-Rotor Secondary. The conductors connecting the secondary of a wound-rotor A.C. 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 if for continuous duty. 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 the table in section 4312. 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 the following table:

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

4314. 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 10.

4315. 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 4314, or, for a single motor, in accordance with section 4312.

4316. **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 4314 and 4315, 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.

Motor Overcurrent Protection

4321. **General.** The following provisions specify overcurrent devices intended to protect the motors, the motor-control apparatus, and the branch-circuit conductors against excessive heating due to motor overloads.

For fire-pump motors, see National Fire Codes Vol. IV or NFPA pamphlet No. 20—Standards for the Installation and Operation of Centrifugal Fire Pumps.

4322. **Continuous Duty Motors.** Each continuous duty motor shall be protected against running over-current as follows:

a. **More Than One Horsepower.** For a motor rated more than one horsepower, this protection shall be secured 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 set at not more than 125 per cent of the motor full-load current rating for motors marked to have a temperature rise not over 40C, and at not more than 115 per cent for all other types of motors. For other than sealed (hermetic-type) refrigeration compressor motors this value may be modified as permitted by section 4324.

2. A protective device integral with the motor which is responsive to motor current or to both motor current and temperature. This device must be approved for use with the motor which it protects on the basis that it will prevent dangerous over-heating 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 must 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. Any motor of one horsepower or less which is manually started and which is within sight from the starter 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 20, Chapter 10, 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 out of sight from the starter location shall be protected as specified in paragraph c for automatically started motors.

A distance of more than 50 feet is considered equivalent to being out of sight.

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 set at not more than 125 per cent of the motor full-load current rating for motors marked to have a temperature rise not over 40C, and at not more than 115 per cent for all other types of motors. For other than sealed (hermetic-type) refrigeration compressor motors this value may be modified as permitted by section 4324.

2. A protective device integral with the motor which is responsive to motor current or to both motor current and temperature. This device must be 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 must be so arranged that the opening of the control circuit will result in interruption of current to the motor.

3. If 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 name-plate of the assembly where it will be visible after installation.

4. If 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 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.

4323. **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 the table in section 4312) is considered as protected against overcurrent by the branch-circuit overcurrent device, provided the overcurrent protection does not exceed that specified in Tables 26 and 27, Chapter 10.

Any motor 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.

4324. **Selection or Setting of Protective Device.** Except for sealed (hermetic-type) refrigeration compressor motors, 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 cutouts, 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 motors marked to have a temperature rise not over 40C and not higher than 130 per cent of the full-load current rating for all other motors. If not shunted during the starting period of the motor (see section 4325), the protective device shall have sufficient time delay to permit the motor to start and accelerate its load.

4325. **Shunting During Starting Period.** If the motor 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 the motor shall be considered as protected against overcurrent during the starting period if 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. The motor-running overcurrent protection shall not be shunted or cut out during the starting period if the motor is automatically started.

4326. Fuses—In Which Conductor. If fuses are used for motor-running protection, a fuse shall be inserted in each ungrounded conductor, except that a fuse shall also be inserted in a grounded conductor under the circumstances set forth in the note following Section 4327 for circuits supplied by wye-delta or delta-wye connected transformers.

4327. Devices Other Than Fuses—In Which Conductor. If devices other than fuses are used for motor running protection, the following table shall govern the minimum allowable number and location of overcurrent units such as trip coils, relays, or thermal cutouts.

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

Kind of Motor	Supply to System	Number and location of over-current units, such as trip coils, relays or thermal cutouts
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.

4328. Number of Conductors Disconnected by Overcurrent Device. Motor-running protective devices, other than fuses or thermal cutouts, shall simultaneously disconnect a sufficient number of ungrounded conductors to interrupt current flow to the motor.

It is recommended that all ungrounded conductors be opened if devices capable of accomplishing this are available.

4329. Motor Controller as Running Protection. A motor controller may also serve as the running overcurrent device if the number of overcurrent units complies with the foregoing section 4327, and if these overcurrent units are operative in both the starting and running position in the case of a d-c motor, and in the running position in the case of an a-c motor.

4330. **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.

4331. **Rating of Protective Device.** Motor-running overcurrent devices other than fuses shall have a rating of at least 115 per cent of the full-load current rating of the motor.

4332. **With Lamps or Receptacles.** Overcurrent protection for motors used on branch circuits which also supply lamps or receptacles, as permitted in Article 210, shall be provided as follows:

a. One or more motors without individual overcurrent protection may be connected to the branch circuits described in Article 210 only when the limiting conditions specified for each of two or more motors in paragraph a of section 4343 are complied with.

b. Motors of larger ratings than specified in paragraph a of section 4343 may be connected to the branch circuits described in Article 210 only if provided with individual running overcurrent protection selected to protect the motor as specified in section 4322. 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.

c. If a motor is connected to a branch circuit by means of a plug and receptacle, and individual overcurrent protection is omitted as provided in paragraph a, the rating of the plug and receptacle shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts. If individual overcurrent protection is required as provided in paragraph 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.

4333. 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.

Motor-Branch-Circuit Overcurrent Protection

4341. General. The following provisions 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.

4342. Rating or Setting for Individual Motor. 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 Tables 26 or 27, Chapter 10; 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 7, 8, 9 and 10 of Table 20, Chapter 10.

See Example No. 8, Chapter 10, and Diagram No. 20, Chapter 10.

4343. 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 1 horsepower in rating and each having a full-load rated current 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 4322.

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 4342 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 4330 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 4312; the conductors to the motor running protective device being not more than 25 feet long and being protected from mechanical injury.

4344. Combined Overcurrent Protection. Motor-branch-circuit overcurrent protection and motor-running overcurrent protection may be combined in a single overcurrent device if the rating or setting of the device provides the running overcurrent protection specified in section 4322.

4345. Overcurrent Devices—In Which Conductor. Overcurrent devices shall comply with the provisions of section 2405.

4346. **Capacity of Fuseholder.** If 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 20; except that where fuses having time delay appropriate for the starting characteristics of the motor are used, fuse-holders of smaller size than specified in Table 20 may be used.

4347. **Rating of Circuit-Breaker.** Circuit-breakers for motor-branch-circuit protection shall have a continuous current rating of not less than 115 per cent of the full-load current ratings of the motors.

4348. **Feeder Taps in Inaccessible Location.** If the location 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 1/3 that of the feeder and are not more than 25 feet long and are protected from mechanical injury.

4349. **Selection or Setting of Protective Device.** If the values for branch circuit protective devices given in Table 26 or Table 27 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.

Motor-Feeder Overcurrent Protection

4361. **General.** The following provisions specify overcurrent devices intended to protect feeder conductors supplying motors against overcurrents due to short-circuits or grounds.

4362. **Rating or Setting—Motor Load.** A feeder which supplies a specific fixed motor load and consisting of conductor sizes based on section 4314 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 26 and 27, Chapter 10), plus the sum of the full-load currents of the other motors of the group. 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.

If 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.

If 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 10.

4363. **Rating or Setting—Power and Light Loads. If 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 4342: and, for two or more motors, the rating permitted by section 4362.

Remote-Control Circuits

4371. **General.** The following deviations from the general requirements in this code are intended to provide for the peculiar conditions governing remote-control circuits.

4372. **Overcurrent Protection.** Conductors of control circuits of remote-controlled equipment shall be protected against overcurrent in accordance with section 2403, paragraph g, except that such conductors shall be considered as being properly protected by the branch-circuit overcurrent devices under any one of the following conditions:

a. If 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.

b. If 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.

c. If the opening of the control circuit would create a hazard; as for example, the control circuit of fire-pump motors, and the like.

4373. **Mechanical Protection of Conductor.** Where damage to a remote-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 mechanical injury outside the control device itself.

It is recommended that control circuits be so arranged that an accidental ground will not start the motor.

4374. **Switching.** Control circuits shall be so arranged that they will be disconnected from all sources of supply when the disconnecting means specified in section 4406 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, and the other, the control circuit from its power supply. If two separate devices are used they should be located immediately adjacent one to the other. If a transformer or other device is used to obtain a reduced voltage for control circuits, such transformer or other device shall be connected to the load side of the disconnecting means.

Motor Controllers

For the purpose of this article, the term "controller" includes any switch or device normally used to start and stop the motor.

4381. **General.** The following provisions are intended to require suitable controllers for all motors.

See Diagram No. 20, Chapter 10.

4382. **Suitability.** 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.

4383. **Rating.** The controller shall have a horsepower rating, which shall not be lower than the horsepower rating of the motor, except as follows:

a. **Stationary Motor of 1/8 Horsepower or Less.** For a stationary motor rated at 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.

b. **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.

c. **Portable Motor of 1/3 Horsepower or Less.** For a portable motor rated at 1/3 horsepower or less, the controller may be an attachment plug and receptacle.

d. **Circuit-Breaker as Controller.** A branch-circuit circuit-breaker, rated in amperes only, may be used as a controller. When this circuit-breaker is also used for overcurrent protection, it shall conform to the appropriate provisions of this article governing overcurrent protection.

e. Sealed (Hermetic-Type) Refrigeration Compressor Motors. Motor controllers rated in terms of full-load current and current interrupting capacity shall be selected on the basis of both the name plate full-load current and locked-rotor current, respectively, of the compressor. Motor controllers rated in horsepower or in horsepower and full-load current, shall be selected on the basis of the name plate full-load current and locked-rotor current, respectively, of the compressor. For full-load current, the horsepower rating shall be selected from Tables 22 to 24 incl., and for locked-rotor current, the horsepower rating shall be selected from Table 25. If the name plate full-load current and locked-rotor current do not correspond to the currents shown in Tables 22 to 24 and Table 25, respectively, the horsepower rating corresponding to the next higher value shall be selected. If two different horsepower ratings are obtained when applying Tables 22 to 24 and Table 25, a horsepower rating at least equal to the larger of the two values obtained shall be selected.

4384. **Need Not Open All Conductors.** Except when it serves also as a disconnecting means (see section 4407), the controller need not open all conductors to the motor.

4385. **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.

4386. **In Sight from the Controller Location.** A motor and its driven machinery shall be within sight from the controller location unless one of the following conditions is complied with:

a. The controller or its disconnecting means is capable of being locked in the open position.

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 remote-control circuit of a remote-control type of switch.

A distance of more than 50 feet is considered equivalent to being out of sight.

c. Special permission is given by the authority enforcing this code.

d. As otherwise specified in Article 500 of this code.

4387. **Number of Motors Served by Each Controller.** Each motor shall be provided with an individual controller, except that for motors of 600 volts or less a single controller may serve a group of motors under any one of the following conditions:

a. If a number of motors drive several parts of a single machine or piece of apparatus such as metal and woodworking machines, cranes, hoists, and similar apparatus.

b. If a group of motors is under the protection of one overcurrent device as permitted in paragraph a of section 4343.

c. If a group of motors is located in a single room within sight from the controller location.

A distance of more than 50 feet is considered equivalent to being out of sight.

4388. **Adjustable-Speed Motors.** Adjustable-speed motors, if 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.

4389. **Speed Limitation.** Machines of the following types shall be provided with speed limiting devices, 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, or unless the machine is always under the manual control of a qualified operator.

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.

4390. **Fuseholder Rating.** 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 20, Chapter 10, for motor-running protection.

Disconnecting Means

4401. **General.** The following provisions are intended to require disconnecting means for motors and controllers capable of disconnecting them from the circuit.

See Diagram No. 20, Chapter 10.

4402. Type. The disconnecting means shall be a motor-circuit switch, rated in horsepower, or a circuit-breaker, except as permitted in the following paragraphs a, b, c, d, or e. Every switch in the motor branch circuit within sight from the controller location shall comply with these requirements.

A distance of more than 50 feet is considered equivalent to being out of sight.

a. One-Eighth Horsepower or Less. For stationary motors of 1/8 horsepower or less, the branch-circuit overcurrent 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 at least twice the full-load current rating of the motor.

c. Over Two Horsepower to and Including 50 Horsepower. The separate disconnecting means required for a motor with a compensator type of controller may be a general-use switch if all of the following provisions are complied with:

1. The motor drives a generator which is provided with overcurrent protection.

2. The compensator (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-overcurrent 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.

It is recommended that isolating switches for motors exceeding 50 horsepower, not capable of interrupting stalled-rotor currents, 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.

4403. **Carrying Capacity and Interrupting Capacity.**

a. The disconnecting means shall have a carrying capacity of at least 115 per cent of the name-plate current rating of the motor.

b. The disconnecting means for sealed (hermetic-type) refrigeration compressors shall be selected on the basis of the name plate full-load current and locked-rotor current, respectively, of the compressor motor. For full-load current, the horsepower rating shall be selected from Tables 22 to 24 incl., and for locked-rotor current, the horsepower rating shall be selected from Table 25. If the name plate full-load current and locked-rotor current do not correspond to the currents shown in Tables 22 to 24 and Table 25, respectively, the horsepower rating corresponding to the next higher value shall be selected. If two different horsepower ratings are obtained when applying Tables 22 to 24 and Table 25, a horsepower rating at least equal to the larger of the two values obtained shall be selected.

4404. Grounded Conductors. One pole of the disconnecting means may be placed in a permanently grounded conductor if the disconnecting means is so designed that the pole in the grounded conductor cannot be opened without simultaneously disconnecting all conductors of the circuit.

4405. To Be Indicating. The disconnecting means shall plainly indicate whether it is in the open or closed position.

4406. 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.

4407. Switch or Circuit-Breaker as Both Controller and Disconnecting Means. A switch or circuit-breaker complying with the provisions of section 4383 may serve as both controller and disconnecting means if 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 on a circuit exceeding this capacity if under expert supervision and by special permission.

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.

A compensator type of controller is not included above and will require a separate disconnecting means.

4408. Service Switch as Disconnecting Means. If 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.

A distance of more than 50 feet is considered equivalent to being out of sight.

4409. 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.

A distance of more than 50 feet is considered equivalent to being out of sight.

4410. Motors Served by a Single Disconnecting Means. Each motor shall be provided with individual disconnecting means, except that for motors of 600 volts or less a single disconnecting means may serve a group of motors under any one of the following conditions. The disconnecting means serving a group of motors shall have a rating not less than is required by section 4402 for a single motor whose rating equals the sum of the horsepowers or currents of all the motors of the group.

a. If 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. If a group of motors is under the protection of one set of overcurrent devices as permitted by paragraph a of section 4343.

c. If a group of motors is in a single room within sight from the location of the disconnecting means.

A distance of more than 50 feet is considered equivalent to being out of sight.

4411. Readily Accessible. The disconnecting means shall be readily accessible.

Requirements for Over 600 Volts

4421. General. The following provisions 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.

4422. More Than 7500 Volts. Motors operating at more than 7500 volts between conductors shall be installed in fire-resistant motor rooms.

4423. Motor Overcurrent 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 protection.

4424. Circuit Overcurrent 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.

4425. Disconnecting Means. The circuit-breaker or the fuses specified in section 4424 may constitute the disconnecting means if they conform to the other applicable requirements of this article.

Protection of Live Parts — All Voltages

4431. General. The following provisions specify that live parts shall be protected in a manner judged adequate to the hazard involved.

4432. Where Required. Exposed live parts of motors and controllers operating at 50 volts or more between terminals, except for 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, 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.

4433. **Guards for Attendants.** If 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 4432, and if 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.

Grounding

4435. **General.** The following provisions 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 for motors under certain conditions.

4436. **Stationary Motors.** The frames of stationary motors shall be grounded if any of the following conditions exist:

a. If supplied by means of metal-clad wiring.

b. If located in a wet place and not isolated or guarded.

c. If in a hazardous location. (See Article 500.)

d. If the motor operates with any terminal at more than 150 volts to ground.

Grounding of the motor frame is preferable, but if the frame of the motor is not grounded, it shall be permanently and effectively insulated from the ground.

4437. **Portable Motors.** The frames of portable motors which operate at more than 150 volts to ground shall be guarded or grounded. See paragraph c of section 2545 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 if this can be readily accomplished.

See paragraph b of section 2559 for color of grounding conductor.

4438. **Controllers.** Controller cases, except those attached to ungrounded portable equipment and except the lined covers of snap switches, shall be grounded regardless of voltage.

4439. **Method of Grounding.** Grounding where required shall be done in the manner specified in Article 250.

a. **Grounding Through Terminal Housings.** If the wiring to fixed motors is in armored cable or metal raceways, junction boxes to house motor terminals shall be provided. These housings shall be of ample size to properly make connections, they shall be of substantial metal construction, 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 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 3/8 inch electrical trade size, the armor or raceway being connected both to the motor and to the box. If 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.

ARTICLE 445 — GENERATORS

4451. **Location.** Generators shall be located in dry places, and also so as to meet the requirements for motors in section 4310. Generators installed in hazardous locations as described in Article 500, or in other locations as described in Article 510, 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.

4452. **Identification.** Each generator shall be provided with a nameplate giving the maker's name, the rating in kilowatts or kilo-volt-amperes, the normal volts and amperes corresponding to the rating, and the revolutions per minute.

4453. **Drip Pans.** Generators shall be provided with suitable drip pans if required by the authority enforcing this code.

4454. **Overcurrent Protection.** Constant-potential generators, except alternating-current generators and their exciters, shall be protected from excessive current by circuit-breakers or fuses.

a. **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.

b. **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.

c. **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.

d. **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.

4455. **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. Neutral conductors shall be the same size as the conductors of the outside legs.

4456. **Protection of Live Parts.** Live parts of generators of more than 150 volts to ground shall not be exposed to accidental contact if accessible to unqualified persons.

4457. **Guards for Attendants.** Where necessary for the safety of attendants the provisions of section 4433 shall be complied with.

4458. **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.

ARTICLE 450 — TRANSFORMERS AND TRANSFORMER VAULTS

(Including Secondary Ties)

4501. 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.

See also 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.

General Provisions

4511. Location. They shall be located and arranged to minimize possible life and fire hazards. The location of transformer vaults as affected by ventilating requirements is covered elsewhere in this article.

4512. 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 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 if the primary circuit overcurrent device provides the protection specified in this paragraph, and except as provided in paragraph b of this section.

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 have 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 if necessary to limit the possible short-circuit current to a value within the interrupting capacity of the fuse.

4513. 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 subparagraphs 1 and 2 of this section, in which cases the overcurrent protection may be in accordance with subparagraph 3 of this section.

1. Loads at Transformer Supply Points Only. If 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. If 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 sub-paragraph 4.

3. **Tie Circuit Protection.** Under the conditions described in sub-paragraphs 1 and 2 of this section, 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.** If 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 sub-paragraph 3 shall be provided in each tie conductor at this point, except as follows:

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 sub-paragraph 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.** If 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.

4514. Parallel Operation. Transformers may be operated in parallel and protected as a unit if their electrical characteristics are such that they will divide the load in proportion to their rating.

4515. 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 if the transformers are located where they are exposed to mechanical injury.

b. Exposed Live Parts. The transformer installation shall conform with the provisions for guarding of live parts in section 1113.

c. 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.

4516. Grounding. Exposed non-current carrying metal parts of transformer installations including fences shall be grounded under the conditions and in the manner prescribed for electrical equipment and other exposed metal parts in Article 250.

4517. Nameplate. 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, if any, if the transformer rating exceeds 25 kva. If Class B insulation as defined in American Standard for Transformers C 57.1 is used in the construction of dry-type transformers of more than 100 kva, the nameplate shall so indicate.

Specific Provisions Applicable to Different Types of Transformers

4521. Dry-Type Transformers Installed Indoors. Transformers rated 112½ 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 112½ kva rating shall be installed in a transformer room of fire-resistant construction unless they are constructed with Class B insulation, as defined in American Standard for Transformers C 57.1, 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.

4522. Askarel-Insulated Transformers Installed Indoors. Askarel-insulated transformers rated in excess of 25 kva shall be furnished with a pressure-relief vent. If 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.

4523. 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 112½ kva Total Capacity.** The provisions for transformer vaults specified in 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 if arrangements necessary to prevent a transformer oil fire spreading to other combustible material are provided.

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 presents a fire hazard to any other building or property, and provided the building is used only in supplying electric service and is accessible only to qualified persons.

4524. 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.

Provisions for Transformer Vaults

4541. 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.

4542. 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 ¾ 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. The quality of the material used in the construction of the vault shall be of the grade approved by the inspection authority having jurisdiction.

4543. **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 standard of the National Fire Protection Association for Protection of Openings in Walls and Partitions Against Fire.* The authority enforcing this code may require such a door on each side of the wall if 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.

4544. **Ventilation.** The ventilation shall be adequate to prevent a transformer temperature in excess of the values prescribed in American Standard for Transformers, publication C 57.1.

4545. **Ventilation Openings.** 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 oc-

*National Fire Codes, Vol. III; NBFU pamphlet No. 80.

cupied 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. If 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. Care should be taken to avoid unintentional closing of automatic dampers.

f. Ducts. Ventilating ducts shall be constructed of fire-resistant material.

4546. Drainage. If practicable, vaults containing more than 100 kva transformer capacity shall be provided with a drain which will carry off any accumulation of oil or water that may collect in the vault. The floor shall be pitched to the drain opening.

4547. Water Pipes and Accessories. Any pipe or duct systems foreign to the electrical installation should not enter or pass through a transformer vault. If 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 if 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.

4548. Storage in Vaults. Materials shall not be stored in transformer vaults.

ARTICLE 460—CAPACITORS

4601. Application of Other Articles. This article shall not apply to capacitors constituting a component part of other apparatus and conforming with the requirements for such apparatus. Capacitors installed in hazardous locations shall comply with the provisions of this article except as modified by Article 500.

4602. Location. Capacitors shall be enclosed in vaults complying with the provisions of Article 450 unless they are askarel insulated or unless each unit contains not more than 3 gallons of a combustible oil.

4603. Mechanical Protection. Appropriate provisions shall be made to minimize the possibility of damage to capacitors from external causes if the capacitors are located where they are exposed to mechanical injury.

4604. Transformers Used with Capacitors. Transformers used with capacitors shall be installed in accordance with Article 450. The kvar rating shall be not less than 135 per cent of the capacitor kvar rating.

4605. 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.

4606. Capacitor Rating. 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.

4607. **Capacitor Circuits.** Capacitor circuits shall conform to the following:

a. **Conductor Rating.** The rating of capacitor circuit conductors shall be not less than 135 per cent of the rated current of the capacitor. The rating 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 rating of the motor circuit conductors or the rating shall be determined as explained above if this method gives a greater value.

b. **Overcurrent Protection.** An overcurrent device shall be provided in each ungrounded conductor, except that an overcurrent device is not required for a capacitor connected on the load side of a motor overcurrent device. The rating or setting of the overcurrent device shall be as low as practicable without causing unnecessary opening of the circuit. A rating or setting of 165 to 250 per cent of the rated current of the capacitor will be suitable under average conditions although the setting or rating may have to exceed 250 per cent in some cases.

c. **Disconnecting Means.** A disconnecting device shall be provided in each ungrounded conductor except that a disconnecting device is not required for a capacitor connected on the load side of a motor disconnecting device. The disconnecting device need not open all ungrounded conductors simultaneously. The disconnecting device may be used for disconnecting the capacitor from the line as a regular operating procedure. The continuous current carrying capacity of the disconnecting device shall be not less than 135 per cent of the rated current of the capacitor.

4608. **Rating or Setting of the Motor Overcurrent Device.** If a motor installation includes a capacitor connected on the load side of the motor 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 4322 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 4312 applies with respect to the rating of the motor circuit conductors.

4609. Grounding. Capacitor cases shall be grounded in accordance with Article 250.

4610. 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 7125.

4611. Name-Plate. Each capacitor shall be provided with a name-plate giving the maker's name, rated voltage, frequency, kvar or amperes, number of phases, and if liquid-filled, the amount of liquid in gallons, together with a statement that the liquid will or will not burn, as the case may be. The name-plate shall indicate whether or not a capacitor unit has a discharge device inside the case.

ARTICLE 470—RESISTORS AND REACTORS

For Rheostats see sections 4305, 4306 and 94303.

4701. Location. Resistors and reactors shall not be placed where exposed to mechanical injury. If in the immediate vicinity of easily ignitible material they shall be of the oil-immersed type or shall be enclosed in metal boxes or cabinets. See Article 500 for Hazardous Locations.

4702. Space Separation. Unless attached to a switchboard or other non-combustible material, or unless mounted as provided in section 4703, resistors and reactors shall be separated from combustible material by a distance of not less than 1 foot.

4703. On or In Proximity to Combustible Material. If 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 non-combustible, non-absorptive 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 ½ 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 ⅛ inch below the rear surface of the slab and shall be covered with insulating material.

4704. **Mounting.** Casings when mounted on plain surfaces shall make contact with such surfaces only at the point of support, an air space of at least ¼ inch being maintained between the casings and surfaces.

4705. **Conductor Insulation.** If insulated conductors are used for connection between resistance elements and controllers, the conductors shall be suitable for an operating temperature of not less than 90C (194F), except that for motor-starting service other conductor insulations may be used. For elevator motor starting service, see paragraph a of section 6204.

4706. **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 receptables on non-combustible 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. **Name-Plate.** 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

4801. 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.

4802. Definition of Nominal 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.

4803. 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.

4804. 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. If 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 non-conducting 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, if 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 if the total nominal voltage of all cells in series does not exceed 150 volts. If 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. If 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.

4805. Insulation of Batteries of Over 250 Volts. The provisions of section 4804 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.

a. 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; except that if 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; and except that 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.

4806. 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 non-conducting 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 non-conducting material, so constructed or treated as to be resistant to deteriorating action by the electrolyte.

4807. **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. **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.

c. **Varnished-Cambric Conductors.** Varnished-cambric-covered conductors, Type V, shall not be used.

d. **Bare Conductors.** Bare conductors shall not be taped.

e. **Raceway.** Rigid metal conduit, or electrical metallic tubing, if used, shall be of corrosion-resistant material or shall be suitably protected from corrosion.

f. **Terminals.** If 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.

g. **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.

CHAPTER 5. SPECIAL OCCUPANCIES

ARTICLE 500—HAZARDOUS LOCATIONS

5001. Scope. The provisions of this article apply to locations in which the authority enforcing this code judges the apparatus and wiring to be subject to the conditions indicate 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 by this article, all other applicable rules contained in this code shall apply to electrical apparatus and wiring installed in hazardous locations. For definitions of "approved," "explosion-proof" and "dust-tight" as used in this article, refer to Article 100.

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 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 the 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.

5002. Special Precaution. The intent of this article 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;

Group F, Atmospheres containing carbon black, coal or coke dust;

Group G, Atmospheres containing flour, starch, or grain dusts.

5003. **Specific Occupancies.** See Article 510 for rules applying to garages, aircraft hangars, gasoline dispensing and service stations, bulk storage plants, finishing processes, and combustible anesthetics.

5004. **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 ignitible 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; 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.

5005. 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 ignitible 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 ignitible 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 ignitible 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, in 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 a of this section, and into which explosive or ignitible concentrations of suspended dust might be communicated only under abnormal operating conditions; rooms or areas where the formation of explosive or ignitible 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.

5006. Class III Locations. Class III locations are those which are hazardous because of the presence of easily ignitible fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in air in quantities sufficient to produce ignitible mixtures. Class III locations shall include the following:

a. **Class III, Division 1.** Locations in which easily ignitible 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.

b. **Class III, Division 2.** Locations in which easily ignitible fibers are stored or handled (except in process of manufacture).

Easily ignitible 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.

Class I—Installation

5011. 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 5004 of this article except as modified by sections 5012 to 5026 inclusive.

5012. 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 4541 to 4548 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 sub-paragraph a-1 of this section, 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 4521 to 4524 inclusive.

5013. **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 possible.

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 a of this section 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 a of this section, 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 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 if vents adequate to permit prompt escape of any gases or vapors are provided.

4. Where an assembly is made up of components for which general purpose enclosures are acceptable under subparagraphs b.1, b.2 and b.3 of this section, a single general purpose enclosure is acceptable for the assembly. If such an assembly includes any of the equipment described in subparagraph 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.

5014. **Wiring Methods.** Wiring methods shall conform to the following:

a. **Class I, Division 1.** In Class I, Division 1 locations, rigid metal conduit with threaded explosion-proof joints, and explosion-proof boxes and fittings, shall be the wiring method employed. All threaded joints shall be made up with at least five threads fully engaged. 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 threaded electrical metallic tubing conforming to section 3487 shall be the wiring method employed. 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 is provided.

5015. Sealing. Seals are provided to prevent the passage of gases, vapors or flames from one portion of the electrical installation to another through the conduit and 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.

Where two or more enclosures for which seals are required under sub-paragraphs 1 and 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 if not larger than the trade size of the conduit.

2. 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 sub-paragraphs a.1. and a.2. of this section. All portions of the conduit run or nipple between the seal and such enclosure shall conform to paragraph a, section 5014.

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 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 93C. (200F.).

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 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 water or other condensed vapor may be trapped within housings or enclosures or at any point in the raceway system, approved means shall be provided to prevent accumulation or to permit periodic draining of such water or condensed vapor.

6. **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 sub-paragraph a.2. of this section.

5016. Switches, Circuit-Breakers, Motor Controllers and Fuses. Switches, circuit-breakers, motor controllers and fuses shall conform to the following:

a. **Class 1, 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 subparagraph b-4 of this section, (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 provided 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 b-3 of this section need not be included in counting the 10 sets of fuses permitted in general purpose enclosures.

5017. **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 section 5016, paragraph 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 locations, unless resistance is non-variable and maximum operating temperature 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).

5018. 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 motors, such as squirrel cage induction motors, without brushes, switching mechanism, etc., in Class I, Division 2 locations.

5019. 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. **Mechanical Injury.** Each fixture shall be protected against mechanical injury 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 sub-paragraph a.1. of this section.

2. **Fixed Lighting.** Lighting fixtures for fixed lighting shall be protected from mechanical injury 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. If 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 of the gas or vapor involved, as determined by A.S.T.M. test procedure (Designation D 286-30), fixtures shall conform to sub-paragraph a.1. of this section.

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 sub-paragraph b-1, section 5016.

6. **Starting Equipment.** Starting and control equipment for mercury-vapor and fluorescent lamps shall conform to the requirements of paragraph b, section 5017.

5020. 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 sub-paragraph b of section 5018.

3. **Switches, Circuit-breakers, and Fuses.** Switches, circuit-breakers and fuses shall conform to paragraph b of section 5016.

5021. 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 94003, (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 5023.

5022. Receptacles and Attachment Plugs, Class I, Divisions 1 and 2. Receptacles and attachment plugs shall be of polarized type providing for connection to the grounding conductor of the flexible cord, and shall be approved for Class I locations.

5023. 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.

5024. 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 paragraph a, section 5014, and paragraphs a and c, section 5015.

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 sub-paragraph b.2. of section 5013.

3. Protectors. Enclosures which may be of general purpose type shall be provided for lightning protective devices and for fuses.

5025. Live Parts, Class I, Divisions 1 and 2. There shall be no exposed live parts.

5026. 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. If flexible conduit is used as permitted in subparagraph b of section 5014, 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 if of soft copper, or No. 12 if of medium or hard-drawn copper.

f. Multiple Grounds. Where, in the application of section 2521, 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 d and e of this section shall not be abandoned while any other grounding connection remains connected to the supply system.

Class II—Installation

5051. 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 5005 of this article except as modified by sections 5052 to 5066 inclusive.

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.

5052. 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 4541 to 4548 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 4541 to 4548 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 the production of magnesium, aluminum or aluminum bronze powders 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 4541 to 4548 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.

5053. Surge Protection, Class II, Divisions 1 and 2. In geographical locations where lightning disturbances are prevalent, wiring systems in Class II locations shall, if 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 if overhead secondary lines exceed 300 feet in length or if 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.

5054. Wiring Methods. Wiring methods shall conform to the following:

a. **Class II, Division 1.** In Class II, Division 1 locations, wiring shall be in rigid metal conduit with threaded boxes and fittings.

1. **Fittings and Boxes.** Fittings and boxes shall be provided with threaded bosses for conduit connection, 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 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. 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. An additional conductor for grounding shall be provided in the flexible cord unless other acceptable means of grounding is provided.

b. **Class II, Division 2.** In Class II, Division 2 locations, wiring shall be in rigid metal conduit or electrical metallic tubing.

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 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 sub-paragraph a-2 of this section shall apply.

5055. **Sealing, Class II, Divisions 1 and 2.** Where a raceway provides communication between a non-dust-tight fitting or enclosure and one which is required to be dust-tight, suitable means shall be provided to prevent the entrance of dust into the dust-tight 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-tight enclosure.

5056. **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 enclosures approved 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 the production of magnesium, aluminum or aluminum bronze powders 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 subparagraph a-2 of this section.

5057. **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 enclosures approved for Class II locations. No control transformer, impedance coil or resistor shall be installed in a location where dust from the production of magnesium, aluminum or aluminum bronze powders 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 sub-paragraph a-2 of section 5056.

2. **Coils and Winding.** If 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 enclosures approved for Class II locations, except that non-adjustable resistors for which maximum operating temperatures will not exceed 120° C. (248° F.) may have enclosures conforming to sub-paragraph b.2. of this section.

5058. **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 for Class II locations. Motors, generators or other rotating electrical machinery shall not be installed in locations where dust from the production of magnesium, aluminum or aluminum bronze powders 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 protected or splashproof type shall not be installed in such locations.

5059. 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 non-combustible 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 mechanical 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-tight 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.

5060. 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 approved for Class II locations. Fixed or portable appliances shall not be installed or used in locations where dust from magnesium, aluminum or aluminum bronze powders may be present unless such appliances are 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 approved for Class II locations.

2. Motors. Motors of motor-driven appliances shall conform to paragraph b of section 5058.

3. Switches, Circuit-breakers and Fuses. Enclosures for switches, circuit-breakers, and fuses shall conform to sub-paragraph a-2 of section 5056.

4. Transformers, Impedance Coils and Resistors. Transformers, solenoids, impedance coils and resistors shall conform to paragraph b of section 5057.

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.

5061. 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 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 or aluminum bronze powders may be present, fixtures for fixed or portable lighting, and all auxiliary equipment, shall be specifically approved for such locations.

2. Mechanical Injury. Each fixture shall be protected against mechanical injury 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 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, if 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. **Mechanical Injury.** Lighting fixtures for fixed lighting shall be protected from mechanical injury 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 ap-

proved 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 b of section 5057.

5062. **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 94003, (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-tight.

5063. **Receptacles and Attachment Plugs.**

a. **Class II, Division 1.** In Class II, Division 1 locations, receptacles and attachment plugs shall be of polarized type providing for connection to the grounding conductor of the flexible cord, and shall be approved for Class II locations.

b. **Class II, Division 2.** In Class II, Division 2 locations, receptacles and attachment plugs shall be of polarized 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.

5064. **Signal, Alarm, Remote-Control, and Local Loud-Speaker Intercommunication Systerms.** 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 or electrical metallic tubing shall be the wiring method employed, and the number of conductors in a raceway 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 mechanical 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 enclosures approved for Class II locations.

4. **Rotating Machinery.** Motors, generators and other rotating electrical machinery shall conform to paragraph a of section 5058.

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 or aluminum bronze powders may be present, all apparatus and equipment shall be specifically approved for such locations.

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 sub-paragraph a-2 of this section or contacts shall have tight metal enclosures designed to minimize the entrance of dust, and having 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 sub-paragraph a-3 of this section except that enclosures for thermionic tubes, non-adjustable resistors or rectifiers for which maximum operating temperatures will not exceed 120°C. (248°F.) may be of general purpose type.

5065. Live Parts, Class II, Divisions 1 and 2. There shall be no exposed live parts.

5066. 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. If flexible conduit is used as permitted in section 5054, 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, 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 if of soft copper, or No. 12 if of medium or hard-drawn copper.

f. **Multiple Grounds.** Where, in the application of section 2521, it is necessary to abandon one or more grounding connections to avoid objectionable passage of current over the grounding conductors, the connection required in paragraphs d or e of this section shall not be abandoned while any other grounding connection remains connected to the supply system.

Class III—Installation

5071. 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 5006 of this article except as modified by sections 5072 to 5087 inclusive.

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.

5072. Transformers and Capacitors, Class III, Divisions 1 and 2. Transformers and capacitors shall conform to paragraph b of section 5052.

5073. Wiring Methods. Wiring methods shall conform to the following:

a. **Class III, Division 1.** In Class III, Division 1 locations, rigid metal conduit 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 sub-paragraph a-2 of section 5054 shall apply.

b. **Class III, Division 2.** In Class III, Division 2 locations, the wiring method shall conform to paragraph a of this section, except that in sections, compartments or areas used solely for storage and containing no machinery, open wiring on insulators may be employed if installed to conform to Article 320, but only on condition that protection as required by section 3212 be provided where conductors are not run in roof spaces, and well out of reach of sources of mechanical injury.

5074. **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.

5075. **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 b of section 5057.

5076. **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. Protected Type, Class III, Divisions 1 and 2. Motors, generators or other rotating electrical machinery of the protected or splash-proof type shall not be installed in Class III locations.

5077. 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 non-combustible 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 mechanical 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.

5078. 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 b of section 5076. 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 5074.

5079. **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. **Mechanical Injury.** A fixture which may be exposed to mechanical injury 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 a of this section.

5080. **Flexible Cords, Class III, Divisions 1 and 2.** Flexible cords shall conform to section 5062.

5081. **Receptacles and Attachment Plugs, Class III, Divisions 1 and 2.** Receptacles and attachment plugs shall conform to paragraph b of section 5063.

5082. **Signal, Alarm, Remote-Control and Local Loud-Speaker Intercommunication Systems, Class III, Divisions**

1 and 2. Signal, alarm, remote-control and local loud-speaker intercommunication systems shall conform to paragraph a of section 5064.

5083. **Electric Cranes, Class III, Divisions 1 and 2.** Electric cranes may be installed under the following conditions: Electric cranes operating over combustible fibers shall not be operated on a system with a grounded conductor. Feeders for electric cranes shall be furnished with a recording ground detector, and protected by a relay which will automatically open the feeder circuit-breaker in the event of the insulation of the system falling below 1000 ohms. Bare conductors for cranes operating in rooms used for the storage of combustible fibers shall be protected by barriers so arranged as to prevent any escape of sparks or hot particles, and the moving current collectors shall be so designed as to minimize sparking at sliding contacts.

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 take-up device.

5084. **Electric Trucks.** Electric trucks shall conform to the following:

a. **Class III, Division 1.** Electric trucks shall not be used in Class III, Division 1 locations.

b. **Class III, Division 2.** Electric trucks which are or may be used in Class III, Division 2 locations shall be of a type approved for such locations. Electric truck batteries shall be charged only in rooms meeting the requirements of Section 5085.

5085. **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 non-combustible materials so constructed as to adequately exclude flyings or lint, and shall be well ventilated.

5086. **Live Parts, Class III, Divisions 1 and 2.** There shall be no exposed live parts except as provided in section 5083.

5087. **Grounding, Class III, Divisions 1 and 2.** Wiring and equipment shall be grounded in conformity with section 5066.

ARTICLE 510—SPECIFIC OCCUPANCIES

5101. Scope. The provisions of this article 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 Article 500, and to set forth such additional special requirements as are applicable to the specific occupancy.

5102. General. The general rules of this Code shall apply to the installation of electrical wiring and equipment in occupancies within the scope of this Article except as such rules are modified in the following sections. 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 this Article.

Commercial Garages, Repair and Storage

5105. a. Definitions. This classification 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.

b. Hazardous Areas. Classification under Article 500.

1. 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.

2. 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.

3. 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.

4. 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.

c. **Wiring and Equipment in Hazardous Areas.** Within hazardous areas as defined in paragraph b of this section, wiring and equipment shall conform to applicable provisions of sections 5011 to 5026 inclusive of Article 500.

d. **Sealing.** Approved seals conforming to the requirements of section 5015 of Article 500 shall be provided, and sub-paragraph b.2. of section 5015 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.

e. **Wiring in Spaces Above Hazardous Areas.**

1. All fixed wiring shall be in metallic raceways which shall be construed to include 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.

2. For pendants, flexible cord suitable for the type of service and approved for hard usage shall be used.

3. 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.

4. If 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.

5. If 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 paragraph b of this section. Attachment plug receptacles in fixed position shall be located above the level specified in paragraph b.

f. Equipment Above Hazardous Areas.

1. Equipment which is less than 12 feet above floor level, 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.

2. Lampholders for fixed lighting shall have non-conducting outer casings.

3. Portable lamps shall be equipped with handle, lampholder, hook and substantial guard attached to the lampholder 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 paragraph b of this section, they shall be of a type approved for such hazardous locations.

g. Battery-Charging Equipment. Battery chargers and their control equipment, and batteries being charged shall not be located within hazardous areas classified in paragraph b of this section. Tables, racks, trays, and wiring shall, in addition, conform to the provisions of Article 480.

h. Electric Vehicle Charging.

1. 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.

2. Connectors shall have a rating not less than the current carrying capacity of the cord, and in no case less than 50 amperes.

3. 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 paragraph b of this section.

4. Where plugs are provided for direct connection to vehicles, the point of connection shall not be within a hazardous area as defined in paragraph b of this section, and if 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. If the vehicle is equipped with an approved plug which will readily pull apart, and if an automatic arrangement is provided to pull both cord and plug beyond the range of mechanical injury, no additional connector is required in the cable or at the outlet.

Residential Storage Garages

5110. a. Definition. A residential storage garage is a building or room in which not more than three vehicles of the types described in paragraph a of section 5105 are or may be stored, but which will not normally be used for other than minor service or repair operations on such stored vehicles.

b. 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.

c. Below Grade. Where the lowest floor is below adjacent ground or driveway level, the following shall apply.

1. 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 sections 5011 to 5026 inclusive of Article 500.

2. Wiring and equipment above the defined hazardous location shall conform to the requirements of this Code for non-hazardous locations.

3. 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.

Aircraft Hangars*

5115. a. Definition. This classification 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.

b. Hazardous Areas. Classification under Article 500.

1. 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.

2. 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.

3. 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.

4. 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 if adequately ventilated and if cut off from the hangar itself by walls or partitions which are essentially vapor-tight.

c. 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 paragraph b of this section shall conform to ap-

*Section 5115 contains Tentative Interim Amendment No. 98 adopted in accordance with the Rules of Procedure for Tentative Interim Amendments (See Page 446).

plicable provisions of sections 5011 to 5026 inclusive of Article 500. 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.

d. Wiring Not Within Hazardous Areas.

1. All fixed wiring in a hangar, but not within a hazardous area as defined in paragraph b of this section, shall be installed in metallic raceways which shall be construed to include Type MI cable, except that wiring in non-hazardous locations as defined in sub-paragraph b.4. may be of any type recognized in Chapter 3 of this Code.

2. 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.

3. 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.

4. If 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 pendant fixtures, portable lamps, and portable appliances.

e. Equipment not Within Hazardous Areas.

1. In locations other than those described in paragraph b of this section, 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 sub-paragraph b.4. may be of general purpose type.

2. Lampholders of metal shell, fiber-lined type shall not be used for fixed incandescent lighting.

3. Portable lamps which are or may be used within a hangar shall be approved for Class I locations.

4. 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.

f. Stanchions, Rostrums and Docks.

1. 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 sub-paragraph b.3 of this section shall conform to the requirements for Class I, Division 2 locations.

2. Where stanchions, rostrums, or docks are not located or likely to be located in a hazardous area as defined in sub-paragraph b.3, wiring and equipment shall conform to paragraphs d and e of this section, except that such wiring and equipment not more than 18 inches above the floor in any position shall conform to sub-paragraph f.1. Receptacles and attachment plugs shall be of locking type which will not break apart readily.

3. Mobile stanchions with electrical equipment conforming to sub-paragraph f.2. shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

g. Sealing. Approved seals shall be provided in conformance with section 5015 of Article 500, and sub-paragraphs a.3. and b.2. shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas. Raceways in or under the floor shall be considered to be in a Class I, Division 1 location.

h. 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.

i. Aircraft Battery—Charging and Equipment.

1. Aircraft batteries should not be charged when installed in an aircraft located inside or partially inside a hangar.

2. Battery chargers and their control equipment shall not be located or operated within any of the hazardous areas defined in paragraph b of this section, and should preferably be located in a separate building or in an area such as described in sub-paragraph b.4. 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.

j. Energizing Aircraft from External Power Sources.

1. 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 sub-paragraph b.3.

2. 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."

3. 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.

k. Mobile Servicing Equipment with Electrical Components.

1. 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 sub-paragraph b.3 of this section and shall carry at least one permanently affixed warning sign to read: "WARNING—KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

2. 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.

3. Equipment not of a type suitable for Class I, Division 2 locations should not be operated in areas where maintenance operations likely to release hazardous vapors are in progress.

l. 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.

Gasoline Dispensing and Service Stations

5120. a. Definitions. This classification shall include locations where gasoline or other volatile flammable liquids 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, salesroom, compressor rooms and similar locations shall conform to section 5105 with respect to electrical wiring and equipment.

b. Hazardous Areas.

1. 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.

2. 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 below the surface of such areas shall be considered to be within a Class I, Division 1 location.

c. Wiring and Equipment Within Hazardous Areas. All electrical equipment and wiring within the hazardous areas defined in paragraph b shall conform to applicable provisions of sections 5011 to 5026 inclusive of Article 500.

d. Wiring and Equipment not Within Hazardous Areas. Wiring and equipment not within hazardous areas defined in paragraph b of this section shall conform to paragraphs e and f of section 5105.

e. Circuit Disconnects. Each circuit supplying equipment in or on a dispensing pump shall be provided with a switch or other acceptable means to disconnect all conductors of the circuit from the source of supply.

f. Sealing.

1. An approved seal shall be provided in each conduit run entering a dispensing pump or other equipment 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 enters the pump or other equipment.

2. Additional seals shall be provided in conformance with section 5015 of Article 500, and sub-paragraphs a.3. and b.2. of that section shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas.

g. 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.

Bulk-Storage Plants

5125. a. Definition. This classification 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).

b. Hazardous Areas.

1. 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.

2. Rooms in which volatile flammable liquids are transferred to individual containers shall be considered to be Class I, Division 1 locations.

3. In outdoor locations, areas adjacent to loading racks or platforms, or to above-ground 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.

4. Basements, pits or depressions which are within 25 feet of above-ground 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.

5. 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.

6. 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.

c. **Wiring and Equipment Within Hazardous Areas.** All electrical wiring and equipment within the hazardous areas defined in paragraph b shall conform to applicable provisions of sections 5011 to 5026 inclusive of Article 500.

d. **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 500 for the class of location above which they are connected or used.

e. **Underground Wiring.**

1. Underground wiring shall be installed in rigid metal conduit, or, if 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. If 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 above-ground raceway.

2. Conductor insulation shall conform to section 5023 of Article 500.

3. If 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.

f. **Sealing.** Approved seals shall be provided in conformance with section 5015 of Article 500, and sub-paragraphs a.3. and 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.

g. **Gasoline Dispensing.** Where gasoline dispensing is carried on in conjunction with bulk station operations, applicable provisions of section 5120 shall apply.

h. **Grounding.** All metallic raceways, and all non-current-carrying metallic portions of electrical equipment shall be grounded as provided in Article 250.

Finishing Processes

5130.a. **Definition.** This classification 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, N.F.P.A. Pamphlets No. 33 and No. 34 should be consulted.

b. **Hazardous Areas.** Classification with respect to flammable vapors. For deposits and residues, see paragraph c.

1. 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.

2. 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 sub-paragraph b.1. 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.

3. 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.

4. 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 if the code-enforcing authority so judges.

c. Wiring and Equipment in Hazardous Areas.

1. All electrical wiring and equipment within the hazardous areas defined in paragraph b shall conform to applicable provisions of sections 5011 to 5026 inclusive of Article 500.

2. 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.

3. Illumination of readily ignitable areas through panels of glass or other transparent or translucent material is permissible only if (a) fixed lighting units are used as the source of illumination, if (b) the panel effectively isolates the hazardous area from the area in which the lighting unit is located, if (c) the lighting unit is approved for its specific location, if (d) the panel is of a material or is so protected that breakage will be unlikely and if (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.

4. Portable electric lamps or appliances shall not be used within a hazardous area during operation of the finishing process. If 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.

5. Electrostatic spraying or detearing equipment shall be installed and used only as provided in paragraph d of this section.

d. Electrostatic Equipment. Where electrostatic spraying and detearing equipment is installed, such equipment shall be of approved type, and shall conform to the following requirements.

1. 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 paragraph b. of this section unless of a type approved for the location.

2. 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 non-combustible insulators.

3. 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.

4. 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.

5. 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 sub-paragraph 4.

6. 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 per-

manently posted designating the process zone as dangerous because of high voltage.

e. Wiring and Equipment Above Hazardous Areas.

1. All fixed wiring above hazardous areas shall be in metallic raceways which shall be construed to include 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.

2. 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, if 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.

f. 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.

Combustible Anesthetics

5135. a. Definitions.

1. Combustible 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.

2. Anesthetizing locations in hospitals are areas in which combustible 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 combustible anesthetics to patients. Recovery rooms are not classed as anesthetizing locations unless used for administering combustible anesthetics.

For further information regarding safeguards for hospital operating rooms, N.F.P.A. Pamphlet No. 56 should be consulted.

b. Hazardous Areas.

1. Any room or space in which combustible anesthetics or volatile flammable disinfecting agents are stored shall be considered to be a Class I, Division 1 location throughout.

2. In an anesthetizing location as defined in paragraph a., 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.

c. Wiring and Equipment Within Hazardous Areas.

1. In hazardous areas as defined in paragraph b., 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 5011 to 5025 inclusive and of paragraphs a. and b. of section 5026 in Article 500, for Class I Division 1 locations, and all such equipment shall be specifically approved for the hazardous atmospheres involved.

2. 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 boundary 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.

3. 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.

4. 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 polarized type with provision for connection of the grounding conductor, and if 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.

d. Wiring and Equipment Above Hazardous Areas.

1. Wiring above a hazardous area as defined in subparagraph b.2. shall be installed in metal raceways which shall be construed to include Type MI cable.

2. Equipment which may produce arcs, sparks or particles of hot metal, such as lamps and lampholders for fixed lighting, 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.

3. Ceiling suspended surgical and other lighting fixtures shall conform to paragraph b. section 5019 of Article 500.

e. Sealing. Approved seals shall be provided in conformance with section 5015 of Article 500, and sub-paragraph a.3. of that section shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas.

f. Circuits in Anesthetizing Locations.

1. Each circuit within or partially within an anesthetizing location as defined in sub-paragraph a.2. of this section 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 other areas. 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.

2. Circuits supplying 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 of motor-generator sets shall be ungrounded, and shall be protected against overcurrent in the same manner as transformer secondary circuits.

3. 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.

4. In addition to all usual control and protective devices, the ungrounded system shall be provided with an approved ground contact indicator which will respond if any conductor of the system becomes grounded, and which will limit the

leakage current under such conditions to 2 milliamperes. A green signal lamp conspicuously visible to personnel in the anesthetizing location shall remain lighted while the system is isolated from ground, but an adjacent red signal lamp and an audible alarm signal shall be energized when the indicator responds to leakage current. 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.

g. Low Voltage Equipment and Instruments.

1. 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.

2. If a low voltage unit receives current from an individual transformer located within a hazardous area, the flexible cord shall conform to sub-paragraph c.4. of this section, the core and case of the transformer shall be effectively grounded, and the transformer shall be approved for Class I locations.

3. If 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. If 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.

4. 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.

5. Resistance or impedance devices may be used to control low voltage units but shall not be used to limit input voltage. If a low voltage unit includes a switch or other make and break or sliding contact, or if 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 (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.

h. Other Equipment.

1. Suction, pressure, or insufflation equipment involving electrical elements, and located or used within a hazardous area shall be approved for Class I locations.

2. X-ray equipment installed or operated in an anesthetizing location as defined in sub-paragraph a-2 of this section 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 if 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.

3. Equipment for generating high frequency currents or voltages used in electrocautery, diathermy, television, etc., if installed or used in an anesthetizing location, shall conform to paragraphs c and d of this section.

i. 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 a and b section 5026 of Article 500.

ARTICLE 520—THEATERS AND ASSEMBLY HALLS

5201. **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, public auditoriums, television studios and other buildings used for public assembly.

5203. **Motion-Picture Projectors.** Motion-picture projectors shall comply with Article 540.

5204. **Sound Reproduction.** Sound-reproducing equipment shall comply with Article 640.

Installation

5211. **Wiring Method.** The wiring method shall be metal raceways or Type MI cable except (1) as provided in Articles 640 and 800; (2) when the auditorium has a seating capacity of 100 persons or less, 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 336 may also be used. Portable cables may be used only where fixed wiring methods are impracticable.

5212. **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 9 of Chapter 10. The number of conductors for border or stage pocket circuits or for remote-control conductors in auxiliary gutters or metal wireways shall have a total cross sectional area not exceeding 20 per cent of the cross sectional area of the gutter or wireway.

5213. **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 125C (257F). See the table in section 3102.

Stage Switchboard

5221. **Dead Front.** Stage switchboards shall be of the dead-front type.

5222. Guarding. 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.

5223. 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.

5224. Metal Hood. Stage switchboard shall be provided with a metal hood extending the full length of the board to protect all equipment on the board from falling objects, unless the switchboard is recessed in the building construction or is of the completely enclosed, dead-front and dead-rear type.

5225. Dimmers. Dimmers shall conform to the following:

a. Disconnection from Supply. If 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 leg of the circuit. If designed to open either the supply circuit to the dimmer or the circuit controlled by it, the dimmer shall then comply with section 3801.

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. An auto-transformer type of dimmer shall be energized by a circuit operating at not more than 150 volts between conductors and the grounded conductor shall be common to both the input and the output of the auto-transformer.

Stage Equipment — Fixed

5241. 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.

5242. **Footlights.** If the metal trough construction specified in section 5281 is not used, footlights shall consist of individual outlets with lamp holders, 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.

5243. **Cables for Border Lights.** Cables for border lights shall be types K, S, SO, or ST flexible cord. See Table 31 of Chapter 10. The cables shall be suitably supported. Such cables shall be employed only where flexible conductors are necessary.

5244. **Receptacles.** Receptacles intended for the connection 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 connection 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.

5245. **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.

5246. **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.

5247. **Flue-Damper Control.** If 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. It shall be located in the loft above the scenery and shall be enclosed in a suitable iron box having a tight, self-closing door.

Stage Equipment — Portable

5251. **Arc Lamps.** Arc-lamp frames and standards shall be so installed and guarded as to prevent their becoming grounded.

5252. **Lights on Scenery.** 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. Fixtures shall be securely fastened in place.

5253. **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.

5254. **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.

5255. Connectors for Flexible Conductors. Connectors for flexible conductors shall be so constructed that tension on the cord or cable will not be transmitted to the connections. The female half of the connector shall be attached to the live end of the cord or cable.

5256. 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 if the cord is not liable to severe mechanical injury and is protected by an overcurrent protection rated at not over 20 amperes.

Dressing Rooms

5261. Lamp Pendants. Lamp pendants shall not be installed in dressing rooms.

5262. Lamp Guards. All incandescent lamps in dressing rooms, if 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.

5263. 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.

Grounding

5271. 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, if employed, shall be done in the manner specified in Article 250.

Construction

5281. Footlights. If 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 ½ inch from the metal of the trough. The circuit conductors shall be soldered to the lampholder terminals.

5282. **Borders and Proscenium Sidelights.** Borders and proscenium sidelights shall be constructed as prescribed in section 5281, shall be suitably stayed and supported, and shall be so designed that the flanges of the reflectors or other adequate guards will protect the lamps from mechanical injury and from accidental contact with scenery or other combustible material.

5283. **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 5244.

5284. **Arc Lamps.** Arc lamps shall comply with the following:

a. **General.** 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. 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.

b. **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.

c. **Insulation.** Mica shall be used for the insulation of the lamp frame.

d. **Switch.** The switch on the standard shall be of such design that accidental contact with any live part will be impossible.

e. **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. If the rheostat is mounted on the standard, a clearance of 3 inches above the floor shall be maintained. Asbestos-covered type AA conductors shall be used between the rheostat and the lamp.

f. **Terminals.** If stranded conductors are used, they shall be connected to lamp, rheostat and switch terminals by means of approved lugs or connectors; provided that approved pressure connectors shall be used at arc lamp terminals.

5285. Portable Strips. Portable strips shall be constructed in accordance with the requirements for border lights and proscenium side lights in section 5282. 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.

5286. 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 current-carrying capacity of not less than 30 amperes, and shall be protected by overcurrent devices installed in an approved 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.

Portable Switchboards on Stage

5291. Supply. Portable switchboards shall be supplied only from outlets especially provided for this purpose. Such outlets shall consist of 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.

5292. Overcurrent Protection. Circuits from portable switchboards directly supplying equipment containing incandescent lamps of the medium base or smaller types shall be protected by overcurrent devices having a rating or setting of not more than 20 amperes. Circuits for heavy-duty lampholders may be used if 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.

5293. 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 if not of corrosion-resistant type shall be well galvanized, enamelled, or otherwise properly coated to prevent corrosion.

b. Live Parts. Except as provided for dimmer face plates in paragraph 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 200C (392F). Each conductor shall have a current-carrying capacity at least equal to the rating of the circuit-breaker, switch or cutout 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 when connected to clamps or binding screws not specifically approved as pressure connectors.

ARTICLE 530 — MOTION PICTURE STUDIOS AND SIMILAR LOCATIONS

5301. **Scope.** The requirements of this article shall apply to motion picture studios, exchange, factory, laboratory, stage, or a portion of the building in which other than approved slow burning (cellulose acetate or equivalent) motion picture films are manufactured, exposed, developed, printed, cut, edited, rewound, repaired or stored.

For recommendations for protection against nitro-cellulose film hazards refer to N.F.P.A. Pamphlet No. 40.

5302. **Permanent Wiring.** The permanent wiring shall be in approved metal raceways or Type MI cable except that communication circuits, and sound recording and reproducing equipment may be wired as permitted by the articles covering those installations. (See Articles 640 and 800.)

5303. **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. These requirements 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.

5304. **Dressing Rooms.** Fixed wiring in dressing rooms shall be installed in accordance with wiring methods covered in Chapter 3.

5305. **Lamps at Patching and Viewing Tables.** Only approved composition or metal-sheathed porcelain keyless lampholders, equipped with suitable means to guard lamps from mechanical injury and from film and film scrap, shall be used at patching, viewing and cutting tables.

5306. **Lamps in Film Storage Vaults.** Lamps in film storage vaults shall be rigid fixtures, equipped with vapor-tight globes. Lamps shall be controlled by a switch having a pole in each ungrounded conductor. This switch shall be located outside of the vault. This switch shall disconnect from all sources of supply all ungrounded conductors terminating in any outlet in the vault. No electric motors, heaters, portable lights, or other portable electric equipment shall be located in the film storage vaults.

5307. **Portable Lamps.** Portable lamps and work lights shall be equipped with approved portable cords, approved composition or metal-sheathed porcelain sockets and substantial guards. 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.

5308. **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.

5309. **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 pendant 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.

5310. Stage **Lighting and Effects. Switches and Contactors for Stage Set Lighting and Effects.** 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, if located at a distance of not more than 6 feet from the location board.

5311. **Enclosing or Guarding Live Parts.** 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.

5312. **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.

5313. Overcurrent Protection — Short Time Rating.* 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 1.

(1) 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 1 for the kind of insulation used.

(2) 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.

(3) 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 1 and 2 for the kind of insulation used.

(4) 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."

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*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.

5314. **Plugging Boxes.** Each receptacle of plugging boxes shall have a current-carrying capacity of not less than 30 amperes.

5315. **Substations.** High-voltage wiring and equipment shall conform to Article 710.

5316. **Low - Voltage Equipment.** Low - voltage switchboards shall conform to Article 384.

5317. **Overcurrent Protection of Generators.** Three-wire D.C. 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).

5318. **Working Space and Guarding.** Working space and guarding in permanent fixed substations shall conform to Section 1112. For guarding of live parts on motors and generators, see Sections 4308 and 4310.

Switchboards for voltage of not more than 250 volts D.C. between conductors when located in substations or switchboard rooms accessible to qualified persons only need not be dead-front.

5319. **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.

5320. **Grounding at Substations.** Noncurrent-carrying metal parts shall be grounded except the frames of D.C. circuit breakers installed on switchboards.

ARTICLE 540 — MOTION PICTURE PROJECTORS

5401. **Professional-Type Projectors.** 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.

The professional projector employs a 35-millimeter film which is 1⅜ inch wide and has on each edge 5.4 perforations per inch.

5402. **Non-Professional Type Projectors.** Projectors of the non-professional or miniature type, if employing only approved slow-burning (cellulose acetate or equivalent) film, may be operated without a booth.

5403. **Sound Recording and Reproduction.** Sound recording and reproduction equipment shall comply with Article 640.

Equipment and Projectors of the Professional Type

5411. **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.

5412. **Conductor Size.** 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.

5413. **Conductor Insulation.** Asbestos-covered conductors type AA or other types of insulated conductors having a maximum operating temperature of 200C (392F) shall be used on all lamps or other equipment when the ambient temperature at the conductors as installed will exceed 50C (122F).

5414. **Flexible Cords.** Cords approved for hard service in Table 31 of Chapter 10 shall be used on portable equipment.

5415. **Lamp Guards.** Incandescent lamps in projection rooms or booths shall be provided with an approved lamp guard unless otherwise protected by non-combustible shades or other enclosures.

5416. **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. If 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 5246.

5417. **Rewinding, Examination and Storage of Extra Films.** It is recommended that the authority having jurisdiction refer to the standards of the National Fire Protection Association on "Cellulose Nitrate Motion Picture Film" (NFPA No. 40).

5418. **Equipment Prohibited.** No 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 be installed in such booths or rooms, except remote-control switches for the control of auditorium lights or a switch for the motor operating the curtain at the motion-picture screen.

5419. **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 standards of the National Fire Protection Association on "Cellulose Nitrate Motion Picture Film" (NFPA No. 40).

Construction

5431. **Equipment and Projectors of the Professional Type.** Equipment and projectors of the professional type shall comply with the following:

a. **Approved Type.** Projectors and enclosures for arc or incandescent lamps, rectifiers, transformers, rheostats, and similar equipment, shall be of an approved type.

b. **Name Plate.** Projectors and other equipment as set forth in paragraph a of this section, shall be marked with the name or trademark of the maker and with the voltage and current for which they are designed.

5432. **Projectors of the Non-professional Type. Projectors of the non-professional type shall comply with the** following:

a. **Approved Type.** Projectors, lamp enclosures, and current-controlling devices and similar devices shall be **approved as component parts of the projector equipment.**

b. **Name-Plate.** 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."

c. **Source of Illumination.** The source of illumination shall be a lamp of a type approved for stereopticon use or for motion-picture projection.

d. **Film to be Marked.** 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.

CHAPTER 6. SPECIAL EQUIPMENT

ARTICLE 600 — SIGNS AND OUTLINE LIGHTING

6001. **Scope.** The provisions of this article shall apply to the installation of conductors and equipment for signs and outline lighting as defined in Article 100.

6002. **Switch Required.** Each outline lighting installation, and each sign of other than the portable type, shall be controlled by an externally-operable switch which will open all ungrounded conductors and shall be suitable for conditions of installation, such as exposure to the weather.

6003. **In Sight of Sign.** The switch required by section 6002 shall be within sight of the sign or outline lighting which it controls or may be located elsewhere if capable of being locked in the open position.

6004. **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.

6005. **Grounding.** 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. This does not apply to signs of the portable incandescent-lamp type nor to the portable fluorescent-lamp type where the open-circuit voltage does not exceed 150 volts to ground. Isolated non-current-carrying metal parts of outline lighting may be bonded by No. 14 conductors and grounded in accordance with Article 250.

6006. **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.

6007. **Marking.** All 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. 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. The marking of the sign shall be visible for inspection after installation.

6008. Enclosures. Enclosures for signs and outline lighting shall conform to the following:

a. Conductors and Terminals. Sign boxes, cabinets, and outline troughs shall have conductors and terminals, except the supply leads, enclosed.

b. Cutouts, Flashers, Etc. Cutouts, flashers and similar devices, if a part of the sign, shall be in a separate compartment. If not a part of the sign, they shall be enclosed in approved 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. 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 ½ inch or smaller than ¼ inch. Wiring connections shall not be made through the bottoms of enclosures exposed to the weather unless the enclosures are of the raintight type.

d. Material. Except for portable signs of the indoor type, signs and outline lighting shall be constructed of metal or other non-combustible material. Wood may be used for external decoration if placed at least 2 inches from the nearest lampholder or current-carrying part.

e. Strength. Enclosures shall have ample strength and rigidity.

f. Thickness of 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).

g. Protection of Metal. All metallic parts of enclosures shall be galvanized or otherwise protected from corrosion.

Signs and Outline Lighting — 600 Volts or Less

6021. 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 rigid conduit, electrical metallic tubing, flexible metal conduit, armored cable or in metal troughing 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 rain tight and arranged to drain or where Type MI cable is used.

d. Number of Conductors in Raceway. For sign flashers the number of conductors in conduit or tubing may be in accordance with Table 9 of Chapter 10.

e. Open Conductors. Open conductors on insulators shall comply with the provisions of sections 3002 to 3020 inclusive, Article 320, and, if outdoors, Article 730, except that the separation between conductors need be only 2 inches; provided, that 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.

6022. 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.

Signs and Outline Lighting — Exceeding 600 Volts

6031. 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. 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.

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 non-combustible, non-absorptive insulators. Insulators of porcelain shall be glazed on all exposed surfaces. A separation of at least 1½ inches shall be maintained between conductors and between conductors and other objects. Conductors shall not be located where subject to mechanical injury.

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 1½ 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 non-combustible material and used for no other purpose, except that the primary circuit conductors may be in the same channel. The insulators shall be of non-combustible, non-absorptive material.

f. Show-Windows and Similar Locations. If conductors hang freely in the air, away from combustible material, and if not subject to mechanical injury, as in some show-window displays, they need not be otherwise protected.

g. **Conductors in Raceways.** If 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. 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. In dry locations the insulation shall extend beyond the end of the metal covering or raceways not less than 2½ inches for voltages over 10,000, 2 inches for voltages over 5,000 but not exceeding 10,000 and 1½ inches for voltages of 5,000 or less. For conductors at grounded midpoint terminals, no spacing is required. 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.

h. **Open Conductors — Outdoors.** Open conductors outdoors shall be mounted on non-combustible, non-absorptive 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 mechanical injury, or where within reach from ground, roof, or window, conductors shall be enclosed in raceways or suitably guarded. If guarded, a spacing of not less than 1½ inches shall be maintained between conductors and the enclosure unless the enclosure is non-conducting and non-combustible.

6032. **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 4500 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 unless 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 enclosed 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.

6033. **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 non-combustible, non-absorptive supports. Tubing supports should, if 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 mechanical injury. If operating in excess of 7,500 volts, the tubing shall be supported on non-combustible, non-absorptive, insulating supports which maintain a spacing of not less than ¼ inch between the tubing and the nearest surface.

6034. **Terminals and Receptacles for Electric Discharge Tubing.** Terminals and receptacles for electric discharge tubing shall comply with the following:

a. **Terminals.** The terminals of the tubing shall be inaccessible to unqualified persons and isolated from combustible material and grounded metal or shall be enclosed. If enclosed they shall be separated from grounded metal and combustible material by non-combustible, non-absorptive, insulating material approved for the purpose or by 1½ inches of air. Terminals shall be relieved from stress by the independent support of the tubing.

b. Tube Connections Other Than With Receptacles. If 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 1½ inches between conductors or between conductors and any grounded metal.

c. Receptacles. Electrode receptacles for the tubing shall be of non-combustible, non-absorptive 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 non-combustible, non-absorptive 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 ½ 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. Metal enclosures 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 non-combustible, non-absorptive and approved for the voltage of the circuit.

6035. 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.

6036. Marking. All 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. 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. The marking of the sign shall be visible for inspection after installation.

6037. Enclosures. Enclosures for signs and outline lighting shall conform to the following:

a. Conductors and Terminals. Sign boxes, cabinets, and outline troughs shall have conductors and terminals, except the supply leads, enclosed.

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. Enclosures Exposed to Weather. Enclosures for outside use shall be weatherproof and shall have an ample number of drain holes, each not larger than ½ inch or smaller than ¼ inch.

d. Material. Except for portable signs of the indoor type, signs and outline lighting shall be constructed of metal or other non-combustible material. Wood may be used for external decoration if placed at least 2 inches from the nearest lampholder or current-carrying part.

e. Strength. Enclosures shall have ample strength and rigidity.

f. Thickness of 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).

g. Protection of Metal. All metallic parts of enclosures shall be galvanized or otherwise protected from corrosion.

ARTICLE 610—CRANES AND HOISTS

6101. Scope. The provisions of this article shall apply to the installation of cranes, crane runways, hoists, and monorails. Installations in hazardous locations shall comply with the provisions of section 5083.

For definitions of various kinds of cranes and hoists see American Standard Safety Code for Cranes, Derricks, and Hoists, ASA B30.2 — 1943.

Wiring

6111. Types of Conductors. Conductors shall be of the rubber-covered or the thermoplastic type except:

a. **Exposed to High Temperatures.** Conductors exposed to severe external heat, and those between resistors and contact plates, if not exposed to moisture, shall be asbestos insulated (Types AA or AIA), or if the temperature does not exceed 90C (194F), slow-burning (Type SB). If exposed to moisture, such conductors shall be rubber-covered or Type AVL. If rubber-covered conductors are grouped, the group shall be taped with a flameproof covering.

b. **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.

c. **Flexible Conductors.** Flexible conductors may be used to convey current and where practicable, cable reels or take-up devices may be employed.

d. **Varnished Cambric Conductors.** Varnished-cambric conductors (type V) or asbestos varnished cambric (types AVA and AVB) may be used in dry locations.

e. **Type MI Cable.** Type MI cable may be used in wet or dry locations within its specified temperature ratings.

6112. Conductor Sizes. Conductors shall be of the following sizes:

a. **Current-Carrying Capacity.** The allowable current-carrying capacities of conductors shall be as shown in the following table.

The allowable current-carrying capacities of conductors having other than rubber or thermoplastic insulation, supplying motors of 5-, 15-, 30-, or 60-minute ratings, shall be as given in Tables 1 and 2, Chapter 10, increased by 10 per cent.

For the carrying capacity of conductors between controllers and resistors see section 4313.

Current-Carrying Capacities of Conductors Having Rubber or Thermoplastic Insulation Which Supply Crane and Hoist Motors

Size AWG MCM	AMPERES For Motors Having 30- and 60-Minute Short-time Ratings	AMPERES For Motors Having 5- and 15-Minute Short-time Ratings
16	10	11
14	20	22
12	25	28
10	35	39
8	45	50
6	57	63
5	65	72
4	77	85
3	90	99
2	107	118
1	130	143
0	160	176
00	195	215
000	245	270
0000	300	330
250	350	385
300	410	450
350	460	510
400	515	570
450	565	620
500	620	680

b. Minimum. Conductors shall not be smaller than No. 14 except:

1. On cranes and hoists No. 16 may be used provided the 15 minute motor current does not exceed that shown in the preceding table.

2. On operating circuits, No. 16 may be used provided the conductors are protected against mechanical injury.

c. **Contact Conductors.** The size of contact wires shall be not less than the following:

Distance between end strain insulators	Size of wire
0-30 feet	No. 6
31-60 feet	No. 4
over 60 feet	No. 2

6113. **Wiring Method.** Conductors shall be enclosed in raceways or be Type MI cable except:

a. **Bare Conductors.** Bare conductors used as contact conductors.

b. **Open Conductors.** Short lengths of open conductors at resistors, collectors, and other equipment.

c. **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.

d. **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.

6114. **Raceway Terminal Fittings.** Conductors leaving raceways shall comply with the provisions of sections 3008 and 3009.

6115. **Common Return.** If a crane or hoist is operated by more than one motor, a common-return conductor of proper current-carrying capacity may be used.

Contact Conductors

6121. **Installation of Contact Conductors.** Bare contact conductors shall conform to the following:

a. **Contact Wires.** If wires are used as contact conductors they 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 1½ 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 e of this section. 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 2½ inches apart and, if 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 2½ inches where practicable.

d. **Supports for Rigid Conductors.** Conductors along runways and crane bridges, if of the rigid type specified in section 6111-b, 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 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.

6122. 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 ignitible combustible fibers and materials the requirements of section 5083 shall be complied with.

Control

6131. 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 6132. 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.

6132. Disconnecting Means for Crane. If cranes are operated from cages or cabs, 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.

6133. 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 6132, and main-line 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.

6134. Limit Switch. A limit switch shall be provided for upper limit of travel of crane hoists.

Overcurrent Protection

6141. Contact Conductors. The main contact conductors shall be protected by an overcurrent device.

6142. Crane Motors. If more than one motor is employed on a crane, each motor shall have individual overcurrent protection as provided in Article 430, except that if 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 if there is one.

6143. Resistors—Enclosure. If a crane operates over readily combustible material, the resistors shall be placed in a well-ventilated cabinet composed of non-combustible material so constructed that it will not emit flames or molten metal, except where the resistors are located in a cage or cab constructed of non-combustible 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.

6144. 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 when required by section 2545.

ARTICLE 620—ELEVATORS, DUMBWAITERS, AND ESCALATORS

6201. **Scope.** This Article shall apply to electrical equipment and wiring used in connection with elevators, dumbwaiters, and escalators.

6202. **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.

6203. **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.

6204. **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 wiring 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 be flame-retardant and moisture-resistant.

d. Thickness of Insulation. The thickness of the insulation of all wiring shall be suitable for the voltage to which the wiring is subjected.

6205. 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.

6206. Wiring Methods. Conductors located in hoistways and in 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:

a. 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.

b. Short runs of flexible conduit or armored cable may be used on cars if so located as to be free from oil and if securely fastened in place.

c. 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.

d. Conductors between control panels and machine motors, machine brakes, and motor generator sets, not exceeding six feet (6′) in length, may be grouped together and taped or corded without being installed in a raceway provided the taping or cording is painted with an insulating paint. When so installed, the cable groups shall be supported at intervals of not more than three feet (3′) and so located as to be free from mechanical 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 (6′) 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.

Installation of Conductors

6211. Raceway Terminal Fittings. Conductors leaving raceways shall comply with the provisions of sections 3008 and 3009, but in no case shall the raceway terminate less than 6 inches from the floor.

6212. Metal Wireways. Section 3624 shall not apply to wireways provided the sum of the cross sectional area of the individual conductors shall not be more than 50% of the interior cross sectional area of the wireway.

6213. Number of Conductors in other Raceways. The number of operating and control circuit conductors in other raceways may be in accordance with Table 9 of Chapter 10.

6214. 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.

6215. Auxiliary Gutters (Wiring Troughs). Auxiliary gutters shall not be subject to the restrictions of section 3742 as to length or of section 3745 as to number of conductors.

6217. 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.

6218. 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.

It is not intended to prohibit the interruption of long runs for the purpose of supporting or pulling in conductors, and pull boxes may be installed for this purpose.

Traveling Cables

6231. 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.

6232. Hazardous Locations. In hazardous locations, traveling cables shall be secured to explosion proof cabinets by heavy-duty rubber-bushed threaded connector bushings sealed off at the enclosure as provided in section 5015. For traveling cables for use in hazardous locations see Table 31.

6233. Location of and Protection for Cables. Traveling cable supports shall be so located as to reduce to a minimum the possibility of damage due to the cables coming in contact with the hoistway construction or equipment in the hoistway. Where necessary, suitable guards shall be provided to protect the cables against damage.

Control

6241. General. There shall be in addition to the elevator controller, a means for disconnecting all conductors of the circuit to the elevator motor, or in the case of generator field control, to the motor of the motor-generator set which supplies current to the elevator motor.

a. Type. The disconnecting means shall be an enclosed externally operable motor circuit switch or circuit breaker arranged to be locked in the open position.

b. Location. It shall be located adjacent to and be visible from the elevator machine, unless a disconnect switch in the control circuit of the motor-generator set is placed adjacent to and is visible from the elevator machine.

6242. Electrical Equipment in Garages and Similar Occupancies. Electrical equipment and wiring used for elevators, dumbwaiters and escalators in garages shall conform to the requirements of Article 510, provided that wiring and equipment located under the car platform shall be considered as being located in the hazardous area.

6243. **Phase Protection.** Elevators driven by polyphase alternating current machine motors shall be provided with means to prevent starting of the elevator motor if:

a. The phase rotation is in the wrong direction, or

b. There is a failure in any phase.

Overcurrent Protection

6251. **Overcurrent Protection.** Overcurrent protection shall be provided as follows:

a. Control and operating circuits. Control and operating circuits and signal circuits shall be protected against overcurrent in accordance with the requirements of Section 7268.

b. Motors.

1. Duty on elevator, dumbwaiter, and driving motors of generator sets used with generator field control shall be classed as intermittent. These motors shall be protected against overcurrent in accordance with section 4323.

2. Duty on escalator motors shall be classed as continuous. These motors shall be protected against overcurrent in accordance with section 4322.

Machine Room

6261. **Guarding Equipment.** Elevator, dumbwaiter and escalator driving machines, motor generator sets, controllers and auxiliary control equipment shall be installed in a space secured against unauthorized access.

Such equipment may be located in rooms or spaces containing other equipment essential to the operation of the building provided it is separated therefrom by a substantial metal grille enclosure of a design which will reject a ball two inches (2″) in diameter and is at least six feet (6′) high equipped with a self-closing and self-locking door.

It is not intended to prohibit the installation of dumbwaiter or escalator controllers outside the spaces herein specified, provided they are enclosed in cabinets with doors or removable panels capable of being locked in the closed position; nor is it intended to prevent the installation of dumbwaiter controllers within the hoistway without cabinets, provided removable or hinged panels capable of being locked in the closed position are installed in the hoistway enclosures to provide access to the controllers.

6262. Clearance Around Control Panels. There shall be provided sufficient clear working space around control panels to provide safe and convenient access to all live parts of the equipment necessary for maintenance and adjustment. The minimum clear working space about live parts on control panels shall not be less than set forth in a. and b. unless otherwise specified in these sections.

a. Elevator and Dumbwaiter Panels.

1. In the front—30 inches to live panel parts.

2. In the rear—24 inches to live panel parts.

3. On one side of a panel or a group of panels—18 inches except this clearance can be waived if there is a clear passageway, not less than 18 inches wide at any point, from the front to the rear of the panel or panels.

It shall be permissible to mount control panels on, over or against the hoisting machine or motor generator set or to place auxiliary control equipment in the front or rear of control panels provided the clearances to the live parts are not less than specified and provided there is safe access to the front and/or back of the controller from either side.

Where control panels are mounted in cabinets with swing doors or removable panels, sufficient clear space shall be provided to fully open the doors or remove the panels.

b. Escalator Control Panels. The minimum working clearance for escalator control panels shall be as specified in paragraph a. of this section provided that where the control panel is mounted in the same space as the escalator drive machine and the clearances specified cannot be provided, they may be waived if the entire panel is arranged so that it can be readily removed from the machine space and is provided with flexible leads to all external connections.

Where control panels are not located in the same space as the drive machine they shall be so located in cabinets with doors or removable panels capable of being locked in the closed position. Such cabinets may be mounted in the balustrading on the side away from the moving steps.

Grounding

6271. Metal Raceways Attached to Cars. Conduit or armored cable attached to elevator cars shall be bonded to grounded metal parts of the car with which they come in contact.

6272. Electric Elevators. For electric elevators, the frames of all motors, elevator machines, controllers and the metal enclosures for all electrical devices in or on the car or in the hoistway shall be grounded.

6273. Non-Electric Elevators. For elevators other than electric, if any electrical conductors are attached to the car, the metal frame of the car, if normally accessible to persons, shall be grounded.

6274. Hand-Operated Cables. All hand-operated metallic shifting ropes or cables shall be grounded.

6275. Inherent Ground. Equipment mounted on members of the structural metal frame of a building shall be deemed to be grounded. 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 when the machine is grounded in accordance with Article 250.

Overspeed

6276. Power Rectifiers for Direct Current Elevators. Where dry plate rectifiers or other types of rectifiers which are incapable of absorbing electrical energy are used to transform alternating current to direct current for the operation of a direct current elevator motor or motors, means shall be provided to absorb a sufficient amount of the energy regenerated by the elevator motor or motors under overhauling load conditions to prevent any elevator from attaining at any time a speed of more than 125% of its rated speed (speed in the up direction with rated load in the car).

6277. Motor Generator Overspeed Device. Motor generators driven by direct current motors and used to supply direct current for the operation of elevator machine motors shall be provided with speed limiting devices as required by Section 4389.c., which will prevent the elevator from attaining at any time a speed of more than 125% of its rated speed.

ARTICLE 630—ELECTRIC WELDERS

6301. Scope. This article amplifies or modifies parts of Chapters 1 to 4 inclusive of this code in order to properly cover the operating conditions to which electric welder installations are subjected. Accordingly the appropriate provisions of Chapters 1 to 4 inclusive apply to the component parts of electric welder installations except as otherwise provided in this article. This article covers extensively used types of welders which require special treatment, as distinguished from welders which do not require special treatment and welders not in common use and not yet developed to the extent that rating and construction standards are possible.

Transformer Arc Welders

6311. Capacity of Supply Conductors. The current-carrying capacity of conductors shall be as follows:

a. Individual Welders. The rated current-carrying capacity of the supply conductors shall be not less than the rated primary current of the welder.

b. Group of Welders. The rated current-carrying capacity of conductors which supply a group of welders may be less than the sum of the rated primary currents of the welders supplied. The conductor rating shall be determined in each case according to the welder loading based on the use to be made of each welder and the allowance permissible in the event that all the welders supplied by the conductors will not be in use at the same time. The load value used for each welder shall take into account both the magnitude and the duration of the load while the welder is in use.

Conductor ratings based on 100 per cent of the rated primary current of the two largest welders, 85 per cent for the third largest welder, 70 per cent for the fourth largest welder, and 60 per cent of the rated primary current for all the remaining welders, should provide an ample margin of safety under high production conditions with respect to the maximum permissible temperature of the conductors. Percentage values lower than those given are permissible in cases where the work is such that a high operating duty cycle for individual welders is impossible.

6312. Overcurrent Protection. Overcurrent protection shall be as provided in paragraphs a and b. If the nearest standard rating of the overcurrent device used is under the value specified in this section, or if the rating or setting specified results in unnecessary opening of the overcurrent device, the next higher rating or setting may be used.

a. **For Welders.** Each welder shall have overcurrent protection rated or set at not more than 200 per cent of the rated primary current of the welder, except that an overcurrent device is not required for a welder having supply conductors protected by an overcurrent device rated or set at not more than 200 per cent of the rated primary current of the welder.

b. **For Conductors.** Conductors which supply one or more welders shall be protected by an overcurrent device rated or set at not more than 200 per cent of the conductor rating.

6313. Controller. A controller shall be provided in the supply connection of each welder which is not equipped with a controller mounted as an integral part of the welder. The controller shall be a motor-circuit switch or a circuit-breaker. The ampere rating shall be not less than the rated primary current of the welder. The horsepower rating of a switch used as a controller shall be not less than the numerical value obtained by multiplying the rated primary current of the welder by 0.1, 0.2 or 0.25, respectively, for 220-, 440- and 550-volt welders. These factors apply to 2-pole switches.

6314. Nameplate. A nameplate giving the following information shall be provided: name of manufacturer; frequency; primary voltage; rated primary current; maximum open-circuit secondary voltage; rated secondary current; basis of rating, i.e., the duty cycle, 30-minute rating or 60-minute rating.

Motor-Generator Arc Welders

6321. References. Motor-generator arc welder installations are covered by the appropriate sections of Chapters 1 to 4 inclusive applicable to conductors, motors, generators and associated equipment. Referring specifically to the motor supply connections, the following sections apply in addition to such other provisions as may be applicable. Conductor rating, sections 4312 and 4316. Overcurrent protection: for motors, section 4323; for conductors, section 4342. Controllers, sections 4304, 4305 and 4383. Disconnecting means, section 4407.

Resistance Welders

6331. Capacity of Supply Conductors. The current-carrying capacity of the supply conductors necessary to limit the voltage drop to a value permissible for the satisfactory performance of the welder is usually greater than that required to prevent over-heating as prescribed in paragraphs a and b.

a. Individual Welders. The rated current-carrying capacity for conductors for individual welders shall conform to the following:

1. Varying Operation. The rated current-carrying capacity of the supply conductors for a welder which may be operated at different times at different values of primary current or duty cycle shall be not less than 70 per cent of the rated primary current for seam and automatically fed welders, and 50 per cent of the rated primary current for manually-operated non-automatic welders.

2. Specific Operation. The rated current-carrying capacity of the supply conductors for a welder wired for a specific operation for which the actual primary current and duty cycle are known and remain unchanged shall be not less than the product of the actual primary current and the multiplier given below for the duty cycle at which the welder will be operated.

Duty Cycle (per cent)	50	40	30	25	20	15	10	7.5	5.0 or less
Multiplier	.71	.63	.55	.50	.45	.39	.32	.27	.22

b. Groups of Welders. The rated current-carrying capacity of conductors which supply two or more welders shall be not less than the sum of the value obtained as explained in paragraph a of this section for the largest welder supplied, and 60 per cent of the values obtained as explained in paragraph a of this section for all the other welders supplied.

c. Explanation of Terms. (1) The rated primary current is the rated kva multiplied by 1,000 and divided by the rated primary voltage, using values given on the name-plate. (2) The actual primary current is the current drawn from the supply circuit during each welder operation at the particular heat tap and control setting used. (3) The duty cycle is the percentage of the time during which the welder is loaded. For instance, a spot welder supplied by a 60-cycle system (216,000 cycles per hour) making four hundred 15-cycle welds per hour would have a duty cycle of 2.8 per cent (400 multiplied by 15, divided by 216,000, multiplied by 100). A seam welder operating 2 cycles "on" and 2 cycles "off" would have a duty cycle of 50 per cent.

6332. Overcurrent Protection. Overcurrent protection shall be as provided in paragraphs a and b of this section. If the nearest standard rating of the overcurrent device used is under the value specified in this section, or if the rating or setting specified results in unnecessary opening of the overcurrent device, the next higher rating or setting may be used.

a. For Welders. Each welder shall have an overcurrent device rated or set at not more than 300 per cent of the rated primary current of the welder, except that an overcurrent device is not required for a welder having a supply circuit protected by an overcurrent device rated or set at not more than 300 per cent of the rated primary current of the welder.

b. For Conductors. Conductors which supply one or more welders shall be protected by an overcurrent device rated or set at not more than 300 per cent of the conductor rating.

6333. Disconnecting Means. A switch or circuit-breaker shall be provided by which each welder and its control equipment can be isolated from the supply circuit. The current-carrying capacity of this disconnecting means shall be not less than the supply conductor rating determined as explained in this article. The supply circuit switch may be used as the welder disconnecting means if the circuit supplies only one welder.

6334. Nameplate. A nameplate giving the following information shall be provided: name of manufacturer, frequency, primary voltage, rated kva at 50 per cent duty cycle, maximum and minimum open-circuit secondary voltage, short-circuit secondary current at maximum secondary voltage and specified throat and gap setting.

ARTICLE 640—SOUND RECORDING AND SIMILAR EQUIPMENT

6401. Scope. This article shall apply to installations of equipment and wiring used for sound-recording and reproduction, centralized distribution of sound, public address, speech-input systems and electronic organs.

6402. Application of Other Articles. Except as modified by this article, wiring and equipment from source of power to and between devices connected to the interior wiring systems shall comply with the requirements of Chapters 1 to 4, inclusive, of this code, and wiring and equipment for public-address, speech-input, radio-frequency, audio-frequency systems, and amplifying equipment associated with radio receiving stations in centralized distribution systems, shall comply with Article 725.

6403. Number of Conductors in Raceway. The number of conductors in a conduit or other raceway shall comply with Tables 4 to 11 of Chapter 10 except as follows:

a. Special permission may be granted for the installation of two 2-conductor lead-covered cables in ¾-inch conduit, provided the cross-sectional area of each cable does not exceed .11 square inch.

b. Special permission may be granted for the installation of two 2-conductor No. 19 lead-covered cables in ½-inch conduit, provided the sum of the cross-sectional areas of the cables does not exceed 32 per cent of the internal cross-sectional area of the conduit.

6404. Wireways and Auxiliary Gutters. Wireways and auxiliary gutters shall comply with the requirements of Articles 362 and 374 with the following exceptions where used for sound-recording and reproduction:

a. Number of Conductors in Raceway. Conductors in wireways or gutters shall not fill the raceway to more than 75 per cent of its depth.

b. Auxiliary-Gutter Covers. If the cover of auxiliary gutters is flush with the flooring and is subject to the moving of heavy objects it shall be of steel at least ¼ inch in thickness; if not subject to moving of heavy objects, as in the rear of patch or other equipment panels, the cover shall be at least No. 10 USS gauge (.1345 inch).

c. **Metal-Trough Raceways.** Metal-trough raceways may be installed in concealed places if run in a straight line between outlets or junction boxes. Covers of boxes must be accessible. Edges of metal must be rounded at outlet or junction boxes and all rough projections smoothed to prevent abrasion of insulation or conductors. Raceways made of sections shall be bonded and grounded as prescribed in section 2576.

d. **Grounding Wireways and Auxiliary Gutters.** Metal wireways and auxiliary gutters shall be grounded in accordance with the requirements of Article 250. If the wireway or auxiliary gutter does not contain power supply wires, the grounding conductor need not be larger than No. 14 copper or its equivalent. If the wireway or auxiliary gutter contains power supply wires, the grounding conductor shall not be smaller than the size called for in section 2595.

6405. **Grouping of Conductors.** Conductors of different systems grouped in the same conduit or other metallic enclosure, or in portable cords or cables, shall comply with the following requirements:

a. **Power-Supply Conductors.** Power-supply conductors shall be properly identified and shall be used solely for supplying power to the equipment to which the other conductors are connected.

b. **Leads to Motor-Generator or Rotary Converter.** Input leads to a motor-generator or rotary converter shall be run separately from the output leads.

c. **Conductor Insulation.** The conductors shall be insulated individually, or collectively in groups, by insulation at least equivalent to that on the power-supply and other conductors, except where the power-supply and other conductors are separated by a lead sheath or other continuous metallic covering.

d. **Flexible Cords.** Flexible cords and cables shall be of types P, K, S, SJ, ST, SJO, and SJT or other types specifically approved for the purpose for which they are to be used. The conductors of flexible cords, other than power-supply conductors, may be of a size not smaller than No. 26 provided such conductors are not in direct electrical connection with the power-supply conductors and are equipped with current-limiting means so that the maximum power under any condition will not exceed 150 watts.

e. **Terminals.** Terminals shall be marked to show their proper connections. Terminals for conductors other than power-supply conductors shall be separated from the terminals of the power-supply conductors by a spacing at least as great as the spacing between power-supply terminals of opposite polarity.

6406. Storage Batteries. Storage batteries shall comply with the following:

a. **Installation.** Storage batteries shall be installed in accordance with Article 480.

b. **Conductor Insulation.** Storage-battery leads shall be rubber-covered or thermoplastic-covered.

c. **Overcurrent Protection.** Overcurrent protection shall be provided as follows:

1. "A" circuit, when supplied by branch-lighting circuits, or by storage batteries of more than 20-ampere-hour capacity, shall have overcurrent protection not exceeding 15 amperes.
2. "B" circuits shall have overcurrent protection not exceeding 1 ampere. The overcurrent protection shall be placed in each positive lead.
3. "C" circuits when supplied from branch lighting circuits or from storage batteries of more than 20 ampere-hour capacity shall have overcurrent protection not exceeding one ampere.
4. Overcurrent devices shall be located as near as practicable to the battery.

6407. Equipment. Amplifiers and rectifiers shall be so located as to be ready accessible. They shall be suitably housed and shall be of a type approved for the purpose unless otherwise expressly permitted by the authority enforcing this code. Equipment used in hazardous locations shall be specifically approved for the purpose.

a. **Ventilation.** Amplifiers and rectifiers shall be so located as to provide sufficient ventilation to prevent undue temperature rise within the housing.

b. **Protection Against Mechanical Injury.** Amplifiers, rectifiers, loud-speakers and other equipment shall be so located or protected as to guard against mechanical injury such as might result in fire or personal hazard.

ARTICLE 650—ORGANS

6501. General. This article shall apply to those electric circuits and parts of electrically operated organs which are employed for the control of the sounding apparatus and keyboards. Electronic organs shall comply with the appropriate provisions of Article 640.

6502. Source of Energy. The source of energy shall be a self-excited generator of not over 15 volts, or a primary battery.

6503. Insulation—Grounding. The generator shall be effectively insulated from the ground and from the motor driving it, or both the generator and the motor frames shall be grounded in the manner prescribed in Article 250.

6504. Conductors. Conductors shall comply with the following:

a. Size. No conductor shall be smaller than No. 26, and the common-return conductor shall be not smaller than No. 14.

b. Insulation. Conductors shall have rubber, thermoplastic, asbestos, cotton, or silk insulation, except the common-return conductor which shall be rubber-covered, thermoplastic, asbestos-covered (types AA, AI, or AIA), or slow-burning (type SB). The cotton or silk may be saturated with paraffine if desired.

c. Conductors to Be Cabled. Except the common-return conductor, and conductors inside the organ proper, the organ sections and the organ console, conductors shall be cabled. The common-return conductor may be placed under an additional covering enclosing both cable and return conductor, or may be installed as a separate conductor and may be in contact with the cable.

d. Cable Covering. The cable shall be provided with one or more braided outer coverings, provided that a tape may be used in place of an inner braid. Unless installed in metal raceways the outer braid shall be flame-retardant or shall be covered with a closely-wound fireproof tape.

6505. Installation of Conductors. Cables shall be securely fastened in place and may be attached directly to the organ structure without insulating supports. Cables shall not be placed in contact with other conductors.

6506. Overcurrent Protection. Circuits shall be so arranged that all conductors, except the main supply conductors and the common-return conductor, shall be protected from overcurrent by an overcurrent device of not greater than 15-ampere rating.

ARTICLE 660—X-RAY EQUIPMENT

6601. Scope. The provisions of this article shall apply to all apparatus embodying X-ray operating at any frequency, for medical use, for examination of fabrics, metals, or fruits, or for any other purpose. Unless approved for the location, X-ray and related apparatus shall not be installed nor operated in hazardous locations or operated on a supply potential of more than 600 volts.

Nothing in this article shall be construed as specifying safeguards against direct, stray or secondary X-ray radiation. Such safeguarding for industrial installations is the scope of Parts I and III of American War Standard ASA Z-54.

6602. Overhead Conductors. For new equipment used on new installations of X-ray apparatus, all conductors in the high-voltage circuits that are not in raceways shall be of the approved shockproof type. When existing equipment employing uninsulated or bare overhead conductors is moved to a new location, or where reconditioned used equipment of the uninsulated or bare conductor overhead type is resold for installation at a new location, the authority enforcing this code may require that the overhead stationary conductors be not less than 8 feet from the floor unless guarded from contact, and that any connections from the X-ray tube to exposed overhead uninsulated or bare conductors shall be made with high-voltage cables of the approved shockproof type.

6603. On Fluoroscope Tables. Leads on fluoroscope tables shall be adequately insulated or be provided with barriers which will guard against inadvertent contact.

6604. Milliammeter. If one side or mid-point of the high-voltage circuit is grounded, the milliammeter shall be connected to the grounded lead and need not be guarded.

6605. Wiring Terminals. Equipment covered by this article shall be provided with suitable wiring terminals or leads for the connection of conductors of at least the size required by the load corresponding to the input rating of the equipment.

6606. Connection to Supply Circuit. X-ray apparatus permanently installed shall be connected to the power supply by means of a wiring method meeting the general requirements of this code, except that apparatus properly supplied by branch circuits not larger than a 30-ampere branch circuit may be supplied through suitable plug and heavy-duty cable or cord. Transportable X-ray apparatus of any capacity may be connected to its power supply by suitable temporary connections and heavy-duty cable or cord. A disconnecting means of adequate capacity shall be provided in a location readily accessible from the X-ray control. For apparatus requiring 115-volt line fuses of 30 ampere or less a plug and receptacle of proper size and of an approved make may serve as a disconnecting means.

6607. Number of Conductors in Raceway. The number of control circuit conductors installed in a raceway may be in accordance with Table 9 of Chapter 10.

Control

6611. Stationary Equipment. The low-voltage circuit of the step-up transformer shall contain a circuit-breaker having no exposed live parts and which shall under all operating conditions protect the radiographic circuit against fault conditions. If the design of the high-voltage transformer is such that branch fuses having a current rating lower than the current rating of the circuit-breaker are required for adequate protection for fluorcscopic and therapeutic circuits, they shall be added for the protection of these circuits. It is recommended that, if possible, the circuit-breaker protect all circuits; namely, radiographic, fluoroscopic and therapeutic circuits. The circuit-breaker shall be installed as a part of the equipment or directly adjacent thereto. The circuit-breaker shall be manually operable, or else there shall be at least one other switch which is manually operable in the low-voltage circuit of the step-up transformer, either as a part of the equipment or directly adjacent thereto.

6612. Portable Equipment. Portable equipment shall comply with section 6611, except that no circuit-breaker is required when the high-voltage parts, including the X-ray tube, are within the single metallic enclosure which is provided with a means for grounding. The circuit-breaker, when required, shall be located in or on the portable equipment.

6613. General. In addition to complying with sections 6611 or 6612 as the case may be, medical X-ray apparatus shall be provided with controlling means as follows:

a. **Radiographic Type.** A timer shall be provided and controlled by a switch which shall be designed to open automatically except when held closed by the operator.

b. **Fluoroscopic Type.** A switch shall be provided which shall be designed to open automatically except when held closed by the operator.

c. **Therapy.** A timer shall be provided which is not of the repeating type.

6614. Industrial X-ray Apparatus. Radiographic and Fluoroscopic Types. A switch which shall be designed to open automatically except when held closed by the operator, or a timer, shall be provided.

6615. Foot Switch. Switches operated by foot pressure should be provided with a shield over the contact button to avoid accidental closing unless the equipment is of the fully enclosed shockproof type. When used for radiographic work, the foot switch shall return automatically to the X-ray off position when foot pressure is removed. The foregoing recommendation shall have mandatory effect in the case of X-ray equipment for industrial use.

6616. Independent Control. If more than one piece of apparatus is operated from the same high-voltage circuit, each piece or each group of apparatus as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact with its live parts.

Transformers and Capacitors

6621. General. Transformers and capacitors which are part of an X-ray apparatus shall not be required to conform to the requirements of Articles 450 and 460 of this code.

6622. Draining Capacitor Charge. Unless all current-carrying parts of capacitors, and of the conductors connected therewith, are at least 8 feet from the floor and are inaccessible to unauthorized persons, or unless when within 8 feet from the floor are within enclosures of grounded metal or insulating material, capacitors shall be provided with an automatic means for discharge and grounding the plates whenever the transformer primary is disconnected from the source of supply.

Guarding

6631. General. For new apparatus used on new installations, all high-voltage parts shall be mounted within grounded enclosures. Either air, oil, or other suitable insulating media may be used to insulate the high voltage from the grounded enclosure. When existing apparatus employing open type overhead conductors is moved to a new location, or where reconditioned used apparatus of the open overhead type is resold for installation at a new location, the authority enforcing this code may require that all high-voltage parts within 8 feet of the floor be protected against contact by barriers of grounded metal, or protected by approved insulating material. These requirements do not apply if the high-voltage parts are installed in separate rooms or enclosures which are provided with suitable door-operated switches to open the supply circuit to the X-ray unit except while the door of such room or enclosure is locked from the outside. The connections from the exposed overhead conductors may be made with high-voltage cables of the shockproof type.

6632. Enclosures of Wood. Wooden cabinets containing high-voltage parts shall be lined inside with approved fire-resistant material. The high-voltage parts shall have adequate spacing from walls of the cabinet. High-voltage equipment containing oil shall not be installed in wooden cabinets. Cabinets shall provide sufficient ventilation for safe operation of the equipment therein.

6633. Therapy Tubes and Equipment. X-ray tubes used in therapy shall be mounted in enclosures of grounded metal or insulating material approved for the purpose unless otherwise expressly permitted by the authority enforcing this code. Unless fully enclosed in cabinets or cases of grounded metal or of approved insulating materials, all high-voltage parts of generators, rectifiers, filters and cooling equipment shall be installed in a separate room or enclosure. Suitable arrangements shall be provided whereby the switch controlling the supply circuit to such equipment will necessarily be open, except while the door of such room or enclosure is locked from the outside.

6634. Grounding. Non-current-carrying metal parts of tube stands, fluoroscopic and other apparatus shall be grounded in the manner prescribed in Article 250.

ARTICLE 665—INDUCTION AND DIELECTRIC HEAT GENERATING EQUIPMENT

6651. Scope. The provisions of this article shall apply to the construction and installation of induction and dielectric heat-generating equipment and accessories.

The term "generating equipment" as used in this article shall be understood to mean any equipment used to change the voltage and/or frequency of the power supplied to such equipment.

Induction heating is the heating of a nominally conducting material due to its own I^2R losses when the material is placed in a varying electro-magnetic field.

Dielectric heating is the heating of a nominally insulating material due to its own dielectric losses when the material is placed in a varying electric field.

The term "therapeutic high frequency equipment" as used in this article shall be understood to mean generating equipment capable of producing alternating currents having frequencies greater than those frequencies which elicit neuromuscular response. In order to comply with the above, the output frequency of the therapeutic high frequency equipment shall not be less than 2 megacycles.

6652. Application of Other Articles. Wiring from the source of power to generating equipment shall comply with Code Chapters 1 to 4 inclusive. Circuits and equipment operating on a supply circuit of more than 600 volts shall comply with the provisions of Article 710.

6653. Capacity of Supply Conductors.

a. For Motor Generator Equipment. Capacity of supply conductors shall be determined from Article 430 of this Code.

b. For Other Than Motor Generator Equipment. Capacity of supply conductors shall be determined as follows:

1. The current-carrying capacity of the circuit shall be at least 100 per cent of the nameplate current rating of the equipment.

2. The current-carrying capacity of conductors supplying two or more equipments shall be equal to at least 100 per cent of the sum of nameplate current ratings on all equipment involved except as follows: If, when supplying

two or more equipments from the same feeder, simultaneous operation of said equipments is not possible, the capacity of the feeder shall be at least 100 per cent of the sum of the nameplate currents for the largest group of machines capable of simultaneous operation, plus 100 per cent of the standby currents of the remaining machines supplied.

6654. Overcurrent Protection.

a. **For Motor Generator Equipment.** Overcurrent protection shall be provided as specified in Article 430 of this Code.

b. **Other Than Motor Generator Equipment.** Overcurrent protection shall be provided, if not supplied as part of the equipment, to protect the equipment as a whole. The overcurrent device shall have a rating or setting of not more than 200 per cent of the nameplate current rating.

6655. Disconnecting Means. A readily accessible disconnecting means shall be provided by which each generating equipment can be isolated from the supply circuit. The current-carrying capacity of this disconnecting means shall be at least 100 per cent of the nameplate current rating of equipment. The supply circuit switch may be used as the generating equipment disconnecting means if the circuit supplies only one equipment.

6656. Output Circuits. Output circuits shall conform to the following:

a. Output circuit parts shall include all high frequency components external to the generator, including interconnecting radio frequency transmission lines, load tuning networks, and work applicators. With respect to guarding, all such parts shall be considered with the generating equipment as a complete assembly.

b. The work applicator shall be so guarded that safe operation of the equipment will always be assured.

c. When the connections between the generator and work applicator exceed two feet in length the connections shall be enclosed or guarded with non-combustible material.

d. The generator output shall be at direct-current ground potential (coupled outputs alone, without other precautions, will not suffice because of the danger existing during possible flashovers).

6657. Grounding and Bonding. Grounds or inter-unit bonding shall be used wherever required for circuit operation and for limiting to a safe value radio frequency potentials between all exposed non-current-carrying parts of the equipment and earth ground, also between all equipment parts and surrounding objects and between such objects and earth ground. Such grounding and bonding shall be installed in accordance with Article 250 of this Code.

6658. Low Frequency A.C. in Generating Equipment Output. Commercial frequencies of 25 to 60 cycle alternating-current output may be coupled for control purposes, but shall be limited to a value of 150 volts available only during periods of circuit operation.

6659. Hazardous Locations. Induction and dielectric heat generating equipment shall not be installed in hazardous locations as defined in Article 500 unless the equipment is designed and approved for hazardous locations.

6660. Enclosure of Generating Apparatus. The generating apparatus including the D.C., low-, and high-frequency electrical circuits but excluding the output circuits shall be completely contained in an enclosure of noncombustible material. The metal housings of motors, generators and the like may serve as a part of this enclosure.

6661. Panel Controls. All panel controls shall be of "dead front" construction.

6662. Access to Internal Equipment. Doors or detachable panels may be employed for internal access. Where doors are used, giving access to voltages above 500 volts A.C. or D.C., either door locks shall be provided or interlocking shall be installed with the choice of precaution optional. Detachable panels not normally used for access to such parts shall be fastened in a manner not conveniently removable.

6663. Warning Labels. Warning labels, definitely indicating danger, shall be attached to doors, access panels or at other vantage points on equipment, so that the labels will be plainly visible when doors are opened or panels are removed from compartments containing voltages above 250 volts A.C. or D.C.

6664. Foot Switch. Switches operated by foot pressure, except those for electro-surgical apparatus, shall be provided with a shield over the contact button to avoid accidental closing.

6665. Nameplate Data. Each generating equipment shall be provided with a nameplate giving the manufacturers' name and model identification and the following input data: line volts, frequency, number of phases, maximum current, full load kva, and power factor.

6666. Remote Control. When remote controls are used for applying power, a "Local-Remote" switch shall be provided and interlocked so as to prevent the possibility of applying power from other than one selected control point or points.

6667. Capacitors. When capacitors in excess of 0.1 Mfd. are used in D.C. circuits, either as rectifier filter components, arc suppressors, etc., having circuit voltages exceeding 230 volts above ground, bleeder resistors or grounding switches shall be used as grounding devices.

Where auxiliary rectifiers are used with filter capacitors in the output for bias supplies, tube keyers, etc., bleeder resistors shall be used even though the D.C. voltage may not exceed 230 volts.

6668. Keying. Where high speed keying circuits dependent on the effect of "oscillator blocking" are employed, the peak RF output voltage during the blocked portion of the cycle shall not exceed 100 volts.

6669. Protective Cages and Shielding. Protective cages or adequate shielding shall be used to guard work applicators. Interlock switches shall be used on all hinged access doors, sliding panels or other easy access means normally intended for quick access to the applicator. All interlock switches shall be connected in such a manner as to remove all power from the applicator when any one of the access doors or panels is open.

6670. Power Supply for Therapeutic Equipment.

a. Where portability is not essential, equipment shall be permanently installed in accordance with Chapters 1 to 3 inclusive.

b. Where portability is essential, the power supply cord shall be three-conductor hard service cord of such current-carrying capacity as to be not less than the marked rating of the equipment, and it shall be provided with one conductor whose insulation is green in color for equipment grounding. If the marked rating of the equipment exceeds 15 amperes the cord shall terminate in an approved three-blade attachment-plug cap. If the marked rating of the appliance does not exceed 15 amperes the cord may be terminated in an approved two-blade attachment-plug cap with grounding wire. (see section 2559)

6671. Applicators for Therapeutic Equipment. Application of the high frequency power to the patient may be made by means of an electric field or of an induction field. Current-carrying parts of applicators shall be so insulated or enclosed that reliable isolation of the patient shall be assured.

ARTICLE 670—MACHINE TOOLS

General

6701. Scope. The provisions of this article apply to the electrical equipment for motor-driven, complete metal-working machines, not portable by hand, having one or more tool and work holding devices used for progressively removing metal in the form of chips.

6702. Application of Other Articles. The following provisions cover the requirements for electrical wiring and equipment on machine tools within the scope of this article. They are in addition to or amendatory of the applicable provisions of other articles of this code, which apply except as modified in this article.

6703. Identification. Each electrically operated machine tool shall be marked where plainly visible to show the voltage, full-load current and frequency required for each external circuit supplying the machine tool. For a multi-motored machine tool, this full-load current marking shall be not less than the sum of the full-load currents required for all motors which may be in operation at one time under normal conditions of use. If only a single motor is used, the motor nameplate may serve if plainly visible.

6704. Lighting. Lighting fixtures which are a part of or attached to any machine tool shall conform to the following:

a. Voltage. The lighting circuit voltage shall not exceed 150 volts between conductors and shall be a grounded circuit.

b. Flexible Cord. Flexible cord if used shall be of a type suitable for hard usage (see Table 31), and shall be resistant to coolant and oil. It shall be arranged so it cannot be damaged by moving parts of the machine.

Wiring Method

6711. Wiring Method. Conductors shall be in rigid metal conduit or be Type MI cable, except as provided in sections 6712 to 6714 inclusive.

6712. Flexible Metal Conduit. Flexible metal conduit, including the liquid-tight type, may be used only where necessary to employ flexible connections for small or infrequent movements, as at motor terminals.

6713. Continuously Moving Parts. Wiring connections to continuously moving parts of a machine tool shall be of approved type, extra-flexible, non-metallic-covered, multi-conductor cable. Conductors shall conform to section 6722. In lieu of cable, individual conductors enclosed in flexible tubing may be used. The tubing and its fittings shall be approved for the purpose, and conductors in such tubing shall be considered as subject to oil or coolant.

6714. Compartments and Raceways. Compartments and raceways within the framework of a machine tool may be used to enclose conductors, provided they are isolated from coolant and oil reservoirs and are entirely enclosed. Conductors in machine compartments and raceways shall be secured and so arranged that they will not be subject to mechanical injury or abrasion.

6715. Number of Bends in Conduit. If a run of rigid metal conduit does not exceed 25 feet in length, and the conductor fill does not exceed 30 per cent of the cross-sectional area of the conduit, the requirements of section 3471 shall not apply.

Conductors

6721. Sizes Permitted. Circuit and control conductors on or in machines shall not be smaller than No. 14 except as follows:

a. **Conductors to Moving Parts.** Copper conductors for control purposes to continuously moving parts may be No. 16 if all such conductors are insulated for the maximum voltage of any conductor in the cable or tubing.

b. **Conductors to Electronic and Precision Devices.** Copper conductors to electronic and precision devices may be No. 20, except if pulled into raceways they shall be not smaller than No. 18.

6722. Type. Conductors shall be of a type suitable for conditions of use. Flexible, non-metallic, multi-conductor cable shall have an oil- and moisture-resistant insulation with a flame-retardant outer covering.

6723. Identification of Conductors. Conductors shall be identified either by color code or by other distinctive means. White or natural gray coloring shall be used only

for a grounded conductor, and green only for a conductor used to ground the frame of equipment.

Control Equipment

6731. Mounting. Controllers shall be mounted in such a manner as to guard against mechanical injury, oil, coolant, dust, and dirt.

6732. In Machine Compartments. Compartments in the column or base of a machine may serve as enclosures for control equipment if the following provisions are complied with:

a. **Thickness of Metal.** The wall thickness shall be not less than No. 14 USS gauge if of sheet steel, not less than ⅛-inch if of cast metal, or not less than 3/32-inch if of malleable iron.

b. **Covers.** Compartments shall have tight-fitting hinged covers, not thinner than specified in paragraph a. Covers shall have adequate means for fastening securely in a closed position.

c. **Control Enclosures.** Compartments used for control enclosures shall be readily accessible and shall not contain moving parts not directly connected to electrical control equipment, and shall be so located as to guard the control devices against oil, coolant, chips, and dirt.

d. **Venting.** A compartment enclosing group control equipment with branch circuit fusing as specified in paragraph b of section 6742, shall have a clear opening of at least 2 square inches, vented to another compartment within the column or base and having at least one-half the volume of the control compartment.

e. **No Floor Opening.** Compartments enclosing control equipment shall not be open to the floor or foundation upon which the machine rests.

6733. Not In Machine Compartment. Controllers not in machine compartments shall comply with the following:

a. Controllers with overcurrent protection as permitted by section 6742 may be mounted on the outside of the machine tool or on the floor as close to the machine tool as possible provided the enclosures comply with all the provisions of section 6732.

b. Other controllers may be mounted on the outside of the machine tool or elsewhere if they comply with the provisions of Article 430.

Motor Branch-Circuit Overcurrent Protection

6741. Branch Circuits. Any motor on a machine tool may be supplied from an individual branch circuit in accordance with the provisions of Article 430, or may be connected to a branch circuit which also supplies other motors on the same machine tool in accordance with the provisions of section 4343 or of section 6742. The conductors supplying all motors on a single machine tool may be considered a single branch circuit if all of these motors are protected in accordance with the provisions of section 4343 or of section 6742.

6742. Several Motors on One Branch Circuit. Controllers and running overcurrent protective devices for two or more motors connected to the branch circuit of a single machine tool need not comply with the provisions of section 4343, if all of the following provisions are complied with:

a. **Motor-Running Protection.** Each motor shall be protected by a motor-running overcurrent protective device.

b. **Rating of Overcurrent Devices.** The branch circuit shall have overcurrent protection of a rating equal to that specified in section 4342 for the largest motor connected to the circuit, plus an amount equal to the sum of the full-load current ratings of all other motors on the machine tool which may be in operation at one time under normal conditions of use and which are connected to the same circuit. In no case shall overcurrent protection be more than 200 amperes at 250 volts or less, or 100 amperes at 600 volts or less.

c. **Enclosures.** Enclosures for control equipment and running protective devices enclosed in machine compartments, or mounted on or adjacent to the machine, shall comply in all respects with the provisions of sections 6732 or 6733.

d. **Conductors.** The conductors of the branch circuit shall comply with the provisions of paragraph b of section 4343.

Protection and Grounding

6751. **Protection Against Damage.** If the failure of one motor to operate while others continue to run could cause damage, they shall be so connected that the tripping of any overload or undercurrent device will result in stopping all of these motors.

6752. **Grounding.** All machine tools within the scope of this article, including connected portable equipment, shall be effectively grounded as specified in Article 250.

6753. **Moving Parts.** A machine part that moves on grounded metal guides or supporting ways shall be considered as adequately grounded if the movable part may not readily be removed by hand.

CHAPTER 7. SPECIAL CONDITIONS

ARTICLE 700—EMERGENCY SYSTEMS

7001. **Scope.** The provisions of this article apply to the installation, operation, and maintenance of circuits, systems, and equipment intended to supply illumination and power in the event of failure of the normal supply or in the event of accident to elements of a system supplying power and illumination essential for safety to life and property where such systems or circuits are legally required by Municipal, State, Federal or other codes, or by any governmental agency having jurisdiction.

Emergency systems are generally installed in places of assembly where artificial illumination is required, such as buildings subject to occupancy by large numbers of persons, hotels, theaters, sports arenas, hospitals and similar institutions. Emergency systems may provide power for such functions as essential refrigeration, operation of mechanical breathing apparatus, ventilation when essential to maintain life, illumination and power for hospital operating rooms, fire pumps, industrial processes where current interruption would produce serious hazards, public address systems and similar functions.

See NFPA Building Exits Code for specification of locations where emergency lighting is considered essential to life safety.

7002. **Capacity.** Emergency systems shall have adequate capacity and rating for the emergency operation of all equipment connected to the system.

7003. **Other Requirements.** All requirements of the National Electrical Code shall apply to emergency systems, except as modified by this article. All equipment shall be approved for use on emergency systems.

7004. **Tests and Maintenance.** The authority having jurisdiction shall conduct or witness a test on the complete system upon installation and periodically afterward. Systems shall be tested periodically on a schedule acceptable to the authority having jurisdiction to assure their maintenance in proper operating condition. Where battery systems or unit equipments are involved, including batteries used for starting or ignition in auxiliary engines, the authority having jurisdiction shall require periodic maintenance. A written record shall be kept of such tests and maintenance.

Current Supply

7011. **Systems.** Current supply shall be such that in event of failure of the normal supply to or within the building or group of buildings concerned, emergency lighting, or emergency power, or both emergency lighting and power, will be immediately available. The supply system for emergency purposes may comprise one or more of the types of system covered in Section 7012 to Section 7015. Unit equipments in accordance with Section 7061 shall satisfy the applicable requirements of this article.

Consideration must be given to the type of service to be rendered, whether of short time duration, as for exit lights of a theater, or for supplying emergency power and lighting due to a long period of current failure from trouble either inside or outside the building, as in the case of a hospital.

Assignment of degree of reliability of the recognized emergency supply system depends upon the careful evaluation of the variables at each particular installation.

7012. **Storage Battery.** One service, in accordance with Article 230, and a storage battery of suitable rating and capacity to supply and maintain at not less than 91 per cent of system voltage the total load of the circuits supplying emergency lighting and emergency power for a period of at least ½ hour. Automobile type batteries shall not be used. Lead batteries of other than the sealed glass jar type should not be used.

7013. **Generator Set.** One service, in accordance with Article 230, and a generator set driven by some form of prime mover and of sufficient capacity and proper rating to supply circuits carrying emergency lighting or lighting and power, with suitable means for automatically starting the prime mover on failure of the normal service. Automobile type storage batteries, dry cell batteries or lead batteries of other than the sealed glass jar type should not be used for starting or ignition uses in engine driven generators.

7014. **Separate Service.** Two services, each in accordance with Article 230, widely separated electrically and physically to minimize possibility of simultaneous interruption of supply.

7015. **Sub-service tapped ahead of service disconnecting means.** Connections on the line side of the main service if sufficiently separated from main service to prevent simultaneous interruption of supply through an occurrence within the building or group of buildings served.

7016. Derangement Signals. Audible and visual signal devices shall be provided where practicable, to give warning of derangement of emergency or auxiliary current sources jeopardizing their proper functioning, to indicate when batteries or generator sets are carrying load, and to indicate when battery charger is properly functioning.

Lighting and Power

7021. Emergency Illumination. Emergency illumination shall include all required exit lights and all other lights specified as necessary to provide sufficient illumination to enable persons to see their way out of the building.

7022. Circuits for emergency lighting. Branch circuits intended to supply emergency lighting shall be so installed as to provide service immediately when the normal supply for lighting is interrupted. Such installations shall provide either one of the following:

a. An emergency lighting supply, independent of the general lighting system with provisions for automatically transferring, by means of devices approved for the purpose, the emergency lights upon the event of failure of the general lighting system supply.

b. Two or more separate and complete systems with independent power supply, each system providing sufficient current for emergency lighting purposes. Unless both systems are used for regular lighting purposes and are both kept lighted, means shall be provided for automatically energizing either system upon failure of the other. Either or both systems may be part of the general lighting system of the protected occupancy if circuits supplying lights for emergency illumination are installed in accordance with other sections of this article.

Emergency lighting systems should be so designed and installed that the failure of any individual lighting element, such as the burning out of a light bulb, cannot leave any space in total darkness.

7023. Circuits for emergency power. Branch circuits which supply equipment classed as emergency shall be supplied with an emergency supply source to which the load will be transferred automatically and immediately upon the failure of the normal supply.

7024. **Independent Wiring.** Emergency circuit wiring shall be kept entirely independent of all other wiring and equipment and shall not enter the same raceway, box or cabinet with other wiring except in the case of transfer switches or exit and emergency lights supplied from two sources or as otherwise permitted in this Article.

7025. **Connection of Appliances.** No appliances and no lamps, other than those specified as required for emergency use shall be supplied by emergency lighting circuits except as provided in this Article.

7026. **Auxiliary Source.** The requirements of section 7002 and 7011 shall also apply to installations where the entire electrical load on a service or sub-service is arranged to be supplied from a second source. Current supply from a standby power plant shall satisfy the requirements of availability in section 7011.

Control

7041. **Switch required.** Circuits for emergency illumination shall be controlled through switches accessible only to authorized persons. Where two or more switches are installed to control a single circuit these switches shall be of the single throw type and be connected in parallel and at least one of these switches shall be accessible only to authorized persons. Switches in series or three and four way switches shall not be used. Additional switches which act only to put emergency lights into operation but not disconnect them are permissible.

7042. **Switch location.** All manual switches for controlling emergency circuits shall be in locations convenient to authorized persons responsible for their actuation. In places of assembly such as theatres a switch for controlling emergency lighting systems shall be located in the lobby or at a place conveniently accessible thereto. In no case shall a control switch for emergency lighting in a theatre or motion picture theatre be placed in a motion picture projection booth or on a stage, except that where multiple switches are provided, one such switch may be installed in such location if so arranged that it can energize, but not disconnect, the circuit.

7043. **Other Switches.**

a. Those lights on the exterior of the building which are not required for illumination when there is sufficient daylight may be controlled by an automatic light-actuated device approved for the purpose.

b. Switching arrangements to transfer corridor lighting in patient areas of hospitals from overhead fixtures to fixtures designed to provide night lighting may be permitted, provided the switching system is so designed that switches can only select between two sets of fixtures and cannot extinguish both sets at the same time.

Overcurrent Protection

7051. Accessibility. The branch-circuit overcurrent devices shall be accessible to authorized persons only.

Unit Equipments

7061. Unit equipments. Where permitted by the authority having jurisdiction, in lieu of other methods specified elsewhere in this article, individual unit equipments for emergency illumination shall consist of (a) a battery, (b) battery charging means when a storage battery is used, (c) one or more lamps, and (d) a relaying device arranged to energize the lamps automatically upon failure of the normal supply to the building. The batteries shall be of suitable rating and capacity to supply and maintain at not less than 91% of rated lamp voltage the total lamp load associated with the unit for a period of at least ½ hour. Automobile type batteries or lead batteries of other than the sealed glass jar type should not be used.

Unit equipments shall be permanently fixed in place (i.e. not portable) and shall have all wiring to each unit installed in accordance with the requirements of any of the wiring methods in Chapter 3. They shall not be connected by flexible cords. The supply circuit between the unit equipment and the service, feeders, or the branch circuit wiring shall be installed as required by Section 7024. Emergency illumination fixtures which obtain power from a unit equipment and are not part of the unit equipment shall be wired to the unit equipment as required by Section 7024 and by one of the wiring methods of Chapter 3.

ARTICLE 710—CIRCUITS AND EQUIPMENT OPERATING AT MORE THAN 600 VOLTS BETWEEN CONDUCTORS

7101. Scope. This Article applies to all circuits and equipment operated at more than 600 Volts except those covered in Article 410, Lighting Fixtures, Lampholders, Lamps, Receptacles and Rosettes; Article 600, Signs and Outline Lighting; Article 660, X-Ray Equipment, and Article 665, Induction and Dielectric Heat Generating Equipment.

7102. Installations Covered in Other Articles. Provisions applicable to specific types of installations are included in Article 230, Services; Article 430, Motors and Controllers; Article 450, Transformers and Transformer Vaults; Article 460, Capacitors, and Article 730, Outside Wiring.

7103. Grounding. Wiring and equipment installations shall conform with the applicable provisions of Article 250.

7105. Installation Methods. Circuit conductors shall be suitable for the voltage and the conditions under which they are installed. They shall be installed in rigid metal conduit, in raceways or ducts or as open runs of metal armored cable suitable for the use and purpose except that in locations accessible to qualified persons only, open runs of non-metallic sheathed cable, bare conductors and bare bus bars may also be used.

7106. Flame-Retardant Braid for Braid-Covered Insulated Conductors. Open runs of braid-covered insulated conductors shall have a flame-retardant braid. If the conductors used do not have this protection a flame-retardant saturant shall be applied to the braid covering after installation. This treated braid covering shall be stripped back a safe distance at conductor terminals, according to the operating voltage. This distance should be not less than one inch for each kilovolt of the conductor-to-ground voltage of the circuit, if practicable.

7107. Shielding of Rubber Insulated Conductors. If non-leaded, fibrous covered*, rubber insulated conductors for permanent installation operate at voltages higher than those

*Fibrous covering is a woven braid, tape, serving or wrap or combination thereof, made from textile fibers, such as asbestos, cotton, glass, jute, rayon and silk, classified as textile materials and applied over the insulation on electrical wires and cables.

indicated in the following table and under the conditions mentioned, they shall be of a type having metallic or semi-conducting shielding for the purpose of confining their dielectric field. The semi-conducting shield shall be an approved type.

Method of Installation	Voltage in Kv. Above Which Shielding is Required Neutral Grounded	Neutral Ungrounded
In ducts or metal conduits in wet or damp locations	2	2
In ducts or metal conduits in permanently dry locations	6**	3**
On insulators, only if multiple conductor	6	3

**Supposedly dry metallic conduits in some cases may contain sufficient moisture to allow formation of ozone and thus damage nonshielded cable at voltages above 2000. For conservative practice it may be desirable to shield below the limits given.

This rule is necessary because of the susceptibility to damage of rubber-covered conductors by corona which occurs at the higher voltages, particularly under alternately moist and dry conditions.

7108. **Shielding Tape of Cables to be Grounded.** The metallic or semi-conducting tape used as a static voltage shield under the outer covering of shielded cable shall be stripped back a safe distance according to the circuit voltage, at all terminations of the shielding, as in potheads and joints. At such points stress cones shall be made and shielding tape grounded.

Equipment—General Provisions

7110. **Indoor Installations.** Indoor electrical equipment installations shall conform with subparagraphs a., b. and c. of this section.

a. **In Public Places.** In places which are regularly open to the public, electrical installations shall conform with sections 7120 to 7125 inclusive.

b. **In Places Frequented Only By Persons Employed on the Premises.** In places where access is normally restricted to persons employed on the premises, enclosure of electrical installations is not mandatory provided that: (1) No live parts are exposed or readily accessible; (2) The associated conduits or armored cables terminate in, and are securely fastened to, the terminal chamber, casing or enclosure of the equipment.

c. **In Places Accessible to Qualified Persons Only.** Electrical installations shall conform with sections 7120 to 7125 inclusive.

7111. **Outdoor Installations.** Outdoor installations shall be accessible to qualified persons only. Installations are considered to be accessible to qualified persons only when enclosed as provided in section 7120 or when isolated by elevation. Live parts are deemed to be isolated by elevation (1) if the clearance to ground and to buildings conforms with Article 730, for outdoor installations, and (2) as provided in section 7125, for locations accessible to qualified persons only.

Equipment—Specific Provisions

See also references to specific types of installations in Section 7102.

7113. **Circuit Breakers.** Indoor installations shall consist of metal-enclosed units or fire-resistant cell-mounted units except that open mounting of circuit breakers is permissible in locations accessible to qualified persons only.

Circuit breakers used to control oil-filled transformers should be located outside the transformer vault.

Circuit breakers shall have a means of indicating the open and closed position of the breaker at the point(s) from which they may be operated.

Oil circuit breakers shall be so arranged or located that adjacent readily combustible structures or materials are safeguarded in an approved manner. Adequate space separation, fire-resistant barriers or enclosures, trenches containing sufficient coarse crushed stone and properly drained oil enclosures such as dikes or basins are recognized as suitable for this purpose.

7114. **Fuse Holders and Fuses.** Fuse holders shall not be used unless they can be deenergized to replace a fuse or unless the fuse and fuse holder are designed to permit fuse replacement without deenergizing the fuse holder by qualified persons using equipment designed for the purpose. Fuses which expel flame in opening the circuit shall be so designed or arranged that they will function properly without hazard to persons and property.

7115. **Isolating Means.** Means shall be provided to completely isolate an item of equipment. The use of isolating switches is not necessary if there are other ways of deenergizing the equipment for inspection and repairs. Isolating switches should be interlocked with the associated circuit interrupting device to prevent their being opened under load, otherwise signs warning against opening them under load shall be provided. Barriers should be provided on both sides of each pole of indoor open-type isolating switches. A fuse holder and fuse, designed for the purpose, may be used as an isolating switch.

Installations Accessible To Qualified Persons Only

7120. **Enclosure for Electrical Installations.** Electrical installations in a vault, room, closet or in an area surrounded by a wall, screen or fence, access to which is controlled by lock and key or other approved means, are considered to be accessible to qualified persons only. The type of enclosure used in a given case shall be designed and constructed according to the nature and degree of the hazard(s) associated with the installation. Article 450 covers minimum construction requirements for oil-filled transformer vaults.

Isolation by elevation is covered in sections 7111 and 7125.

7121. **Circuit Conductors.** They may be installed in conduit; in duct systems; as metal-armored cable; as bare wire, cable and buses, or as non-metallic sheathed cables or conductors as provided in section 7105 to 7108 inclusive. Bare live conductors shall conform with sections 7122 to 7125 inclusive.

Insulators, together with their mounting and conductor attachments, when used as supports for wires, single conductor cables and bus bars, shall be capable of safely withstanding the maximum magnetic forces which would prevail if two or more conductors of a circuit were subjected to short-circuit current.

Open runs of insulated wires and cables, having a bare lead sheath or a braided outer covering, shall be supported in a manner designed to prevent mechanical injury to the braid or sheath. Supports for lead covered cables shall be designed to prevent electrolysis of the sheath.

7122. **Minimum Space Separation Between Live Parts and Adjacent Surfaces.** The minimum indoor air separation between bare live conductors and between such conductors and adjacent surfaces shall be not less than the values given below. This section applies to interior wiring design and construction. It does not apply to the space separation provided in electrical apparatus and wiring devices.

Circuit Voltage	Minimum Air Separation In Inches, Indoors* Between Bare Live Conductors	Between Bare Live Conductors and Adjacent Surfaces
5,000	3.5	2.5
15,000	7	5.5
25,000	11	8.5

*The values given are the minimum permissible space separation under favorable service conditions. They should be increased under unfavorable service conditions or wherever space limitations permit. Proportional values may be used for intermediate voltages.

7123. **Guards for Live Parts.** Live parts should be enclosed, isolated or guarded against possible accidental contact.

7124. **Working Space.** Working space not less than the distances given in Table 33, Chapter 10, shall be provided in locations where it is necessary to work in close proximity to live parts.

7125. **Isolation by Elevation.** The distance from the floor, ground, or other working surface, to open-type isolating switches, fuse holders or other unguarded live parts should be not less than the values given in Table 32 of Chapter 10.

ARTICLE 720—CIRCUITS AND EQUIPMENT OPERATING AT LESS THAN 50 VOLTS

7201. **General.** This article shall apply to installations operating at less than 50 volts, direct current or alternating current, except such as are treated in Articles 650 and 725.

7202. **Larger Current at Lower Voltage.** Conductors, devices, and equipment shall have current ratings sufficient for the greater current required to deliver equal power at the lower voltage than at usual voltages.

7203. **Conductors.** Conductors shall be not smaller than No. 12, and for appliance branch circuits supplying more than one appliance or appliance receptacle, conductors shall be not smaller than No. 10.

7204. **Branch Circuit.** Not more than 8 lampholders or receptacles, nor a total load of more than 320 watts, shall be connected to a branch circuit. Motors or appliances of rating more than 320 watts shall have a separate branch circuit.

7205. **Lampholders.** Standard lampholders of rating not less than 660 watts shall be used.

7206. **Receptacle Rating.** Receptacles shall have a rating not less than 15 amperes.

7207. **Receptacles Required.** Receptacles of not less than 20-ampere rating shall be provided in kitchens, laundries, and other locations where portable appliances are likely to be used.

7208. **Overcurrent Protection.** Overcurrent protection shall comply with the provisions of Article 240.

7209. **Batteries.** Batteries shall conform to the following:

a. **Location.** Batteries shall be located in rooms or spaces having natural ventilation.

b. **Support.** Battery jars and cells, if not composed of insulating material such as glass or hard rubber, shall be mounted on insulating supports of glass or porcelain.

7210. **Grounding.** Equipment and circuits shall be grounded as follows:

a. **Machines.** The grounding of frames of engines or generators is not required.

b. **Conductors.** One of the circuit conductors shall be grounded if conductors are run overhead between buildings, or if the circuit is supplied through a transformer from an ungrounded circuit or from a grounded circuit of more than 150 volts.

ARTICLE 725—REMOTE-CONTROL, LOW-ENERGY POWER, LOW-VOLTAGE POWER AND SIGNAL CIRCUITS

7251. Scope. Provisions of this article shall apply to remote-control circuits, low-energy power circuits, low-voltage power circuits and signal circuits, as defined in Article 100, Definitions.

The provisions of this article are not intended to apply to remote-control, low-energy or signal circuits which form an integral part of a device.

7252. Hazardous Locations. Circuits or equipment coming within the scope of this article and installed in hazardous locations shall also comply with the appropriate provisions of Article 500.

7253. Classification. Remote-control and signal circuits shall be classified as follows:

a. Class 1 Circuits. Control and signal circuits in which power is not limited in accordance with section 7281.

b. Class 2 Circuits. Control and signal circuits in which the power is limited in accordance with section 7281.

7254. Low-Energy Power Circuits. Circuits which are neither remote-control nor signal circuits, but which have the power limited in accordance with section 7281 shall, for the purpose of this code, be treated as Class 2 remote-control circuits.

7255. Low-Voltage Power Circuits. Circuits which are neither remote-control nor signal circuits but which operate at not more than 30 volts, where the current is not limited in accordance with section 7281, and which are supplied from a source not exceeding 1000 volt-amperes shall for the purpose of this Code be treated as Class I remote-control circuits.

7256. Safety-Control Devices. Remote-control circuits to safety-control devices, the failure of operation of which would introduce a direct fire or life hazard, shall be considered as Class 1 circuits.

Room thermostats, service hot-water temperature regulating devices, and similar controls used in conjunction with electrically-controlled domestic heating equipment, are not considered to be safety-control devices.

7257. **Remote-Control and Signal Circuits in Communication Cables.** Remote-control and signal circuits, which use conductors in the same cable with communication circuits, shall, for the purpose of this article, be classified as communication circuits and meet the requirements of Article 800, of this code.

Class 1 System

7261. Wiring Method. Conductors and equipment of Class 1 remote-control and signal systems shall be installed in accordance with the requirements of the appropriate articles in Chapter 3 of this code, except as provided in sections 7262 to 7265 inclusive.

7262. **Other Articles.** The wiring method required in section 7261 does not apply where other articles of this code specifically permit or require other methods for remote-control or signal circuits. See Article 620, Elevators, for example.

7263. **Conductor Sizes.** Nos. 18 and 16 gauge conductors may be used if installed in a raceway or a cable approved for the purpose, or in flexible cords in accordance with the provisions of Article 400.

7264. Conductor Insulation. Conductors larger than No. 16 shall be rubber-covered Type R, thermoplastic-covered Type T, or other approved type. Fixed conductors Nos. 18 and 16 gauge shall have an insulation at least equal to that of Type RF-2 rubber-covered or Type TF thermoplastic-covered fixture wire. Conductors approved for the purpose having rubber insulation of a thickness less than specified above or having other kinds of insulation may be used.

7265. Number of Conductors in Raceways. The number of conductors of remote-control or signal circuits in a raceway may be determined according to Tables 4 or 9 of Chapter 10; and Note 4 of Table 1 need not be observed. Where there are four or more conductors in a raceway, some of which are remote-control, as permitted by section 3011, the provisions of note 4 following Tables 1 and 2 of Chapter 10 shall apply, as determined by the number of power and lighting circuit conductors only.

7266. **Conductors of Different Systems.** Conductors of two or more Class 1 remote-control and/or signal circuits may occupy the same enclosure or raceway without regard to whether the individual systems or circuits are alternating or direct current, provided all conductors are insulated for the maximum voltage of any conductor in the enclosure or raceway. Conductors of remote-control, low-energy power and signal circuits, in which the current is limited as for Class 2 systems, shall be considered as Class 1 system conductors for the purpose of this requirement if insulated and installed in accordance with the provisions for Class 1 system conductors. Power supply conductors may occupy the same enclosure or raceway with Class 1 system conductors when supplying only equipment to which Class 1 system conductors are connected.

7267. **Mechanical Protection of Remote-Control Circuits.** Where damage to a remote-control circuit would constitute a hazard as covered in section 7256 all conductors of such remote-control circuits shall be installed in conduit, electrical metallic tubing, Type MI cable or be otherwise suitably protected from mechanical injury.

7268. **Overcurrent Protection.** Conductors shall be protected against overcurrent in accordance with the carrying capacities of Tables 1 and 2, Chapter 10 except as follows:

a. **Other Articles.** Where other articles of this code specifically permit or require other overcurrent protection. See sections 4372 and 6251.

b. **Conductors of Nos. 18 and 16.** Conductors of Nos. 18 and 16 shall be considered as protected by overcurrent devices of 20-ampere rating or setting.

c. **Omission of Overcurrent Protection.** In remote-control and signal circuits having main and branch circuits, the branch circuits need not be individually protected against overcurrent, if the operating voltage does not exceed 30 volts.

7269. **Location of Overcurrent Protection.** Overcurrent devices shall be located at the point where the conductor to be protected receives its supply unless the overcurrent device protecting the larger conductor also protects the smaller conductor in accordance with Tables 1 and 2 of Chapter 10.

7270. **Circuits Extending Beyond One Building.** Class 1 remote-control and signal circuits which extend aerially beyond one building shall also meet the requirements of Article 730, Outside Wiring.

7271. **Grounding.** Class 1 remote-control and signal circuits shall be grounded in accordance with Article 250 as follows:

a. If supplied by a separate control transformer from a system having a nominal voltage to ground of more than 150 volts.

b. If run overhead outside of buildings, and so run as to be liable to accidental contact with power conductors operating at a potential exceeding 300 volts.

Limitation of Low-Voltage Power Circuit

7275. **Overcurrent Protection.** Transformer devices supplying low-voltage power circuits shall be provided with over-current protection in the secondary circuit rated or set at not more than 250 per cent of the rated secondary current of the transformer. Such protection and mounting shall be approved for the purpose. Over-current protection of different ratings shall not be of an interchangeable type. The over-current protection may be an integral part of a transformer or other power supply device approved for the purpose.

7276. **Transformer Rating.** Transformer devices supplying low-voltage power circuits shall be approved for the purpose and be restricted in their rated output to not exceeding 1000 volt-amperes and to not exceeding 30 volts. They shall be marked where plainly visible to show their rated output and the voltage to be applied to the circuit.

A transformer is considered as meeting the 1000 volt-ampere requirement if the approximate temperature limit is reached at 1000 volt-ampere load.

Limitation of Class 2 Remote-Control and Signal Systems

7281. **Limitation of Class 2 Systems.** Class 2 remote-control and signal systems, depending on the voltage shall have the current limited as follows:

a. **Maximum 15 Volts: 5 Amperes.** Circuits in which the open-circuit voltage does not exceed 15 volts and having overcurrent protection of not more than 5-amperes rating. If the current supply is from a transformer or other device having energy-limiting characteristics and approved for the purpose, or from primary batteries, the overcurrent protection may be omitted.

b. 15 to 30 Volts: 3 Amperes. Circuits in which the open-circuit voltage exceeds 15 volts but does not exceed 30 volts, and having overcurrent protection of not more than 3-amperes rating. If the current supply is from a transformer or other device having energy-limiting characteristics and approved for the purpose, or from primary batteries, the overcurrent protection may be omitted.

c. 30 to 60 Volts: 1 1/3 Amperes. Circuits in which the open-circuit voltage exceeds 30 volts but does not exceed 60 volts, and having overcurrent protection of not more than 1 1/3-amperes rating. If the current supply is from a transformer or other device having energy-limiting characteristics and approved for the purpose, the overcurrent protection may be omitted.

d. 60 to 150 Volts: 1 Ampere. Circuits in which the open-circuit voltage exceeds 60 volts but does not exceed 150 volts, and having overcurrent protection of not more than 1-ampere rating, provided that such circuits are equipped with current-limiting means other than overcurrent protection which will limit the current as a result of a fault to not exceeding 1 ampere.

7282. Overcurrent Protection and Mounting. Where current is limited in class 2 systems by means of overcurrent protection, such protection and its mounting shall be approved for the purpose. Overcurrent protection of different ratings shall not be of an interchangeable type. The overcurrent protection may be an integral part of a transformer or other power supply device approved for the purpose.

7283. Transformer Rating. Transformer devices supplying Class 2 systems shall be approved for the purpose and be restricted in their rated output to not exceeding 100 volt-amperes. They shall be marked where plainly visible to show the voltage to be applied to the circuit.

A transformer is considered as meeting the 100 volt-ampere requirement if the approximate temperature limit is reached at a 100-volt-ampere load.

Installation of Class 2 Remote-Control and Signal Circuits

7291. On Supply Side of Overcurrent Protection, Transformers or Current-Limiting Devices. Conductors and equipment on supply side of overcurrent protection, transformers or current-limiting devices shall be installed in accordance with the appropriate requirements of Chapter 3 of this code. Transformers or other devices supplied from electric light and power circuits shall be protected by an overcurrent device with a rating or setting not exceeding 20 amperes.

7292. On Load Side of Overcurrent Protection, Transformer or Current-Limiting Devices. Conductors on load side of overcurrent protection, transformer or current-limiting devices shall be insulated and shall comply with the following:

a. Separation from Other Conductors. Conductors shall be separated from conductors of electric light and power circuits as follows:

1. Open Conductors. Conductors shall be separated at least 2 inches from any light or power conductors not in a raceway unless permanently separated from the conductors of the other system by a continuous and firmly fixed nonconductor, such as porcelain tubes or flexible tubing, additional to the insulation on the wire.

2. In Raceways and Boxes. Conductors of Class 2 remote-control and signal circuits shall not be placed in any raceway, compartment, outlet box or similar fitting with conductors for either light and power circuits or Class 1 signal and control circuits, unless the conductors of the different systems are separated by a partition; provided that this shall not apply to conductors in outlet boxes, junction boxes or similar fittings or compartments where power supply conductors are introduced solely for supplying power to the remote-control or signal equipment to which the other conductors in the enclosure are connected.

3. In Shafts. Conductors may be run in the same shaft with conductors for light and power if the conductors of the two systems are separated at least 2 inches, or if the conductors of either system are encased in noncombustible tubing. In hoistways conductors shall be installed in rigid conduit or electrical metallic tubing except as provided for in paragraph a of section 6206.

b. **Vertical Runs.** Conductors in a vertical run in a shaft or partition shall have a fire resistant covering capable of preventing the carrying of fire from floor to floor except where conductors are encased in tubing or other outer covering of non-combustible material or are located in a fireproof shaft having fire stops at each floor.

The kind of insulation for the conductors shall be suitable for the particular application but is not specified in further detail as reliance is placed on current limitation to stop dangerous currents. Where 3 or more conductors are used, it is recommended that such conductors be grouped under a common braid or covering.

7293. Circuits Extending Beyond One Building. Class 2 remote-control and signal circuits which extend beyond one building and are so run as to be subject to accidental contact with light or power conductors operating at a potential exceeding 300 volts, shall also meet the requirements of sections 8011, 8021, and 8022 of Article 800 of this code.

ARTICLE 730—OUTSIDE WIRING

7301. Scope. The requirements of this article shall apply to electrical equipment or wiring located on private or public premises, attached to the outside of or run between buildings or structures, but shall not apply to wiring for signs and outline lighting, nor to equipment or wiring of an electric or communication utility used in the exercise of its function as a utility, except as otherwise provided in this code.

7302. Application of Other Articles. Equipment and wiring for service conductors shall comply with Article 230. Equipment and wiring located in hazardous locations shall comply with Article 500. Equipment and wiring for signs and outline lighting shall comply with Article 600. Equipment and wiring for remote control, low-energy power and signal circuits shall comply with Article 725, and equipment and wiring for communication circuits shall comply with Article 800.

General

7311. Wiring Method. Outside wiring may be installed as open conductors on insulating supports, as multiple-conductor cable approved for the purpose, in rigid metal conduit, in busways as provided in sections 2331 and 3646, or in electrical metallic tubing; except that for circuits of more than 600 volts run on the exterior building walls conductors may be installed in electrical metallic tubing only for sign and outline lighting as provided in Article 600. Except as provided in Section 2387, other conductors of more than 600 volts shall be installed in rigid metal conduit or cable approved for the purpose.

7312. Common Neutral. For the supply of lighting equipment installed on a single pole or structure, the branch circuits shall comply with the requirements of Article 210 for multi-wire branch circuits. A common neutral may be employed for the branch circuits, provided not more than 8 ungrounded conductors are used. Such a common neutral shall have a carrying capacity not less than twice the carrying capacity of one of the ungrounded conductors.

7313. Conductor Insulation. Open conductors supported on insulators shall be of the rubber-covered type, thermoplastic type or weatherproof (Type WP), where within

10 feet of any building or structure. Conductors in cables or raceways, except Type MI Cable, shall be of the rubber-covered type or thermoplastic type and in wet locations shall comply with paragraph b. of section 3102. Conductors for festoon lighting shall be of the rubber-covered or thermoplastic type.

7314. **Size of Conductors.** The size of conductors shall conform to the following:

a. **Carrying Capacity.** Conductors shall conform to the allowable current-carrying capacities of Tables 1 and 2 of Chapter 10.

b. **Overhead Spans.** Overhead conductors shall not be smaller than No. 10 for spans up to 50 feet in length, and not smaller than No. 8 for longer spans.

c. **Festoon Lighting.** Overhead conductors for festoon lighting shall not be smaller than No. 12 unless supported by messenger wires.

d. **Over 600 Volts.** Overhead conductors of over 600 volts shall not be smaller than No. 6 unless in cable. Conductors in cable shall not be smaller than No. 8.

Open Conductors

7321. **Supports.** Open conductors shall be supported as follows:

a. **Open Conductors.** Open conductors shall be supported on glass or porcelain knobs, racks, brackets, or strain insulators, approved for the purpose.

b. **Festoons.** In spans exceeding 40 feet the conductors shall be supported by a messenger wire supported by approved strain insulators. Conductors or messenger wires shall not be attached to any fire escape, downspout, or plumbing equipment.

7322. **Spacings.** Conductors shall conform to the following spacings:

a. **Open Conductors Not Exposed to Weather.** Open conductors not exposed to the weather shall be supported at intervals not exceeding 4½ feet, and shall be separated not less than 2½ inches from each other and 1 inch from the surface wired over.

b. **Open Conductors Exposed to the Weather.** Except in open spans, conductors exposed to the weather shall be supported at intervals not exceeding 9 feet, separating the conductors at least 6 inches from each other and at least 2 inches from the surface wired over; provided that supports may be placed at intervals not exceeding 15 feet if conductors are separated at least 12 inches from each other. For 300 volts or less, conductors may have a separation of not less than 3 inches if supports are placed at intervals not exceeding 4½ feet and conductors are not less than 2 inches from the surface wired over. In open spans conductors shall be separated at least 12 inches from each other.

c. **Over 600 Volts.** Except in open spans, open conductors on circuits of over 600 volts shall be separated not less than 8 inches from each other and not less than 2 inches from the surface wired over for voltages of 2500 volts or less and 3 inches for voltages exceeding 2500 volts. In open spans, conductors shall be separated at least 12 inches from each other.

d. **Separation from Other Conductors.** Open conductors shall be separated from open conductors of other circuits or systems by not less than 4 inches.

e. **Line Conductors.** Line conductors shall have a separation of not less than 1 foot except when placed on racks or brackets. Line conductors supported on poles shall provide a horizontal climbing space not less than the following:

Power conductors, below communication conductors	30 in.
Power conductors alone or above communication conductors:	
Less than 300 volts	24 in.
Exceeding 300 volts	30 in.
Communication conductors below power conductors	same as power conductors
Communication conductors alone or above power conductors	no requirement

7323. **Clearance from Ground.** Open conductors shall be not less than 10 feet from the ground and shall conform to the following:

a. **Over Driveways.** Conductors above alleys and above driveways on other than residence property shall have a clearance above ground of not less than 18 feet, and if more than 600 volts, 20 feet, see section 2324.

b. Over Lots. Conductors supplying lights in automobile parking lots, drive-in establishments, and similar commercial areas shall have clearances above ground of not less than 12 feet.

c. Over Footwalks, Etc. On residential property, and elsewhere across spaces accessible to pedestrians only, conductors between buildings shall have a clearance of not less than 10 feet for conductors of not more than 150 volts to ground, and 12 feet for higher voltages to ground.

7324. Clearance from Buildings. Conductors shall have a clearance from buildings as follows:

These requirements apply specifically to open conductors, but where other approved wiring methods as provided in section 7311 are employed it is necessary to obtain clearance spacings, etc., as called for by paragraphs a and/or b of this section or by attaching the raceways, cables, or messenger-supported cables in an approved manner.

a. Over Roofs. Open conductors shall not be less than 8 feet from the highest point of roofs but service drops operating at 300 volts or less may be not less than 3 feet from the highest point of roofs that cannot be readily walked upon. Conductors attached to roof structures shall be substantially supported. Wherever practicable, conductors crossing over buildings shall be supported on structures which are independent of the building.

b. Horizontal Clearances. Open conductors shall be not less than 36 inches from windows, doors, porches, fire escapes, or similar locations and shall conform to the following:

1. Zone for Fire Ladders. If buildings exceed 3 stories, or 50 feet in height, overhead lines shall be arranged where practicable so that a clear space (or zone) at least 6 feet wide will be left either adjacent to the buildings or beginning not over 8 feet from them, to facilitate the raising of ladders when necessary for fire fighting.

2. Less Than 7500 Volts. Open conductors of less than 7500 volts between conductors shall be at least 3 feet horizontally from buildings unless 8 feet higher than the roof.

3. Exceeding 7500 Volts. Open conductors of voltages between 7500 and 15,000 between conductors shall be kept at least 8 feet horizontally, and open conductors of more than 15,000 volts between conductors shall be kept at least 10 feet horizontally from all buildings except central stations, sub-stations, and transformer vaults.

4. **Service Drops.** Service drops or final spans of feeders to buildings which they serve or from which they are fed must necessarily approach the building more closely than indicated, but they shall be kept away from windows, doors, porches, fire escapes or similar locations and shall be run to the building in such a way as to avoid any hazard.

7325. Protection on Buildings or Structures. Where open conductors are subject to mechanical disturbance, or are readily accessible, they shall be protected by rigid metal conduit, electrical metallic tubing, shall be of multiple conductor cable approved for the purpose, or shall have equivalent protection.

7326. Protection on Poles. Conductors on a pole shall be protected from mechanical injury to a point at least 8 feet from the ground. Such protection shall conform to section 7325.

7327. Entering Buildings—Drip Loops. Open conductors where they enter or leave a building shall pass upward and inward through slanting, non-combustible, non-absorptive insulating tubes. Drip loops shall be formed on the conductors outside the building.

Multiple-Conductor Cables

7331. Multiple-Conductor Cables. Multiple cables of Type SD shall have insulating supports at intervals not exceeding 15 feet and maintaining a distance of not less than 2 inches from the surface wired over; and shall be protected where within 8 feet from the ground or where subject to mechanical injury. Multiple-conductor cables of Type SE or ASE mounted in contact with the building shall be supported at intervals not exceeding 4½ feet.

Raceways

7341. Raceways. Conduit and electrical metallic tubing on exterior of building shall be made raintight and suitably drained.

Underground Conductors

7351. Mechanical Protection. Underground conductors shall be protected against mechanical injury by being installed in duct, conduit, in the form of a cable approved for the purpose, or by other approved means.

7352. Draining. Underground conduits or ducts, when not located below the frost line, shall be arranged to drain.

7353. Protection Where Entering Building. Where underground conductors enter a building, they shall have mechanical protection in the form of rigid or flexible conduit, electrical metallic tubing, auxiliary gutters, cables approved for the purpose, or other approved means.

7354. Protection on Poles. Underground conductors carried up a pole shall conform to section 7326.

Fixtures

7361. Lampholders. Lampholders shall be of molded composition, or other approved material of the weatherproof type, and if they are attached as pendants shall have the connections to the circuit wires staggered. If lampholders have terminals of a type which puncture the insulation and make contact with the conductors, they shall be attached only to conductors of the stranded type.

7362. Location of Lamps. For outdoor lighting, lamps shall be located below all live conductors, transformers, or other electrical equipment, unless clearances or other safeguards are provided for relamping operations, or unless the installation is controlled by a disconnecting means which can be locked in the open position.

CHAPTER 8. COMMUNICATION SYSTEMS

ARTICLE 800—COMMUNICATION CIRCUITS

8001. Scope. The provisions of this article shall apply to telephone, telegraph (except radio), district messenger, fire and burglar alarms, and similar central station systems. Circuits and apparatus coming within the scope of this article and installed in Class I hazardous locations, shall comply with Section 5024 of Article 500.

Such protective measures as are essential to safeguard these systems under the various conditions to which they are subjected are outlined in these rules.

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

Protection

8011. Protective Devices. A protector approved for the purpose shall be provided on each circuit, aerial or underground, so located within the block containing the building served as to be liable to accidental contact with light or power conductors operating at a potential exceeding 300 volts, and on each circuit run partly or entirely in aerial wire or cable not confined within a block.

The word "block" as used in this article shall be construed to mean a square or portion of a city, town, or village enclosed by streets and including the alleys so enclosed but not any street.

a. Location. The protector shall be located in or on the building as near as practicable to the point where the conductors enter. In the case of an underground entrance the protector may be located at the junction of the underground and the aerial wires.

b. Hazardous Locations. The protector shall not be located in any hazardous location as defined in Article 500, nor in the vicinity of easily ignitible material.

c. Protector Requirements. The protector shall be mounted on a non-combustible, non-absorptive insulating

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*The N.F.P.A. standards on fire alarm and supervisory systems are published in the National Fire Codes Vol. IV and in separate pamphlet form by the N.F.P.A. and the National Board of Fire Underwriters. (Pamphlets 71, 72, 73, and 74) base and shall consist of an arrester between each line conductor and the ground, and a fuse in each line conductor, the fuses protecting the arrester except as specified in paragraph d. The protector terminals shall be plainly marked to indicate line, instrument, and ground.

d. **Omission of Fuses.** (1) Fuses protecting the arrester may be omitted on circuits entering a building through metal-sheathed cable, provided the metal sheath of the cable is grounded and the conductors in the cable are No. 24 or smaller. (2) A protector without fuses may be used where insulated conductors, in accordance with Sections 8021-c-1 and 8021-c-2, are used to extend circuits to a building from a cable having a grounded metal sheath, provided the protector is approved for this purpose.

8012. Installation of Conductors. Conductors from the protector to the equipment or, where no protector is required, conductors attached to the outside of, or inside the building shall comply with the following:

a. **Separation from Other Conductors.** Conductors shall be separated from conductors of electric light and power circuits as follows:

1. **Open Conductors.** Conductors shall be separated at least 2 inches from any light or power conductors not in metallic raceways or metal-sheathed cable unless permanently separated from the conductors of the other system by a continuous and firmly fixed non-conductor, additional to the insulation on the wire, such as porcelain tubes or flexible tubing.

2. **In Raceways and Boxes.** Communication conductors shall not be placed in any raceway, compartment, outlet box, junction box or similar fitting with conductors for light and power circuits or Class I signal and control circuits unless the conductors of the different systems are separated by a partition; provided, that this shall not apply to conductors in outlet boxes, junction boxes or similar fittings or compartments where such conductors are introduced solely for power supply to communication equipment or for connection to remote-control equipment.

3. **In Shafts.** Conductors may be run in the same shaft with conductors for light and power if the conductors of the two systems are separated at least 2 inches, or if the

conductors of either system are encased in non-combustible tubing.

b. Vertical Runs. Conductors bunched together in a vertical run in a shaft shall have a fire-resistant covering capable of preventing the carrying of fire from floor to floor, except where conductors are encased in non-combustible tubing or are located in a fireproof shaft having fire stops at each floor.

The conductors referred to in this section would ordinarily be insulated but the kind of insulation is not specified as reliance is placed on the protective device to stop all dangerous voltages and currents.

Outside Conductors

8021. Overhead Conductors. Overhead conductors entering buildings shall comply with the following:

a. On Poles. Where communication conductors and light or power conductors are supported by the same pole, the following conditions shall be met:

1. **Relative Location.** The conductors should preferably be located below the light or power conductors.

2. **Attachment to Cross Arms.** Conductors shall not be attached to a crossarm which carries light or power conductors.

3. **Climbing Space.** The climbing space through signal conductors shall comply with the requirements of section 7322.

b. On Roofs. Conductors passing over buildings shall be kept at least 8 feet above any roof which may be readily walked upon, except small auxiliary buildings such as garages and the like.

c. Circuits Requiring Protectors. Circuits which require protectors (see section 8011) shall comply with the following:

1. **Insulation, Single or Paired Conductors.** Each conductor, from the last outdoor support to the protector, shall have 1/32-inch rubber insulation, except that when such conductors are entirely within a block the insulation on the conductor may be less than 1/32-inch, but not less than 1/40-inch in thickness. In addition, the conductor,

either individually or over the pair, shall be covered with a substantial fibrous covering or equivalent protection. Conductors approved for the purpose having rubber insulation of a thickness less than specified above, or having other kinds of insulation may be used.

2. **Insulation, Cables.** Conductors within a cable of the metal-sheathed type, or within a cable having a rubber sheath of at least 1/32-inch thickness and covered with a substantial fibrous covering, may have paper or other suitable insulation. If the metal or rubber sheath is omitted, each conductor shall be insulated as required in sub-paragraph c-1 of this section, and the bunched conductors shall be covered with a substantial fibrous covering or equivalent covering.

3. **On Buildings.** Open conductors shall be separated at least 4 inches from light or power conductors not in conduit or cable, unless permanently separated from conductors of the other system by a continuous and firmly fixed non-conductor additional to the insulation on the wires, such as porcelain tubes or flexible tubing. Open conductors exposed to accidental contact with light and power conductors operating at over 300 volts, and attached to buildings, shall be separated from woodwork by being supported on glass, porcelain or other insulating material approved for the purpose except that such separation is not required where conductors approved for the purpose are used to extend circuits to a building from a cable having a grounded metal sheath.

4. **Entering Buildings.** Where a protector is installed inside the building, the conductors shall enter the building either through a non-combustible, non-absorptive insulating bushing, or through a metal raceway. The insulating bushing may be omitted where the entering conductors (1) are in metal-sheathed cable, (2) pass through masonry, or (3) are approved for the purpose and are used to extend circuits to a building from a cable having a grounded metal sheath. Raceways or bushings shall slope upward from the outside or where this cannot be done drip loops shall be formed in the conductors immediately before they enter the building. Raceways shall be equipped with an approved service head. More than one conductor may enter through a single raceway or bushing. Conduits or other metallic raceways located ahead of the protector shall be grounded.

8022. **Lightning Conductors.** When practicable, a separation of at least six feet shall be maintained between open conductors of communication systems on buildings and lightning conductors.

Underground Circuits

8031. **Underground Circuits.** Underground conductors of communication circuits entering buildings shall comply with the following:

a. **Not With Electric Light or Power Conductors.** Underground conductors shall not be placed in a duct, handhole, or manhole containing electric light or power conductors, except in a section separated from such conductors by means of brick, concrete, or tile partitions.

b. **Underground Block Distribution.** Where the entire street circuit is run underground and the circuit within the block is so placed as to be free from liability of accidental contact with electric light or power circuits of over 300 volts, the insulation requirements of sub-paragraphs c-1 and c-4 of section 8021 shall not apply, the conductors need not be placed on insulating supports and no bushings shall be required where the conductors enter the building.

Grounding

8041. **Grounding.** Equipment shall be grounded as follows:

a. **Cable Sheath.** The metal sheath of aerial cables entering buildings which are liable to contact with electric light or power conductors shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device.

b. **Protector Ground.** The protector ground shall comply with the following:

1. **Insulation.** The grounding conductor shall have a 1/32-inch rubber insulation and shall be covered by a substantial fibrous covering. Conductors approved for the purpose having less than 1/32-inch rubber insulation or having other kinds of insulation may be used.

2. **Size.** The grounding conductor shall not be smaller than No. 18 copper.

3. **Run in Straight Line.** The grounding conductor shall be run in as straight a line as practicable to the grounding electrode.

4. **Mechanical Injury.** Where necessary, the grounding conductor shall be guarded from mechanical injury.

5. **Electrode.** The grounding conductor shall preferably be connected to a water pipe electrode. Where a water pipe is not readily available and the grounded conductor of the power service is connected to the water pipe at the building, the protector grounding conductor may be connected to the power service conduit, service equipment enclosures, or grounding conductor of the power service. In the absence of a water pipe, connection may be made to a continuous and extensive underground gas piping system, to an effectively grounded metallic structure, or to a ground rod or pipe driven into permanently damp earth. Steam or hot water pipes, or lightning rod conductors shall not be employed as electrodes for protectors. A driven rod or pipe used for grounding power circuits shall not be used for grounding communication circuits unless the driven rod or pipe is connected to the grounded conductor of a multi-grounded neutral power system. The requirements for separate made electrodes for power and lighting system grounds, those for communication systems, and those for a lightning rod installation shall not prohibit the bonding together of all such made electrodes. See section 2586.

6. **Electrode Connection.** The grounding conductor shall be attached to a pipe electrode by means of a bolted clamp to which the conductor is soldered or otherwise connected in an effective manner. If a gas pipe electrode is used, connection shall be made between the gas meter and the street main. In every case the connection to the grounding electrode shall be made as close to the earth as practicable.

ARTICLE 810—RADIO AND TELEVISION EQUIPMENT

8101. Scope. This article shall apply to radio and television receiving equipment and to amateur radio transmitting equipment, but shall not apply to equipment and antennas used for coupling carrier current to power line conductors.

It is recommended that the authority enforcing this code be freely consulted as to the specific methods to be followed in any case of doubt relative to installation of antenna and counterpoise conductors and that the National Electrical Safety Code, Part 5, be followed.

8102. Application of Other Articles. Wiring from the source of power to and between devices connected to the interior wiring system shall comply with Chapters 1 to 4, inclusive, except as modified by sections 6403, 6404 and 6405. Wiring for radio-frequency and audio-frequency equipment and loud speakers shall comply with Article 640.

Antenna Systems—General

8111. Material. Antenna, counter-poise and lead-in conductors shall be of hard copper, bronze, aluminum alloy, copper-clad steel or other high-strength, corrosion-resistant material. Soft-drawn or medium-drawn copper may be used for lead-in conductors where the maximum span between points of support is less than 35 feet.

8112. Supports. Outdoor antenna and counter-poise and lead-in conductors shall be securely supported. They shall not be attached to poles or similar structures carrying electric light or power wires or trolley wires of more than 250 volts. Insulators supporting the antenna or counter-poise conductors shall have sufficient mechanical strength to safely support the conductors. Lead-in conductors shall be securely attached to the antenna.

8113. Avoidance of Contacts with Conductors of Other Systems. Outdoor antenna, counter-poise and lead-in conductors from an antenna to a building shall not cross over electric light or power circuits and shall be kept well away from all such circuits so as to avoid the possibility of accidental contact. Where proximity to electric light and power service conductors of less than 250 volts cannot be avoided, the installation shall be such as to provide a clearance of at least two feet. It is recommended that antenna and counter-poise conductors be so installed as not to cross under electric light or power conductors.

8114. Splices. Splices and joints in antenna and counter-poise span shall be made with approved splicing devices or by such other means as will not appreciably weaken the conductors.

Soldering may ordinarily be expected to weaken the conductor. Therefore, when soldering is employed it should be independent of the mechanical support.

8115. Structures. Metal structures supporting antennas shall be permanently and effectively grounded.

Antenna Systems—Receiving Station

8121. Size of Wire-Strung Antenna and Counter-poise.

a. Outdoor antenna and counter-poise conductors for receiving stations shall be of a size not less than given in the following table:

Material	Minimum Size of Conductors When Maximum Open Span Length Is: Less than 35 feet	35 feet to 150 feet	Over 150 feet
Aluminum alloy, hard-drawn copper	19	14	12
Copper-clad steel, bronze or other high strength material	20	17	14

For very long span lengths larger conductors will be required, depending on the length of the span and the ice and wind loading.

b. Self-Supporting Antennas. Outdoor antennas, such as vertical rods or dipole structures, shall be of non-corrodible materials and of strength suitable to withstand ice and wind loading conditions, and shall be located well away from overhead conductors of electric light and power circuits of over 150 volts to ground so as to avoid the possibility of the antenna or structure falling into or accidental contact with such circuits.

8122. Size of Lead-In. Lead-in conductors from outside antenna, and counter-poise for receiving stations, shall, for various maximum open span lengths, be of such size as to have a tensile strength at least as great as that of the conductors for antenna as specified in section 8121. When the lead-in consists of two or more conductors which are twisted together or are enclosed in the same covering or are concentric, the conductor size shall, for various maximum open span lengths, be such that the tensile strength of the combination will be at least as great as that of the conductors for antenna as specified in section 8121.

8123. **Clearances.**

a. **On Buildings Outside.** Lead-in conductors attached to buildings shall be so installed that they cannot swing closer than two feet to the conductors of circuits of 250 volts or less or ten feet to the conductors of circuits of more than 250 volts, except that in the case of circuits not exceeding 150 volts, if all conductors involved are supported so as to insure permanent separation, the clearance may be reduced but shall not be less than four inches. The clearance between lead-in conductors and any conductor forming a part of a lightning rod system shall be not less than six feet unless the bonding referred to in section 2586 is accomplished.

b. **Antennas and Lead-Ins—Indoors.** Indoor antennas and indoor lead-ins shall not be run nearer than two inches to conductors of other wiring systems in the premises unless

(1) such other conductors are in metal raceways or cable armor, or

(2) unless permanently separated from such other conductors by a continuous and firmly fixed non-conductor such as porcelain tubes or flexible tubing.

8124. Electric Supply Circuits Used in Lieu of Antenna. If an electric supply circuit is used in lieu of an antenna, the device by which the radio receiving set is connected to the supply circuit shall be specially approved for the purpose.

Antenna System—Transmitting Stations

8131. Size of Antenna. Antenna and counter-poise conductors for transmitting stations shall be of a size not less than given in the following table:

Material	Minimum Size of Conductors When Maximum Open Span Length Is Less than 150 feet	Over 150 feet
Hard-drawn copper	14	10
Copper-clad steel, bronze or other high strength material	14	12

For very long span length larger conductors will be required, depending on the span length and the ice and wind loading.

8132. **Size of Lead-In Conductors.** Lead-in conductors for transmitting stations shall, for various maximum span lengths, be of a size at least as great as that of conductors for antenna as specified in section 8131.

8133. **Clearance on Building.** Antenna and counterpoise conductors for transmitting stations, attached to buildings, shall be firmly mounted at least 3 inches clear of the surface of the building on non-absorptive insulating supports, such as treated pins or brackets, equipped with insulators having not less than 3-inch creepage and airgap distances. Lead-in conductors attached to buildings shall also conform to these requirements, except when they are enclosed in a continuous metallic shield which is permanently and effectively grounded. In this latter case the metallic shield may also be used as a conductor.

8134. **Entrance to Building.** Except where protected with a continuous metallic shield which is permanently and effectively grounded, lead-in conductors for transmitting stations shall enter buildings by one of the following methods:

a. Through a rigid, non-combustible, non-absorptive insulating tube or bushing.

b. Through an opening provided for the purpose in which the entrance conductors are firmly secured so as to provide a clearance of at least 2 inches.

c. Through a drilled window pane.

8135. **Protection Against Accidental Contact.** Lead-in conductors to radio transmitters shall be so located or installed as to make accidental contact with them difficult.

Protectors

8141. Lightning Arresters—Receiving Stations. Each conductor of a lead-in from an outdoor antenna shall be provided with a lightning arrester approved for the purpose, except that if the lead-in conductors are enclosed in a continuous metallic shield the lighting arrester may be installed to protect the shield or may be omitted if the shield is permanently and effectively grounded. Lightning arresters shall be located outside the building, or inside the building between the point of entrance of the lead-in and the radio set or transformers, and as near as practicable to the entrance of the conductors to the building. The lightning arrester shall not be located near combustible material nor in a hazardous location.

8142. Lightning Arresters—Transmitting Stations. Except where protected by a continuous metallic shield which is permanently and effectively grounded, or the antenna is permanently and effectively grounded, each conductor of a lead-in for outdoor antenna shall be provided with a lightning arrester or other suitable means which will drain static charges from the antenna system.

Grounding Conductors—General

8151. Material. The grounding conductor shall, unless otherwise specified, be of copper, aluminum, copper-clad steel, bronze, or other corrosion-resistant material.

8152. Insulation. The grounding conductors may be uninsulated.

8153. Supports. The grounding conductors shall be securely fastened in place and may be directly attached to the surface wired over without the use of insulating supports. When proper support cannot be provided the size of the grounding conductor shall be increased proportionately.

8154. Mechanical Protection. The grounding conductor shall be protected where exposed to mechanical injury or the size of the grounding conductor shall be increased proportionately to compensate for the lack of protection.

8155. Run in Straight Line. The grounding conductor shall be run in as straight a line as practicable from the antenna mast and/or lightning arrester to the grounding electrode.

8156. **Grounding Electrode.** The grounding conductor shall be connected to a metallic underground water piping system as specified in section 2581. If the building is not supplied with a water system the connection shall be made to the metal frame of the building if effectively grounded or to a grounding electrode as specified in section 2583. At a penthouse or similar location the ground conductor may be connected to a water pipe or rigid conduit.

Grounding Conductors—Receiving Stations

8161. Inside or Outside Building. The grounding conductor may be run either inside or outside the building.

8162. Size of Protective Ground. The protective grounding conductor for receiving stations shall be not smaller than No. 14 copper or No. 12 aluminum or No. 17 copper-clad steel or bronze, provided that where wholly inside the building it shall not be smaller than No. 18.

8163. **Common Ground.** A single grounding conductor may be used for both protective and operating purposes.

If a single conductor is so used, the ground terminal of the equipment should be connected to the ground terminal of the protective device.

Grounding Conductors—Transmitting Stations

8171. Size of Protective Ground. The protective ground conductor for transmitting stations shall be as large as the lead-in, but not smaller than No. 14 copper, bronze, or copper-clad steel.

8172. Size of Operating Grounding Conductor. The operating grounding conductor for transmitting stations shall be not less than No. 14 copper or its equivalent.

Interior Installation—General

8181. Radio Noise Suppressors. Radio interference eliminators, interference capacitors or radio noise suppressors connected to power supply leads shall be of a type approved for the purpose. They shall not be exposed to mechanical injury.

Transmitting Stations

8191. Clearance From Other Conductors. Except as provided in Article 640, all conductors inside the building shall be separated at least 4 inches from the conductors of any other light or signal circuit unless separated therefrom by conduit or some firmly fixed non-conductor such as porcelain tubes or flexible tubing.

8192. General. Transmitters shall comply with the following:

a. Enclosing. The transmitter shall be enclosed in a metal frame or grille, or separated from the operating space by a barrier or other equivalent means, all metallic parts of which are effectually connected to ground.

b. Grounding of Controls. All external metallic handles and controls accessible to the operating personnel shall be effectually grounded.

No circuit in excess of 150 volts should have any parts exposed to direct contact. A complete dead-front type of switchboard is preferred.

c. Interlocks on Doors. All access doors shall be provided with interlocks which will disconnect all voltages in excess of 350 volts when any access door is opened.

d. Audio-Amplifiers. Audio-amplifiers which are located outside the transmitter housing shall be suitably housed and shall be so located as to be readily accessible and adequately ventilated.

CHAPTER 9. CONSTRUCTION SPECIFICATIONS

This chapter of the code describes the general characteristics of fittings, materials, and devices of the types commonly employed in installations for which provisions are given in other chapters of this code. It is intended as a guide to the classification and identification of types. Such details of construction as are included in this chapter are given as descriptive information and not as a complete basis for judgment of devices or materials.

The section numbers of this chapter are derived from this chapter number, the article number to which the section refers, and a serial number. In the section number 92401, the first figure (9) indicates the chapter number; the next three figures (240) indicate that the section refers to Article 240, Overcurrent Protection; and the last number (1), that this is the first item in this series. Cross references are therefore omitted as the group of three digits following the figure 9 indicates the article referred to.

Cartridge Fuses and Fuseholders

92401. Dimensions. Cartridge fuses and fuseholders shall conform to the dimensions shown in Table 34 of Chapter 10.

92402. Terminals. The terminals of standard cartridge fuses and fuseholders shall be of the ferrule type for ratings of 0-60 amperes, and of the knife-blade type for ratings of 61-600 amperes.

92403. Marking. Fuses shall be plainly marked with the ampere and voltage ratings, and the name or trade mark of the maker. The ampere rating and the voltage for which the fuse is designed shall be in bold type. The markings shall be either by direct printing on the fuse barrel or by means of an attached label.

Link Fuses and Fuseholders

92405. **Dimensions.** Link fuses and fuseholders shall have the following dimensions in inches:

Amperes Capacity	Minimum Separation of Nearest Metal Parts of Opposite Polarity	Minimum Break Distance
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.

92406. **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 if practicable.

92407. **Marking.** Link fuses shall be stamped with 80 per cent of the maximum current which they can carry indefinitely.

92408. **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.

Conductors

93101. **General.** Insulated conductors shall conform to the following:

a. **Marking.** Wires, cables and cords of all kinds except weatherproof and 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, slow-burning weatherproof, weatherproof and asbestos-covered switchboard wires.

2. The words "National Electrical Code Standard."

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, slow-burning weatherproof, and weatherproof wires.

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

b. **Identification of Insulation.** All rubber-insulated conductors and all thermoplastic-insulated conductors, No. 14 and larger, shall have a readily identifiable permanent 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.

c. **Classification.** In addition to the type letters specified in the table in paragraph e of this section, the following letters shall apply:

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

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

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

4. **L.** 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 tables are the operating voltages between phases of single and two-phase systems, and three-phase systems with grounded or ungrounded neutral.

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

d. Identified Conductors. Single insulated conductors of No. 6 or smaller, intended for use as identified conductors of circuits, except conductors of the weatherproof type (type WP and SBW) and 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.

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.

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. For identification requirements for conductors larger than No. 6 see paragraph b of section 2005.

e. Conductor Construction. Insulated conductors for use at 600 volts or less shall conform to the provisions of the tables on pages 365-369.

CONDUCTOR INSULATIONS

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-Covered Fixture Wire—Solid or Stranded	TF	Thermoplastic	18–16 .... 2/64 Inch	None
Thermoplastic-Covered Fixture Wire—Flexible Stranding	TFF	Thermoplastic	18–16 .... 2/64 Inch	None

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
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
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	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
	RUW	90% Unmilled, Grainless Rubber	14–10 . . . . 18 Mils 8–2 . . . . 25 Mils	Moisture-resistant, flame-retardant, non-metallic
Heat Resistant Latex Rubber	RUH	90% Unmilled, Grainless Rubber	14–10 . . . . 18 Mils 8–2 . . . . 25 Mils	Moisture-resistant, flame-retardant, non-metallic
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
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
Mineral-Insulated Metal-Sheathed	MI	Magnesium Oxide	16–4 . . . . 50 Mils 3–4/0 . . . . 55 Mils	Copper

Trade Name	Type Letter	Insulation	Thickness of Insulation	Outer Covering
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	Non-metallic covering or lead sheath
Asbestos and Varnished Cambric	AVA and AVL	Impregnated Asbestos and Varnished Cambric	(Dimensions in Mils) — VC / AVA Asb. / AVL Asb. 14–8 (solid only) 30 20 25	AVA-asbestos braid
			1st Asb. / VC / AVA 2nd Asb. / AVL 2nd Asb. 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	AVL-asbestos braid and lead sheath
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
Asbestos	AI	Impregnated Asbestos	14 . . . . . 30 Mils 12–8 . . . . . 40 Mils	Without asbestos braid
Asbestos	AIA	Impregnated Asbestos	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
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
Slow-Burning Weatherproof	SBW	2 Layers Impregnated 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 fire-retardant coating
Weatherproof	WP	At least 3 Impregnated Cotton Braids or Equivalent		

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 93341. For non-metallic-sheathed cable, see section 93361. For Type UF cable, see section 93391.

f. Insulation Thickness — Over 600 Volts. The thickness of insulation for conductors for use at over 600 volts shall conform to the following:

Thickness of Rubber Insulation for Rubber-Covered Wires and Cables, in 64ths of an Inch.

Conductor Size, AWG or MCM	Classification R) RH)10 RW)	R) RH)20 RW)	R) RH)30 RW)	R) RH)40 RW)	R) RH)50 RW)
14-8	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

Thicknesses of Varnished-Cambric 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

Thicknesses 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.