

NATIONAL ELECTRICAL CODE 1975



National Fire Protection Association

ABOUT THE SPONSOR

This National Electrical Code is sponsored by the National Fire Protection Association under the auspices of the American National Standards Institute. The purpose of the National Electrical Code is detailed in Section 90-1 and the scope of the Code is outlined in Section 90-2.

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

The National Fire Protection Association has acted as sponsor of the National Electrical Code since 1911. The original Code document was developed in 1897 as a result of the united efforts of various insurance, electrical, architectural, and allied interests. Membership in the present National Electrical Code Committee is shown on Pages 70-v through 70-xvi. The Rules of Procedure under which the National Electrical Code Committee operates are published in the Appendix, and the Time Schedule for the next (1978) Edition of the National Electrical Code is also given in the Appendix.

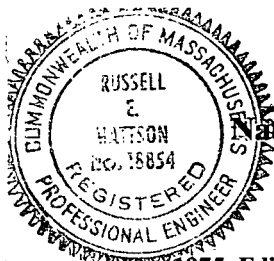
The National Fire Protection Association has an Electrical Section which provides particular opportunity for NFPA members interested in electrical safety to become better informed and to contribute to the development of the National Electrical Code and other NFPA electrical standards. The Electrical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

The 1975 edition of the National Electrical Code is dedicated to the past Secretary of the NFPA Electrical Section and former NFPA Electrical Field Engineer John Watt, whose services to the National Electrical Code will live for generations past his untimely death.

ERRATA

Insert Section 380-8(b) on page 70-222, to follow Exception No. 3:

(b) Snap switches shall not be grouped or ganged in outlet boxes unless they can be so arranged that the voltage between adjacent switches does not exceed 300, or unless they are installed in boxes equipped with permanently installed barriers between adjacent switches.



National Electrical Code 1975 Edition

NFPA No. 70-1975

1975 Edition of National Electrical Code

This 1975 Edition of the National Electrical Code (NFPA No. 70-1975) was adopted by the National Fire Protection Association at its Annual Meeting held May 20-24, 1974 in Miami Beach, Florida. It has been submitted to the American National Standard Institute for approval by that organization and when and if approved, the approval date will be included in the following printings and it will be known as ANSI C1-1975. By a resolution adopted at the annual meeting the 1974 National Electrical Code will hereafter be called the 1975 N.E.C. It supersedes all previous editions of the National Electrical Code, the most recent previous edition being 1971.

Changes in this 1975 Edition of the National Electrical Code (as compared with the 1971 Edition) are indicated by a summary of major revisions, deletions and new material in the latter part of the Appendix. In certain cases, minor editorial changes are not so indicated.

Attention is called to the Appendix for the "Time Schedule for the 1978 National Electrical Code" which is the next regular edition. The "Method of Submitting Proposal to Revise the National Electrical Code" is included in the Appendix to guide anyone concerned with the proper procedures for handling proposed revisions.

This Code is purely advisory as far as the NFPA and ANSI are concerned but is offered for use in law and for regulatory purposes in the interest of life and property protection (see copyright statement on Page 70-ii). Anyone noticing any errors should please notify the NFPA Executive Office, the Chairman and the Secretary of the Committee.

Development of National Electrical Code

Consistent with the Rules of Procedure for the National Electrical Code Committee (see Appendix) a "PREPRINT" OF THE PROPOSED AMENDMENTS FOR THE 1975 NATIONAL ELECTRICAL CODE was published by the National Fire Protection Association in July 1973. This "PREPRINT" recorded the actions of the various Code-Making Panels and the Correlating Committee of the National Electrical Code Committee on each proposal that had been made to revise the 1971 Code. Subsequently, the various Code-Making Panels finalized their recommendations and their reports were processed through the Correlating Committee of the National Electrical Code Committee. This was preparatory to the formal presentation of this 1975 Edition of the National Electrical Code in Volume 2 of the 1974 NFPA TECHNICAL COMMITTEE REPORTS. This latter publication was circulated to all members of the National Electrical Code Committee, to other interested NFPA members, and offered to the public through technical releases in the interested trade papers. The action of the 1974 NFPA Annual Meeting as to the adoption of the 1975 Edition is recorded in the PROCEEDINGS of

that Meeting published by the Association in the September 1974 issue of *Fire Journal*.

Coincident with the above processing procedures, each of the Code-Making Panels and the Chairman of the Correlating Committee reported their recommendations to meetings of the Electrical Section at both the 1973 and 1974 NFPA Annual Meetings. The Electrical Section (See Rules of Procedure, Appendix) thus had opportunity to discuss and review the report of the National Electrical Code Committee prior to the adoption of this Edition of the Code by the Association.

A "One- and Two-Family Residential Occupancy Electrical Code," prepared under authority granted by the Correlating Committee of the National Electrical Code Committee, is an abridged version of the 1971 text, edited only as dictated to eliminate extraneous material not of concern to this type occupancy, and to place in the text only the more popular types of wiring methods, not to exclude any other type authorized by the complete Code.

The NFPA HANDBOOK OF THE NATIONAL ELECTRICAL CODE is published by The McGraw-Hill Book Company, Inc., 1221 Avenue of the Americas, New York, New York 10020. This text is prepared by the Secretary of the National Electrical Code Committee who is the NFPA Electrical Field Specialist.

First Printing, Aug. 1974

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Panel No. 9 — Articles 370, 373, 380, 384

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Panel No. 10 — Articles 422, 424, 426, 427

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Panel No. 11 — Articles 430, 440, 670, 675, Example No. 8, Chapter 9

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Panel No. 13 — Articles 450, 460, 470, 710

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Panel No. 14 — Articles 500, 501, 502, 503, 510, 511, 513, 514, 515, 516

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Abbreviations for Organizations Represented on Various Code Panels

AA	Aluminum Association
AAMI	Association for the Advancement of Medical Instrumentation
ACS	American College of Surgeons
AHA	American Hospital Association
AHAM	Association of Home Appliance Manufacturers
AISI	American Iron & Steel Institute
AMP & TVP	Association of Motion Picture & Television Producers
API	American Petroleum Institute
ARI	Air-Conditioning & Refrigeration Institute
ASA	American Society of Anesthesiologists
AWWA	American Water Works Association
CBEMA	Computer and Business Equipment Manufacturers Association
CMAA	Crane Manufacturers Association of America, Inc.
EFMG	Electric Fuse Manufacturers Guild
EGSMA	Engine Generating Systems Marketing Association
EIA	Electronic Industries Association
EL&PG	Electric Light & Power Group
HMI	Hoist Manufacturers Institute
IAEI	International Association of Electrical Inspectors
IBEW	International Brotherhood of Electrical Workers
IEEE	Institute of Electronic & Electrical Engineers
IES	Illuminating Engineering Society
JCAH	Joint Commission on Accreditation of Hospitals
MCA	Manufacturing Chemists Association
MHMA	Mobile Home Manufacturers Association
NABM	National Association of Building Manufacturers
NAED	National Association of Electrical Distributors
NAHB	National Association of Home Builders
NECA	National Electrical Contractors Association
NEI	National Elevator Industry, Inc.
NEMA	National Electrical Manufacturers Association
NESA	National Electric Sign Association
NSC	National Safety Council
PTI	Power Tool Institute
RVI	Recreational Vehicle Institute
SMP & TE	Society of Motion Pictures and Television Engineers
TCA	Trailer Coach Association
TG	Telephone Group

National Electrical Code

NFPA No. 70

ARTICLE 90 — INTRODUCTION

90-1. Purpose.

(a) The purpose of this Code is the practical safeguarding of persons and property from hazards arising from the use of electricity.

(b) This Code contains provisions considered necessary for safety. Compliance therewith and proper maintenance will result in an installation essentially free from hazard, but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical use.

Hazards often occur because of overloading of wiring systems by methods or usage not in conformity with this Code. This occurs because initial wiring did not provide for increases in the use of electricity. An initial adequate installation and reasonable provisions for system changes will provide for future increases in the use of electricity.

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

90-2. Scope.

(a) **Covered.** This Code covers:

(1) Electric conductors and equipment installed within or on public and private buildings or other structures, including mobile homes and recreational vehicles; and other premises such as yards, carnival, parking and other lots, and industrial substations.

(2) Conductors that connect the installations to a supply of electricity.

(3) Other outside conductors on the premises.

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

(1) Installations in automotive vehicles, other than mobile homes and recreational vehicles, ships, watercraft, railway rolling stock, or aircraft.

(2) Installations underground in mines.

(3) Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communication purposes.

(4) Installations of communication equipment under the exclusive control of communication utilities, located outdoors or in building spaces used exclusively for such installations.

(5) Installations under the exclusive control of electric utilities for the purpose of communication, or metering; or for the generation, control, transformation, transmission, and distribution of electric energy located in buildings used exclusively by utilities for such purposes or

located outdoors on property owned or leased by the utility or on public highways, streets, roads, etc., or outdoors by established rights on private property.

(c) Special Permission. The authority having jurisdiction for enforcing this Code may grant exception for the installation of conductors and equipment, not under the exclusive control of the electric utilities and used to connect the electric utility supply system to the service entrance conductors of the premises served, provided such installations are outside a building or terminate immediately inside a building wall.

90-3. Code Arrangement. This Code is divided into nine Chapters. Chapters 1, 2, 3, and 4 apply generally; Chapters 5, 6, and 7 apply to special occupancies, special equipment, or other special conditions. These latter Chapters supplement or modify the general rules. Chapters 1 through 4 apply except as amended by Chapters 5, 6, and 7 for the particular conditions.

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

Chapter 9 consists of tables and examples.

90-4. Enforcement. This Code is intended to be suitable for mandatory application by governmental bodies exercising legal jurisdiction over electrical installations and for use by insurance inspectors. The authority having jurisdiction of 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 industrial establishments and research and testing facilities, the authority having jurisdiction may waive specific requirements in this Code or permit alternate methods, where it is assured that equivalent objectives can be achieved by establishing and maintaining effective safety and maintenance procedures.

90-5. Formal Interpretations. To promote uniformity of interpretation and application of the provisions of this Code, the National Electrical Code Committee has established interpretation procedures.

See Part D of the Appendix.

90-6. Examination of Equipment for Safety. For specific items of equipment and materials covered by this Code, examinations for safety made under standard conditions will provide a basis for approval where the record is made generally available through promulgation by organizations properly equipped and qualified for experimental testing, inspections of the run of goods at factories, and service-value determination through field inspections. This avoids the necessity for repetition of examinations by different examiners, frequently with inadequate facilities for such work, and the confusion that would result from conflicting reports as to the suitability of devices and materials examined for a given purpose.

It is the intent of this Code that factory-installed internal wiring or the construction of equipment need not be inspected at the time of installation of the equipment, except to detect alterations or damage, if the equipment has been listed by an electrical testing laboratory that is

nationally recognized as having the facilities described above and which requires suitability for installation in accordance with this Code.

See Examination of Equipment, Section 110-3.

See definition of "Listed," Article 100.

90-7. Wiring Planning.

(a) Plans and specifications that provide ample space in raceways, spare raceways, and additional spaces will allow for future increases in the use of electricity. Distribution centers located in readily accessible locations will provide convenience and safety of operation. See Sections 110-16 and 240-24 for clearances and accessibility.

(b) It is elsewhere provided in this Code that the number of wires and circuits confined in a single enclosure be varyingly restricted. Limiting the number of circuits in a single enclosure will minimize the effects from a short-circuit or ground fault in one circuit.

Chapter 1. General

ARTICLE 100 — DEFINITIONS

Scope. Only definitions of terms peculiar to and essential to the proper use of this Code are included. In general, only those terms used in two or more Articles are defined in Article 100. Other definitions are included in the Article in which they are used but may be referenced in Article 100.

Part A of this Article contains definitions intended to apply wherever the terms are used throughout this Code. Part B contains definitions applicable only to the Parts of Articles covering specifically installations and equipment operating at over 600 volts, nominal.

A. General

AC General-Use Snap Switch: See under "Switches."

AC-DC General-Use Snap Switch: See under "Switches."

Accessible: (As applied to wiring methods.) Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building. (See "Concealed" and "Exposed.")

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

Ampacity: Current-carrying capacity of electric conductors expressed in amperes.

Anesthetizing Location: See Section 517-2.

Appliance: Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, deep frying, etc.

Appliance, Fixed: An appliance which is fastened or otherwise secured at a specific location.

Appliance, Portable: An appliance which is actually moved or can easily be moved from one place to another in normal use.

Appliance, Stationary: An appliance which is not easily moved from one place to another in normal use.

Appliance Branch Circuit: See "Branch Circuit, Appliance."

Approved: Acceptable to the authority having jurisdiction.

Approved for the Purpose: Approved for a specific purpose, environment, or application described in a particular Code requirement.

Askarel: A generic term for a group of nonflammable synthetic chlorinated hydrocarbons used as electrical insulating media. Aska-

rels of various compositional types are used. Under arcing conditions the gases produced, while consisting predominantly of noncombustible hydrogen chloride, can include varying amounts of combustible gases depending upon the askarel type.

Attachment Plug (Plug Cap) (Cap): A device which, by insertion in a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

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

Bare Conductor: See under "Conductor."

Block (City, Town, or Village): See Section 800-2.

Bonding: The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

Bonding Jumper: A reliable conductor to assure the required electrical conductivity between metal parts required to be electrically connected.

Bonding Jumper, Circuit: The connection between portions of a conductor in a circuit to maintain required ampacity of the circuit.

Bonding Jumper, Equipment: The connection between two or more portions of the equipment grounding conductor.

Bonding Jumper, Main: The connection between the grounded circuit conductor and the equipment grounding conductor at the service.

Branch Circuit: The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

See Section 240-9 for thermal cutouts, thermal relays, and other devices.

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

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

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

Branch Circuit, Multiwire: A branch 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.

Branch-Circuit Selection Current: See Section 440-3(c), Definition.

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

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

Cell (As Applied to Raceways): See Sections 356-1 and 358-1.

Circuit Breaker: A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a pre-determined overcurrent without injury to itself when properly applied within its rating.

See definition in Part B of this Article for definition applying to circuits and equipment over 600 volts, nominal.

ADJUSTABLE: (As Applied to Circuit Breakers.) A qualifying term indicating that the circuit breaker can be set to trip at various values of current and/or time within a pre-determined range.

INSTANTANEOUS TRIP: (As Applied to Circuit Breakers.) A qualifying term indicating that no delay is purposely introduced in the tripping action of the circuit breaker.

INVERSE TIME: (As Applied to Circuit Breakers.) A qualifying term indicating there is purposely introduced a delay in the tripping action of the circuit breaker, which delay decreases as the magnitude of the current increases.

NONADJUSTABLE: (As Applied to Circuit Breakers.) A qualifying term indicating that the circuit breaker does not have any adjustment to alter the value of current at which it will trip or the time required for its operation.

SETTING: (Of Circuit Breaker.) The value of current and/or time at which an adjustable circuit breaker is set to trip.

Communication Circuit: See Section 800-1.

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. [See "Accessible — (As applied to wiring methods)"]

Conductor:

BARE: A conductor having no covering or electrical insulation whatsoever. (See "Conductor, Covered.")

COVERED: A conductor encased within material of composition or thickness that is not recognized by this Code as electrical insulation. (See "Conductor, Bare.")

INSULATED: A conductor encased within material of composition and thickness that is recognized by this Code as electrical insulation.

Conduit Body: A separate portion of a conduit or tubing system that provides access through a removable cover(s) to the interior of the system at a junction of two or more sections of the system or at a terminal point of the system.

Connector, Pressure (Solderless): A device that establishes a connection between two or more conductors or between one or more conduc-

tors and a terminal by means of mechanical pressure and without the use of solder.

Continuous Duty: See under "Duty."

Continuous Load: A load where the maximum current is expected to continue for three hours or more.

Control Circuit: See Section 430-71.

Controller: A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected. See also Section 430-81(a).

Cooking Unit, Counter-Mounted: A cooking appliance designed for mounting in or on a counter and consisting of one or more heating elements, internal wiring, and built-in or separately mountable controls. (See "Oven, Wall-Mounted.")

Covered Conductor: See under "Conductor."

Current-Limiting Overcurrent Protective Device: (See Section 240-11.)

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.")

Damp Location: See under "Location."

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

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

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

See definition in Part B of this Article for definition applying to circuits and equipment over 600 volts, nominal.

Dry Location: See under "Location."

Dust-Ignition-Proof: See Section 502-1.

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

Dust-tight: So constructed that dust will not enter the enclosing case.

Duty:

CONTINUOUS DUTY: Operation at a substantially constant load for an indefinitely long time.

INTERMITTENT DUTY: Operation for alternate intervals of (1) load and no load; or (2) load and rest; or (3) load, no load and rest.

PERIODIC DUTY: Intermittent operation in which the load conditions are regularly recurrent.

SHORT TIME DUTY: Operation at a substantially constant load for a short and definitely specified time.

VARYING DUTY: Operation at loads, and for intervals of time, both of which may be subject to wide variation.

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

Duty Cycle (Welding): See Section 630-31(b), Fine Print Note.

Electric Sign: A fixed, stationary, or portable self-contained, electrically illuminated utilization equipment with words or symbols designed to convey information or attract attention.

Enclosed: Surrounded by a case, housing, fence or walls which will prevent persons from accidentally contacting energized parts.

Enclosure: The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts, or to protect the equipment from physical damage.

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.

Equipment Grounding Conductor: See "Grounding Conductor, Equipment."

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

Exposed: (As applied to live parts.) Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. (See "Accessible" and "Concealed.")

Exposed: (As applied to wiring methods.) On or attached to the surface or behind panels designed to allow access. [See "Accessible — (As applied to wiring methods)"]

Externally Operable: Capable of being operated without exposing the operator to contact with live parts.

Feeder: All circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the final branch-circuit overcurrent device.

Festoon Lighting: See Section 225-6(b).

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

Fixed Appliance: See "Appliance, Fixed."

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.

See Section 511-1.

General-Purpose Branch Circuit: See "Branch Circuit, General Purpose."

General-Use Snap Switch: See under "Switches."

General-Use Switch: See under "Switches."

Ground: A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Grounded: Connected to earth or to some conducting body that serves in place of the earth.

Grounded (Effectively Grounded Communication System): See Section 800-2(c)(1).

Grounded Conductor: A system or circuit conductor that is intentionally grounded.

Grounding Conductor: A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding Conductor Equipment: The conductor used to connect noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor at the service and/or the grounding electrode conductor.

Grounding Electrode Conductor: The conductor used to connect the grounding electrode to the equipment grounding conductor and/or to the grounded conductor of the circuit at the service.

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

Hazardous Locations: See Article 500.

Header: See Sections 356-1 and 358-1.

Hermetic Refrigerant Motor-Compressor: See Section 440-1.

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

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

Individual Branch Circuit: See "Branch Circuit, Individual."

Insulated Conductor: See under "Conductor."

Intermittent Duty: See under "Duty."

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

Labeled: Equipment or materials having a label, symbol, or other identifying mark of a nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling is indicated compliance with nationally recognized standards or tests to determine suitable usage in a specified manner.

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

Listed: Equipment or materials included in a list published by a nationally recognized testing laboratory, inspection agency, or other organization concerned with product evaluation that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

The means for identifying listed equipment may vary for each testing laboratory, inspection agency, or other organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

Location:

DAMP LOCATION: Partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements, some barns, and some cold-storage warehouses.

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.

WET LOCATION: Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as vehicle washing areas, and locations exposed to weather and unprotected.

Low-Energy Power Circuit: A circuit that is not a remote-control or signaling circuit but has its power supply limited in accordance with the requirements of Class 2 and Class 3 circuits. (See Article 725.)

Multioutlet Assembly: A type of surface or flush raceway designed to hold conductors and receptacles, assembled in the field or at the factory.

Multiwire Branch Circuit: See "Branch Circuit, Multiwire."

Neutral Conductor: See Note 10 to Tables 310-16 to 310-19.

Nonautomatic: Action requiring personal intervention for its control. (See "Automatic.")

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

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

Outline Lighting: An arrangement of incandescent lamps or electric discharge tubing to outline or call attention to certain features such as the shape of a building or the decoration of a window.

Oven, Wall-Mounted: An oven for cooking purposes designed for mounting in or on a wall or other surface and consisting of one or more heating elements, internal wiring, and built-in or separately mountable controls. (See "Cooking Unit, Counter-Mounted.")

Panelboard: A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and with or without switches for the control of light, heat, or power circuits; 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.")

Periodic Duty: See under "Duty."

Portable Appliance: See "Appliance, Portable."

Power Outlet: An enclosed assembly which may include receptacles, circuit breakers, fuseholders, fused switches, buses and watt-hour meter mounting means; intended to supply and control power to mobile homes, recreational vehicles or boats, or to serve as a means for distributing power required to operate mobile or temporarily installed equipment.

Premises Wiring (System): That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

Projector, Nonprofessional: See Section 540-30.

Projector, Professional: See Section 540-10.

Qualified Person: One familiar with the construction and operation of the equipment and the hazards involved.

Raceway: Any channel for holding wires, cables, or busbars that 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, rigid nonmetallic conduit, intermediate metal conduit, flexible metal conduit, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways, and busways.

Rainproof: So constructed, protected, or treated as to prevent rain from interfering with successful operation of the apparatus.

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

Rated-Load Current: See Section 440-3(a) Definition.

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

Receptacle: A receptacle is a contact device installed at the outlet for the connection of a single attachment plug.

A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is a single device containing two or more receptacles.

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

Remote-Control Circuit: Any electric circuit that controls any other circuit through a relay or an equivalent device.

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

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

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

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

Service Drop: The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure.

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

Service-Entrance Conductors, Sub-sets: See Section 230-2 Exception No. 3(b).

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

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

Service Equipment: The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply.

Service Lateral: The underground service conductors between the street main, including any risers at a pole or other structure or from transformers, and the first point of connection to the service-entrance conductors in a terminal box or meter or other enclosure with adequate space, inside or outside the building wall. Where there is no terminal box, meter, or other enclosure with adequate space, the point of con-

nection shall be considered to be the point of entrance of the service conductors into the building.

Service Raceway: The raceway that encloses the service-entrance conductors.

Setting: (Of Circuit Breaker.) The value of the current at which it is set to trip.

Short-Time Duty: See under "Duty."

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

Sign: See "Electric Sign."

Signaling Circuit: Any electric circuit that energizes signaling equipment.

Special Permission: The written consent of the authority having jurisdiction.

Stationary Appliance: See "Appliance, Stationary."

Switches:

GENERAL-USE SWITCH: A switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage.

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

AC GENERAL-USE SNAP SWITCH: See Section 380-14(a).

AC-DC GENERAL-USE SNAP SWITCH: See Section 380-14(b).

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

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

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

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

Thermally Protected: (As applied to motors.) The words "Thermally Protected" appearing on the nameplate of a motor or motor-compressor indicate that the motor is provided with a thermal protector.

Thermal Protector: (As applied to motors.) A protective device for assembly as an integral part of a motor or motor-compressor and which, when properly applied, protects the motor against dangerous overheating due to overload and failure to start.

The thermal protector may consist of one or more sensing elements integral with the motor or motor-compressor and an external control device.

Utilization Equipment: Equipment which utilizes electric energy for mechanical, chemical, heating, lighting, or similar purposes.

Varying Duty: See under "Duty."

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

Volatile Flammable Liquid: A flammable liquid having a flash point below 38°C (100°F) or whose temperature is above its flash point.

Voltage (Of a Circuit): The greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned.

Some systems, such as 3-phase 4-wire, single-phase 3-wire, and 3-wire direct-current may have various circuits of various voltages.

Voltage, Nominal: A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240, 480Y/277, 600, etc.).

The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

See "Voltage Ratings for Electric Power Systems and Equipment (60 Hz)," ANSI C84.1-1970 and supplement C84.1a-1973.

Voltage to Ground: For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded; for 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 enclosure.

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

Rainproof, raintight, or watertight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.

Welder, Electric:

RATED PRIMARY CURRENT: See Section 630-31(b).

ACTUAL PRIMARY CURRENT: See Section 630-31(b).

Wet Location: See under "Location."

X-ray:

LONG TIME RATING: See Section 660-2.

MOMENTARY RATING: See Section 660-2.

B. Over 600 Volts, Nominal

Whereas the preceding definitions are intended to apply wherever the terms are used throughout this Code, the following ones are applica-

ble only to the Parts of Articles covering specifically installations and equipment operating at over 600 volts, nominal.

Circuit Breaker: (See "Switching Devices.")

Cutout: (See "Switching Devices.")

Disconnect (Isolator): (See "Switching Devices.")

Disconnecting Means: (See "Switching Devices.")

Fuse: An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it.

A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

EXPULSION FUSE UNIT (EXPULSION FUSE): A vented fuse unit in which the expulsion effect of gases produced by the arc and lining of the fuse-holder, either alone or aided by a spring, extinguishes the arc.

POWER FUSE UNIT: A vented, nonvented or controlled vented fuse unit in which the arc is extinguished by being drawn through solid material, granular material, or liquid, either alone or aided by a spring.

VENTED POWER FUSE: A fuse with provision for the escape of arc gases, liquids, or solid particles to the surrounding atmosphere during circuit interruption.

NONVENTED POWER FUSE: A fuse without intentional provision for the escape of arc gases, liquids, or solid particles to the atmosphere during circuit interruption.

CONTROLLED VENTED POWER FUSE: A fuse with provision for controlling discharge circuit interruption such that no solid material may be exhausted into the surrounding atmosphere. The discharge gases shall not ignite or damage insulation in the path of the discharge, nor shall these gases propagate a flashover to or between grounded members or conduction members in the path of the discharge when the distance between the vent and such insulation or conduction members conforms to manufacturer's recommendations.

Grounded, Effectively: Permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient ampacity that ground fault current which may occur cannot build up to voltages dangerous to personnel.

Interrupter Switch: (See "Switching Devices.")

Multiple Fuse: An assembly of two or more single-pole fuses.

Oil (Filled) Cutout: (See "Switching Devices.")

Power Fuse: (See "Fuse.")

Regulator Bypass Switch: (See "Switching Devices.")

Switching Device: A device designed to close and/or open one or more electric circuits.

Switching Devices:

CIRCUIT BREAKER: A switching device capable of making, carry-

ing, and breaking currents under normal circuit conditions, and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions, such as those of short circuit.

CUTOUT: An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a non-fusible member.

DISCONNECTING (OR ISOLATING) SWITCH (DISCONNECTOR, ISOLATOR): A mechanical switching device used for isolating a circuit or equipment from a source of power.

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

INTERRUPTER SWITCH: A switch capable of making, carrying, and interrupting specified currents.

OIL CUTOUT (OIL-FILLED CUTOUT): A cutout in which all or part of the fuse support and its fuse link or disconnecting blade are mounted in oil with complete immersion of the contacts and the fusible portion of the conducting element (fuse link), so that arc interruption by severing of the fuse link or by opening of the contacts will occur under oil.

OIL SWITCH: An oil switch is a switch having contacts which operate under oil (or askarel or other suitable liquid).

REGULATOR BYPASS SWITCH: A specific device or combination of devices designed to bypass a regulator.

ARTICLE 110 — REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

A. General

110-1. Mandatory Rules and Explanatory Material. Mandatory rules of this Code are characterized by the use of the word, "shall." Explanatory material is in the form of fine print notes.

110-2. Approval. The conductors and equipment required or permitted by this Code shall be acceptable only when approved.

See Examination of Equipment for Safety, Section 110-3. See definitions of "Approved," "Approved for the purpose," "Labeled," and "Listed."

110-3. Examination, Installation and Use of Equipment.

(a) **Examination.** In judging equipment, considerations such as the following shall be evaluated:

(1) Suitability for installation and use in conformity with the provisions of this Code. Suitability of equipment may be evidenced by listing or labeling.

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

(3) Electrical insulation.

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

(5) Arcing effects.

(6) Classification by type, size, voltage, current capacity, specific use.

(7) Other factors which contribute to the practical safeguarding of persons using or likely to come in contact with the equipment.

(b) Installation and Use. Listed or labeled equipment shall be used or installed in accordance with any instructions included in the listing or labeling.

110-4. Voltages. Throughout this Code the voltage considered shall be that at which the circuit operates.

110-5. Conductors. Conductors normally used to carry current shall be of copper unless otherwise provided in this Code. Where the conductor material is not specified, the sizes given in this Code shall apply to copper conductors. Where other materials are used, the size shall be changed accordingly.

For aluminum and copper-clad aluminum conductors, see Tables 310-18 and 310-19.

110-6. Conductor Sizes. Conductor sizes are expressed in American Wire Gage (AWG) or in circular mils.

110-7. Insulation Integrity. All wiring shall be so installed that when completed the system will be free from short circuits and from grounds other than as permitted in Article 250.

110-8. Wiring Methods. Only wiring methods recognized as suitable are included in this Code. The recognized methods of wiring shall be permitted to be installed in any type of building or occupancy, except as otherwise provided in this Code.

110-9. Interrupting Capacity. Devices intended to break current shall have an interrupting capacity sufficient for the voltage employed and for the current that must be interrupted.

110-10. Circuit Impedance and Other Characteristics. The overcurrent protective devices, the total impedance, and other characteristics of the circuit to be protected shall be so selected and coordinated as to permit the circuit protective devices used to clear a fault without the occurrence of extensive damage to the electrical components of the circuit. This fault shall be assumed to be either between two or more of the circuit conductors, or between any circuit conductor and the grounding conductor or enclosing metal raceway.

110-11. Deteriorating Agents. Unless approved for the purpose, no conductors or equipment shall be located in damp or wet locations; where exposed to gases, fumes, vapors, liquids, or other agents having a

deteriorating effect on the conductors or equipment; nor where exposed to excessive temperatures.

See Section 300-6 for protection against corrosion.

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

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

110-13. Mounting and Cooling of Equipment.

(a) **Mounting.** Electric 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 used.

(b) **Cooling.** Electrical equipment which depends upon the natural circulation of air and convection principles for cooling of exposed surfaces shall be installed so that room air flow over such surfaces is not prevented by walls or by adjacent installed equipment. For equipment designed for floor mounting, clearance between top surfaces and adjacent surfaces shall be provided to dissipate rising warm air.

Electrical equipment provided with ventilating openings shall be installed so that walls or other obstructions do not prevent the free circulation of air through the equipment.

110-14. Electrical Connections. Because of different characteristics of copper and aluminum, devices such as pressure terminal or pressure splicing connectors and soldering lugs shall be suitable for the material of the conductor and shall be properly installed and used. Conductors of dissimilar metals shall not be intermixed in a terminal or splicing connector where physical contact occurs between dissimilar conductors (such as copper and aluminum, copper and copper-clad aluminum, or aluminum and copper-clad aluminum), unless the device is suitable for the purpose and conditions of use. Materials such as solder, fluxes, inhibitors, and compounds, where employed, shall be suitable for the use and shall be of a type which will not adversely affect the conductors, installation, or equipment.

(a) **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.

Exception: Connection by means of wire binding screws or studs and nuts having upturned lugs or equivalent shall be permitted for No. 10 or smaller conductors.

Terminals for more than one conductor and terminals used to connect aluminum shall be of a type approved for the purpose.

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

110-16. Working Space About Electric Equipment (600 Volts or Less, Nominal). Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment.

(a) **Working Clearances.** Except as elsewhere required or permitted in this Code, the dimension of the working space in the direction of access to live parts operating at 600 volts or less and likely to require examination, adjustment, servicing, or maintenance while alive, shall not be less than indicated in Table 110-16(a). In addition to the dimensions shown in Table 110-16(a), the work space shall not be less than 30 inches wide in front of the electric equipment. Distances shall be measured from the live parts if such are exposed or from the enclosure front or opening if such are enclosed. Concrete, brick, or tile walls shall be considered as grounded.

Table 110-16(a). Working Clearances

Voltage to Ground	Minimum clear distance (feet)			
	Condition:	1	2	3
0-150		2½	2½	3
151-600		2½	3½	4

Where the "Conditions" are as follows:

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

2. Exposed live parts on one side and grounded parts on the other side.

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

Exception No. 1: Working space shall not be required in back of assemblies, such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts such as fuses or switches on the back and where all connections are accessible from locations other than the back.

Exception No. 2: By special permission smaller spaces may be permitted where it is judged that the particular arrangement of the installation will provide adequate accessibility.

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

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

(d) **Front Working Space.** In all cases where there are live parts normally exposed on the front of switchboards or motor control centers, the working space in front of such equipment shall not be less than 3 feet.

(e) **Illumination.** Illumination shall be provided for all working spaces about switchboards and motor control centers.

(f) **Headroom.** The minimum headroom of working spaces about switchboards or motor control centers where there are live parts exposed at any time shall be 6¼ feet.

For higher voltages, see Article 710.

As used in this Section, a motor control center is an assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

110-17. Guarding of Live Parts. (600 volts or less, nominal)

(a) Except as elsewhere required or permitted by this Code, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by approved cabinets or other forms of approved enclosures or by any of the following means:

(1) By location in a room, vault, or similar enclosure that is accessible only to qualified persons.

(2) By suitable permanent, substantial partitions or screens so arranged that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.

(3) By location on a suitable balcony, gallery, or platform so elevated and arranged as to exclude unqualified persons.

(4) By elevation of 8 feet or more above the floor or other working surface.

(b) In locations where electric equipment would be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

(c) Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

For motors, see Sections 430-132 and 430-133. For over 600 volts, see Section 710-34.

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

For hazardous locations, see Articles 500 through 517. For motors, see Section 430-14.

110-19. 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.

Exception: Car houses, power houses, or passenger and freight stations operated in connection with electric railways.

110-21. Marking. The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified shall be placed on all electric equipment. Other markings shall be provided giving voltage, current, wattage, or other ratings as are specified elsewhere in this Code. The marking shall be of sufficient durability to withstand the environment involved.

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

B. Over 600 Volts, Nominal

110-30. General. Conductors and equipment used on circuits exceeding 600 volts, nominal, shall comply with all applicable provisions of the preceding Sections of this Article and with the following Sections, which supplement or modify the preceding Sections. In no case shall the provisions of this Part apply to equipment on the supply side of the service conductors.

110-31. Enclosure for Electrical Installations. Electrical installations in a vault, room, or 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, shall be 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.

A wall, screen, or fence less than 8 feet in height shall not be considered as preventing access unless it has other features that provide a degree of isolation equivalent to an 8-foot fence.

Article 450 covers minimum construction requirements for transformer vaults.

Isolation by elevation is covered in paragraph (b) of this Section and in Section 110-34.

(a) Indoor Installations.

(1) In Places Accessible to Unqualified Persons. Indoor electrical installations that are open to unqualified persons shall be made with metal-enclosed equipment or shall be enclosed in a vault or in an area access to which is controlled by a lock. Metal-enclosed switchgear, unit substations, transformers, pull boxes, connection boxes, and other similar associated equipment shall be marked with appropriate caution signs. Openings in ventilated dry-type transformers or similar openings in other equipment shall be designed so that foreign objects inserted through these openings will be deflected from energized parts.

(2) In Places Accessible to Qualified Persons Only. Indoor electrical installations considered accessible to qualified persons only in accordance with this Section shall comply with Sections 110-34, 710-32, and 710-33.

(b) Outdoor Installations.

(1) In Places Accessible to Unqualified Persons. Outdoor electrical

installations that are open to unqualified persons shall comply with Article 225.

For clearances of conductors over 600 volts, see National Electrical Safety Code (ANSI C2-1973).

(2) In Places Accessible to Qualified Persons Only. Outdoor electrical installations having exposed live parts shall be accessible to qualified persons only in accordance with the first paragraph of this Section and shall comply with Sections 110-34, 710-32, and 710-33.

(c) Metal-Enclosed Equipment Accessible to Unqualified Persons.

Ventilating or similar openings in equipment shall be so designed that foreign objects inserted through these openings will be deflected from energized parts. When exposed to physical damage from vehicular traffic suitable guards shall be provided. Metal-enclosed equipment located outdoors accessible to the general public shall be designed so that exposed nuts or bolts cannot be readily removed, permitting access to live parts. If installed so that the bottom of the enclosure is less than 8 feet above the floor, the door or cover shall be kept locked.

110-32. Workspace about Equipment.

Sufficient space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment. Where energized parts are exposed, the minimum clear workspace shall not be less than 6½ feet high (measured vertically from the floor or platform), or less than 3 feet wide (measured parallel to the equipment). The depth shall be as required in Section 110-34(a). In all cases, the workspace shall be adequate to permit at least a 90-degree opening of doors or hinged panels.

110-33. Entrance and Access to Workspace.

(a) At least one entrance not less than 24 inches wide and 6½ feet high shall be provided to give access to the working space about electric equipment. On switchboard and control panels exceeding 48 inches in width, there shall be one entrance at each end of such board where reasonably practicable. Where bare energized parts at any voltage or insulated energized parts above 600 volts are located adjacent to such entrance, they shall be suitably guarded.

(b) Permanent ladders or stairways shall be provided to give safe access to the working space around electric equipment installed on platforms, balconies, mezzanine floors, or in attic or roof rooms or spaces.

110-34. Work Space and Guarding.

(a) Working Space. The minimum clear working space in front of electric equipment, such as switchboards, control panels, switches, circuit breakers, motor controllers, relays, and similar equipment shall not be less than specified in Table 110-34(a) unless otherwise specified in this Code. Distances shall be measured from the live parts if such are exposed, or from the enclosure front or opening if such are enclosed.

Table 110-34(a).

Minimum Depth of Clear Working Space in Front of Electric Equipment

Nominal Voltage to Ground	Conditions		
	1	2	3
	(Feet)	(Feet)	(Feet)
601-2500	3	4	5
2501-9000	4	5	6
9001-25,000	5	6	9
25,001-75 kV	6	8	10
Above 75 kV	8	10	12

Where the "Conditions" are as follows:

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

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

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

Exception: Working space is not required in back of equipment such as dead-front switchboards or control assemblies where there are no renewable or adjustable parts (such as fuses or switches) on the back and where all connections are accessible from other locations than the back.

(b) Separation from Low-Potential Equipment. Where switches, cut-outs, or other equipment operating at 600 volts nominal, or less are installed in a room or enclosure where there are exposed live parts or exposed wiring operating at over 600 volts nominal, the high-potential equipment shall be effectively separated from the space occupied by the low-potential equipment by a suitable partition, fence, or screen.

Exception: Switches or other equipment operating at 600 volts or less, nominal, and serving only equipment within the high-voltage vault, room, or enclosure may be installed in the high-voltage enclosure, room, or vault if accessible to qualified persons only.

(c) Locked Rooms or Enclosures. The entrances to all buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at over 600 volts, nominal, shall be kept locked.

Exception: Where such entrances are under the observation of a qualified person at all times.

(d) Illumination. Adequate illumination shall be provided for all working spaces about electrical equipment. The lighting outlets shall be so arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment.

The points of control shall be so located that persons are not likely to come in contact with any live part or moving part of the equipment while turning on the lights.

(e) **Elevation of Unguarded Live Parts.** Unguarded live parts above working space shall be maintained at elevations not less than required by Table 110-34(e).

Table 110-34(e)

Elevation of Unguarded Energized Parts above Working Space

Nominal Voltage Between Phases	Elevation
601-7500	8' 6"
7501-35000	9'
Over 35kV	9' + 0.37" per kV above 35

Chapter 2. Wiring Design and Protection

ARTICLE 200 — USE AND IDENTIFICATION OF GROUNDED CONDUCTORS

200-1. Scope. This Article provides requirements for: (1) identification of terminals; (2) grounded conductors in premises wiring systems; and (3) identification of grounded conductors.

See Article 100 for definitions of "Grounded Conductor" and "Grounding Conductor."

200-2. General. All premises wiring systems shall have a grounded conductor that is identified in accordance with Section 200-6.

Exception: Circuits and systems exempted or prohibited by Sections 210-10, 215-7, 250-3, 250-5, 250-7, 503-13, and 517-63.

The grounded conductor, when insulated, shall have insulation which is suitable, other than color, for any ungrounded conductor of the same circuit.

200-3. Connection to Grounded System. Premises wiring shall not 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.

For the purpose of this Section, "electrically connected" shall mean connection capable of carrying current as distinguished from connection through electromagnetic induction.

200-6. Means of Identifying Grounded Conductors.

(a) Sizes No. 6 or Smaller. An insulated grounded conductor of No. 6 or smaller shall be identified by a continuous white or natural gray outer finish along its entire length.

Exception: The grounded conductor of a mineral-insulated metal-sheathed cable shall be identified at the time of installation by distinctive marking at its terminations.

(b) Sizes Larger Than No. 6. An insulated grounded conductor larger than No. 6 shall be identified either by a continuous white or natural gray outer finish along its entire length or at the time of installation by a distinctive white marking at its terminations.

(c) Flexible Cords. An insulated conductor intended for use as a grounded conductor, where contained within a flexible cord, shall be identified by a white or natural gray outer finish or by methods permitted by Section 400-22.

200-7. Use of White or Natural Gray Color. A continuous white or natural gray covering on a conductor or a termination marking of white or natural gray color shall be used only for the grounded conductor.

Exception No. 1: An insulated conductor with a white or natural gray finish shall be permitted as an ungrounded conductor where perma-

nently reidentified to indicate its use, by painting or other effective means at its termination and at each outlet where the conductor is visible and accessible.

Exception No. 2: A cable containing an insulated conductor with a white or natural gray outer finish shall be permitted for single-pole 3-way, or 4-way switch loops where the white or natural gray conductor is used for the supply to the switch, but not as a return conductor from the switch to the switched outlet. In these applications, reidentification of the white or natural gray conductor shall not be required.

Exception No. 3: A flexible cord for connecting a portable or stationary appliance having one conductor identified with a white or natural gray outer finish or by any other means permitted by Section 400-22, shall be permitted whether or not the outlet to which it is connected is supplied by a circuit having a grounded conductor.

Exception No. 4: A white or natural gray conductor of circuits of less than 50 volts shall be required to be grounded only as required by Section 250-5(a).

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

200-10. Identification of Terminals.

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

Exception No. 1: Where the electrical connection of a terminal intended to be connected to the grounded conductor is clearly evident.

Exception No. 2: Single-pole devices to which only one side of the line is connected.

Exception No. 3: The terminals of lighting and appliance branch-circuit panelboards.

Exception No. 4: Devices having a normal current rating of over 30 amperes other than polarized attachment plugs and polarized receptacles for attachment plugs as required in (b) below.

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

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

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

hexagonal, not readily removable terminal nut; or (3) A green-colored pressure wire connector. If the terminal for the grounding conductor is not visible, the conductor entrance hole shall be marked with the word "green" or otherwise identified by a distinctive green color.

Exception: Two-wire attachment plugs shall not be required to have their terminals marked for identification.

(c) **Screw-Shells.** For devices with screw-shells, the terminal for the grounded conductor shall be the one connected to the screw-shell.

(d) **Screw-Shell Devices with Leads.** For screw-shell devices with attached leads, the conductor attached to the screw-shell shall have a 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 used to identify the grounded conductor.

(e) **Fixed Appliances.** Marking of terminals for fixed appliances to indicate the proper connection to the grounded conductor shall not be required.

Exception: Where a single-pole switch forms an integral part, then the terminal connected to the switch shall be the terminal for the ungrounded conductor.

(f) **Portable and Stationary Appliances.** Identification marking of terminals for portable and stationary appliances shall not be required.

ARTICLE 210 — BRANCH CIRCUITS

A. General Provisions

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

210-2. Other Articles for Specific-Purpose Branch Circuits. Branch circuits shall comply with this Article and also with the applicable provisions of other Articles of this Code. The provisions for branch circuits supplying equipment in the following list amend or supplement the provisions in this Article and shall apply to branch circuits referred to therein:

Air Conditioning and Refrigerating Equipment	Sections 440-5, 440-31, 440-32
Busways	Section 364-8
Class 1, Class 2, and Class 3 Remote Control, Signaling, and Power Limited Circuits	Article 725
Cranes and Hoists	Section 610-42
Data Processing Systems	Section 645-2
Electrical Floor Assemblies	Article 366

Electric Signs and Outline Lighting	Section	600-6
Electric Welders	Article	630
Elevators, Dumbwaiters, Escalators, and Moving Walks	Section	620-61
Fire Protective Signaling Systems	Article	760
Fixed Electric Space Heating Equipment	Section	424-3
Fixed Outdoor Electric De-icing and Snow Melting Equipment	Section	426-3
Infrared Lamp Industrial Heating Equipment	Sections	422-15, 424-3
Induction and Dielectric Heating Equipment	Article	665
Marinas and Boatyards	Section	555-4
Mobile Homes and Mobile Home Parks	Article	550
Motion Picture Studios and Similar Locations	Article	530
Motors and Motor Controllers	Article	430
Organs	Section	650-6
Recreational Vehicles and Recreational Vehicle Parks	Article	551
Sound Recording and Similar Equipment	Section	640-6
Switchboards and Panelboards	Section	384-22
Systems over 600 Volts	Article	710
Systems under 50 Volts	Article	720
Theaters and Similar Locations	Sections	520-41, 520-52, and 520-62
X-ray Equipment	Section	660-2

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

210-4. Multiwire Branch Circuits. Branch circuits recognized by this Article shall be permitted as multiwire circuits. Multiwire branch circuits shall supply only line to neutral load.

Exception No. 1: A multiwire branch circuit supplying a single appliance.

Exception No. 2: Where all ungrounded conductors of the multiwire branch circuit are opened simultaneously by the branch circuit overcurrent device.

210-5. Color Code for Branch Circuits.

(a) **Grounded Conductor.** The grounded conductor of a branch circuit shall be identified by a continuous white or natural gray color. Where conductors of different systems are installed in the same raceway, box, auxiliary gutter, or other types of enclosures, one system neutral, if required, shall have an outer covering of white or natural gray. Each other system neutral, if required, shall have an outer covering of white with an identifiable colored stripe (not green) running along the insulation or other and different means of identification.

Exception: The grounded conductors of mineral-insulated metal-sheathed cable shall be identified by distinctive marking at the terminals during the process of installation.

(b) Grounding Conductor. The grounding conductor of a branch circuit shall be identified by a continuous green color or a continuous green color with one or more yellow stripes unless it is bare.

Exception No. 1: As permitted in Section 250-57(b).

Exception No. 2: The use of conductor insulation having a continuous green color or a continuous green color with one or more yellow stripes shall be permitted for internal wiring of equipment if such wiring does not serve as the lead wires for connection to branch-circuit conductors.

(c) Ungrounded Conductor. Ungrounded conductors of different voltages shall be of different color or identified by other means.

210-6. Maximum Voltage.

(a) Voltage to Ground. Branch circuits supplying lampholders, fixtures, or standard receptacles rated 15 amperes or less shall not exceed 150 volts to ground.

Exception No. 1: The voltage shall not exceed 300 volts to ground on branch circuits in industrial establishments where all the following conditions are met:

a. The conditions of maintenance and supervision assure that only competent individuals will service the lighting fixtures.

b. The branch circuits supply only lighting fixtures that are equipped with mogul-base screw-shell lampholders or with lampholders of other types approved for the purpose.

c. The fixtures are mounted not less than 8 feet above the floor.

d. The fixtures do not have switch control as an integral part of the fixture.

Exception No. 2: The voltage shall not exceed 300 volts to ground on branch circuits in industrial establishments, stores, health care facilities, office buildings, schools, or public and commercial areas of other buildings, such as hotels or transportation terminals, where all of the following conditions are met:

a. The branch circuits supply only the ballasts for electric-discharge lamps mounted in permanently installed fixtures.

b. The fixtures do not have manual switch control as an integral part of the fixture.

c. Electric-discharge lampholders of the screw-shell type are mounted not less than 8 feet above the floor.

Exception No. 3: For lampholders of infrared industrial heating appliances as provided in Section 422-15(c).

Exception No. 4: The railway properties as described in Section 110-19.

(b) Voltage between Conductors — Poles, Tunnels, and Similar Structures. The voltage shall not exceed 500 volts between conductors on

branch circuits supplying only the ballasts for electric-discharge lamps mounted in permanently installed fixtures as provided in Section 225-7(c) where the fixtures are mounted as follows:

(1) Not less than a height of 22 feet on poles or similar structures for the illumination of outdoor areas, such as highways, roads, bridges, athletic fields, or parking lots.

(2) Not less than a height of 18 feet on other structures, such as tunnels.

(c) **Voltage between Conductors — Dwellings.** The voltage shall not exceed 150 volts between conductors on branch circuits supplying screw-shell lampholders, receptacles, or appliances in dwelling occupancies.

Exception No. 1: Permanently connected appliances.

Exception No. 2: Portable and stationary appliances of more than 1380 watts.

Exception No. 3: Portable motor-operated appliances of ¼ horsepower or greater rating.

(d) **Voltage Between Conductors — Non dwelling Occupancies.** The voltage shall not exceed 150 volts between conductors on branch circuits supplying one or more medium-base, screw-shell lampholders in non dwelling occupancies.

See Exception No. 1 to (a) above for 300-volt limitation for mogul-base screw-shell lampholders under specific conditions in industrial establishments.

210-7. Receptacles and Cord Connectors.

(a) **Grounding Type.** Receptacles installed on 15- and 20-ampere branch circuits shall be of the grounding type. Grounding-type receptacles shall be installed only on circuits of the voltage class and current for which they are rated, except as provided in Tables 210-21(b)(2) and (b)(3).

Exception: Grounding-type receptacles of the type that reject non-grounding-type attachment plugs or which are of the locking type shall be permitted for specific purposes or in special locations. Receptacles required in Sections 517-61(d) and 517-62(e) shall be considered as meeting the requirements of this Section.

(b) **To Be Grounded.** Receptacles and cord connectors having grounding contacts shall have those contacts effectively grounded.

(c) **Methods of Grounding.** The grounding contacts of receptacles and cord connectors shall be grounded by connection to the equipment grounding conductor of the circuit supplying the receptacle or cord connector.

The branch circuit or branch-circuit raceway shall include or provide a grounding conductor to which the grounding contacts of the receptacle or cord connector shall be connected.

Section 250-91(b) describes acceptable grounding means.

Exception: Only for extensions of existing branch circuits that do not have an equipment grounding conductor, the grounding contact of a

grounding-type receptacle shall be permitted to be grounded to a grounded cold water pipe near the equipment.

(d) Replacements. Grounding-type receptacles shall be used as replacements for existing nongrounding types and shall be connected to a grounding conductor installed in accordance with (c) above.

Exception: If it is impractical to reach a source of ground, a non-grounding-type receptacle shall be used.

(e) Portable Equipment. The installation of grounding-type receptacles shall not be used as a requirement that all portable equipment be of the grounded type.

See Section 250-45 for type of portable equipment to be grounded.

(f) Noninterchangeable Types. 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 the attachment plugs used on these circuits are not interchangeable.

210-8. Ground-Fault Circuit Protection.

(a) Residential Occupancies. For residential occupancies all 120-volt, single-phase, 15- and 20-ampere receptacle outlets installed outdoors and in bathrooms shall have ground-fault circuit protection for personnel.

Such ground-fault circuit protection may be provided for other circuits, locations, and occupancies, and where used, will provide additional protection against line-to-ground shock hazard.

See Section 215-9 for feeder protection.

(b) Construction Sites. All 120-volt single phase 15 and 20 ampere receptacle outlets which are not a part of the permanent wiring of the building or structure, shall have ground fault circuit interrupters for personnel protection.

Exception: Receptacles on a portable generator rated not more than 5 kW, where the circuit conductors of the generator are insulated from earth and the generator frame is insulated from earth and all grounded surfaces.

210-9. Circuits Derived from Autotransformers. Branch circuits shall not be supplied by autotransformers.

Exception No. 1: Where the system supplied has a grounded conductor that is electrically connected to a grounded conductor of the system supplying the autotransformer.

Exception No. 2: An autotransformer used to extend or add an individual branch circuit in an existing installation for an equipment load without the connection to a similar identified grounded conductor when transforming from a nominal 208 volts to a nominal 240-volt supply or similarly from 240 volts to 208 volts.

An autotransformer is a transformer in which a part of the winding is common to both primary and secondary circuits.

210-10. Ungrounded Conductors Tapped from Grounded Systems. Two-wire dc circuits and ac circuits of two or more ungrounded conductors shall be permitted to be tapped from the ungrounded conductors of circuits having a grounded neutral conductor. Switching devices in each tapped circuit shall have a pole in each ungrounded conductor. All poles of multipole switching devices shall manually switch together where such switching devices also serve as a disconnecting means as required by Sections 422-21(b) and 422-23(b) for an appliance; 424-20 for a fixed electric space heating unit; 426-21 for electric de-icing and snow melting equipment; 430-85 for a motor controller; and 430-103 for a motor.

B. Specific Requirements

210-19. Conductors — Minimum Ampacity and Size.

(a) **General.** Branch-circuit conductors shall have an ampacity of not less than the rating of the branch circuit and not less than the maximum load to be served. Cable assemblies with the neutral conductor smaller than the ungrounded conductors shall be so marked.

See Tables 310-16 through 310-19 for ampacity ratings of conductors.

See Part B of Article 430 for minimum rating of motor branch-circuit conductors.

Conductors for branch circuits as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency of operation. See Section 215-2(c) for voltage drop on feeder conductors.

(b) **Household Ranges and Cooking Appliances.** Branch-circuit conductors supplying household ranges, wall-mounted ovens, counter-mounted cooking units, and other household cooking appliances shall have an ampacity not less than the rating of the branch circuit and not less than the maximum load to be served. The minimum size shall not be smaller than No. 8 for ranges of $8\frac{3}{4}$ kW or more rating.

Exception No. 1: The neutral conductor of a 3-wire branch circuit supplying a household electric range, a wall-mounted oven, or a counter-mounted cooking unit shall be permitted to be smaller than the ungrounded conductors where the maximum demand of a range of $8\frac{3}{4}$ kW or more rating has been computed according to Column A of Table 220-19, but shall have an ampacity of not less than 70 percent of the ampacity of the ungrounded conductors and shall not be smaller than No. 10.

Exception No. 2: Tap conductors supplying electric ranges, wall-mounted electric ovens, and counter-mounted electric cooking units from a 50-ampere branch circuit shall have an ampacity of not less than 20 and shall be sufficient for the load to be served. The taps shall be no longer than necessary for servicing the appliance.

(c) **Other Loads.** Branch-circuit conductors supplying loads other than cooking appliances as covered in (b) above and as listed in Sec-

tion 210-2 shall have an ampacity sufficient for the loads served and shall not be smaller than No. 14.

Exception No. 1: Tap conductors for such loads shall have an ampacity not less than 15 for circuits rated less than 40 amperes and not less than 20 for circuits rated at 40 or 50 amperes and only where these tap conductors supply any of the following loads:

a. Individual lampholders or fixtures with taps extending not longer than 18 inches beyond any portion of the lampholder or fixture.

b. A fixture having branch-circuit terminal connections operating at a temperature in excess of 60°C having tap conductors not longer than 6 feet as provided in Section 410-67(b)(2).

c. Individual outlets with taps not over 18 inches long.

d. Infrared lamp industrial heating appliances.

e. Nonheating leads of de-icing and snow melting cables and mats.

Exception No. 2: Fixture wires and cords as permitted in Section 240-4.

210-20. Overcurrent Protection.

(a) General. Branch-circuit conductors and equipment shall be protected by overcurrent protective devices having a rating or setting (1) not exceeding that specified in Section 240-3 for conductors; (2) not exceeding that specified in the applicable Articles referenced in Section 240-2 for equipment; and (3) as provided for outlet devices in Section 210-21.

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

See Section 240-1 for the purpose of overcurrent protection and Sections 210-22 and 220-2 for continuous loads.

210-21. Outlet Devices. Outlet devices shall have an ampere rating not less than the load to be served and shall comply with (a) and (b) below.

(a) Lampholders. Where connected to a branch circuit having a rating in excess of 20 amperes, lampholders shall be of the heavy-duty type. A heavy-duty lampholder shall have a rating of not less than 660 watts if of the admedium type and not less than 750 watts if of any other type.

(b) Receptacles.

(1) A single receptacle installed on an individual branch circuit shall have an ampere rating of not less than that of the branch circuit.

See definition of Receptacle in Article 100.

(2) Where connected to a branch circuit supplying two or more receptacles or outlets, a receptacle shall not supply a total portable and/or stationary appliance load in excess of the maximum specified in Table 210-21(b)(2).

(3) Where connected to a branch circuit supplying two or more receptacles or outlets, receptacle ratings shall conform to the values listed in Table 210-21(b)(3).

Table 210-21(b)(2)**Maximum Portable and/or Stationary Appliance Load to Receptacle**

Circuit Rating Amperes	Receptacle Rating Amperes	Maximum Load Amperes
15 or 20	15	12
20	20	16
30	30	24

Table 210-21(b)(3)**Receptacle Ratings for Various Size Circuits**

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

(4) It shall be acceptable to base the ampere rating of a range receptacle on a single range demand load specified in Table 220-19.

210-22. Maximum Loads. The total load shall not exceed the rating of the branch circuit, and it shall not exceed the maximum loads specified in (a) through (c) below under the conditions specified therein.

(a) **Motor-Operated and Combination Loads.** Where a circuit supplies only motor-operated loads, Article 430 shall apply. Where a circuit supplies only air conditioning and/or refrigerating equipment, Article 440 shall apply. For circuits supplying loads consisting of motor-operated appliances of other than the portable or stationary type having a motor larger than $\frac{1}{8}$ hp in combination with other loads, the total computed load shall be based on 125 percent of the largest motor load plus the sum of the other loads.

(b) **Inductive Lighting Loads.** For circuits supplying lighting units having ballasts, transformers, or autotransformers, the computed load shall be based on the total ampere ratings of such units and not on the total watts of the lamps.

(c) **Other Loads.** Continuous loads, such as store lighting and similar loads, shall not exceed 80 percent of the rating of the branch circuit.

Exception No. 1: Motor loads having demand factors computed in accordance with Article 430.

Exception No. 2: Circuits that have been derated in accordance with Note 8 to Tables 310-16 through 310-19.

Exception No. 3: Circuits supplied by an assembly together with its overcurrent devices that is listed for continuous operation at 100 percent of its rating.

It shall be acceptable to apply demand factors for range loads in accordance with Table 220-19, including Note 4.

210-23. Permissible Loads. In no case shall the load exceed the branch-circuit ampere rating. It shall be acceptable for an individual branch circuit to supply any load for which it is rated. A branch circuit supplying two or more outlets shall supply only the loads specified according to its size in (a) through (d) below and summarized in Section 210-24 and Table 210-24.

(a) 15- and 20-Ampere Branch Circuits. A 15- or 20-ampere branch circuit shall be permitted to supply lighting units, appliances, or a combination of both. The rating of any one portable or stationary appliance shall not exceed 80 percent of the branch-circuit ampere rating. The total rating of fixed appliances shall not exceed 50 percent of the branch-circuit ampere rating where lighting units, portable or stationary appliances, or both are also supplied.

Exception: The small appliance branch circuits required in dwellings by Section 220-3(b) shall supply only the receptacle outlets specified in that Section.

(b) 25- and 30-Ampere Branch Circuits. A 25- or 30-ampere branch circuit shall be permitted to supply fixed lighting units with heavy-duty lampholders in other than dwelling occupancies or appliances in any occupancy. The rating of any one portable or stationary appliance shall not exceed 80 percent of the branch circuit ampere rating.

(c) 40- and 50-Ampere Branch Circuits. A 40- or 50-ampere branch circuit shall be permitted to supply fixed lighting units with heavy-duty lampholders or infrared heating units in other than dwelling occupancies, or fixed cooking appliances in any occupancy.

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

210-24. Branch-Circuit Requirements — Summary. The requirements for circuits having two or more outlets, other than the receptacle circuits of Section 220-3(b) as specifically provided for above, are summarized in Table 210-24.

210-25. Receptacle Outlets Required. Receptacle outlets shall be installed where specified in (a) through (c) below.

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

(a) General. Where flexible cords are used.

Exception: Where flexible cords are specifically permitted to be permanently connected, and are so connected in boxes or fittings approved for the purpose, it shall be acceptable to omit receptacles on such equipment.

See Article 400 for use and installation of flexible cords.

Table 210-24
Summary of Branch-Circuit Requirements

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

CIRCUIT RATING	15 Amp	20 Amp	30 Amp	40 Amp	50 Amp
CONDUCTORS:					
(Min. Size)					
Circuit Wires*	14	12	10	8	6
Taps	14	14	14	12	12
Fixture Wires and Cords	Refer to Section 240-4				
OVERCURRENT PROTECTION	15 Amp	20 Amp	30 Amp	40 Amp	50 Amp
OUTLET DEVICES:					
Lampholders Permitted	Any Type	Any Type	Heavy Duty	Heavy Duty	Heavy Duty
Receptacle Rating**	15 Max. Amp	15 or 20 Amp	30 Amp	40 or 50 Amp	50 Amp
MAXIMUM LOAD	15 Amp	20 Amp	30 Amp	40 Amp	50 Amp
PERMISSIBLE LOAD	Refer to Section 210-23(a)	Refer to Section 210-23(a)	Refer to Section 210-23(b)	Refer to Section 210-23(c)	Refer to Section 210-23(c)

* These ampacities are for copper conductors where derating is not required. See Tables 310-16 through 310-19.

** For receptacle rating of cord-connected electric-discharge lighting fixtures see Section 410-14.

(b) Dwelling-Type Occupancies. In every kitchen, family room, dining room, breakfast room, living room, parlor, library, den, sun room, bedroom, recreation room, or similar rooms, receptacle outlets shall be installed so that no point along the floor line in any wall space is more than 6 feet, measured horizontally, from an outlet in that space, including any wall space 2 feet or more in width and the wall space occupied by sliding panels in exterior walls. The wall space afforded by fixed room dividers, such as free-standing bar-type counters, shall be included in the 6-foot measurement.

In kitchen and dining areas a receptacle outlet shall be installed at each counter space wider than 12 inches. Counter top spaces separated by range tops, refrigerators, or sinks shall be considered as separate counter top spaces. Receptacles rendered inaccessible by the installation of stationary appliances shall not be considered as these required outlets.

Receptacle outlets shall, insofar as practicable, be spaced equal distances apart. Receptacle outlets in floors shall not be counted as part of the required number of receptacle outlets unless located close to the wall.

At least one wall receptacle outlet shall be installed in the bathroom adjacent to the basin location.

For a one-family dwelling, at least one receptacle outlet shall be installed outdoors.

At least one receptacle outlet shall be installed in each basement and attached garage.

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

At least one receptacle outlet shall be installed for the laundry.

Exception No. 1: In a dwelling unit that is an apartment or living area in a multifamily building where laundry facilities are provided on the premises that are available to all building occupants, a laundry receptacle shall not be required.

Exception No. 2: In other than single-family dwellings where laundry facilities are not to be installed or permitted, a laundry receptacle shall not be required.

Exception No. 3: A dwelling that is a unit in a hotel, motel, motor court, or motor hotel, a laundry receptacle shall not be required.

As used in this Section a "wall space" shall be considered a wall unbroken along the floor line by doorways, fireplaces, and similar openings. Each wall space two or more feet wide shall be treated individually and separately from other wall spaces within the room. A wall space shall be permitted to include two or more walls of a room (around corners) where unbroken at the floor line.

The purpose of this requirement is to minimize the use of cords across doorways, fireplaces, and similar openings.

The receptacle outlets required by this Section shall be in addition to any receptacle that is part of any lighting fixture or appliance, located within cabinets or cupboards, or located over 5½ feet above the floor.

(c) Guest Rooms. Guest rooms in hotels, motels, and similar occupancies shall have receptacle outlets installed in accordance with (b) above.

Exception: In rooms of hotels and motels, receptacle outlets may be located convenient for the permanent furniture layout.

(d) Show Windows. At least one receptacle outlet shall be installed directly above a show window for each 12 linear feet or major fraction thereof of show window area measured horizontally at its maximum width.

210-26. Lighting Outlets Required. Lighting outlets shall be installed where specified in (a) and (b) below:

(a) Dwelling-Type Occupancies. At least one wall switch controlled lighting outlet shall be installed in every habitable room; in hallways, stairways, and attached garages; and at outdoor entrances.

At least one lighting outlet shall be installed in an attic, underfloor space, utility room and basement where used for storage or containing equipment requiring servicing.

Exception No. 1: In habitable rooms, other than kitchens or bathrooms, one or more receptacles controlled by a wall switch shall be permitted in lieu of lighting outlets.

Exception No. 2: In hallways, stairways, and at outdoor entrances remote, central, or automatic control of lighting shall be permitted.

(b) **Guest Rooms.** At least one wall switch controlled lighting outlet or wall switch controlled receptacle shall be installed in guest rooms in hotels, motels, or similar occupancies.

ARTICLE 215 — FEEDERS

215-1. Scope. This Article covers the installation requirements and minimum size and ampacity of conductors for feeders supplying branch-circuit loads as computed in accordance with Article 220. The requirements of Section 215-8 shall apply to feeders and other applications where identification is equally necessary.

215-2. Minimum Rating and Size. Feeder conductors shall have an ampacity not lower than required to supply the load as computed in Parts B, C, and D of Article 220. The minimum sizes shall be as specified in (a) and (b) below under the conditions stipulated.

(a) **For Specified Circuits.** The feeder conductors shall not be smaller than No. 10 where the load supplied consists of the following number and types of circuits: (1) Two or more 2-wire branch circuits supplied by a 2-wire feeder; (2) More than two 2-wire branch circuits supplied by a 3-wire feeder; (3) Two or more 3-wire branch circuits supplied by a 3-wire feeder.

(b) **Ampacity Relative to Service-Entrance Conductors.** The feeder conductor ampacity shall not be lower than that of the service-entrance conductors where the feeder conductors carry the total load supplied by service-entrance conductors No. 6 or smaller.

(c) **Overloaded Feeders.** Where at any time feeder conductors are or will be overloaded the feeder conductors shall be increased in ampacity to accommodate the actual load served.

See Examples 1 through 8 in Chapter 9.

Conductors for feeders as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency of operation.

See Section 210-19(a) for voltage drop for branch circuits.

215-3. Overcurrent Protection. Feeders shall be protected against overcurrent in accordance with the provisions of Part A of Article 240.

215-4. Feeders with Common Neutral.

(a) **Feeders with Common Neutral.** Feeders containing a common neutral shall be permitted to supply two or three sets of 3-wire feeders, or two sets of 4-wire or 5-wire feeders.

(b) **In Metal Raceway or Enclosure.** Where installed in a metal raceway or other metal enclosure, all conductors of all feeders using a common neutral shall be enclosed within the same raceway or other enclosure as required in Section 300-20.

215-5. Diagrams of Feeders. If required by the authority having jurisdiction, a diagram showing feeder details shall be provided prior to the installation of the feeders. Such a diagram shall show the area in square feet of the building or other structure supplied by each feeder, the total connected load before applying demand factors, the demand factors used, the computed load after applying demand factors and the size and type of conductors to be used.

215-6. Feeder Conductor Grounding Means. Where a feeder supplies branch circuits in which grounding conductors are required, the feeder shall include or provide a grounding means to which the grounding conductors of the branch circuits shall be connected.

215-7. Ungrounded Conductors Tapped from Grounded Systems. Two-wire dc circuits and ac circuits of two or more ungrounded conductors may be tapped from the ungrounded conductors of circuits having a grounded neutral conductor. Switching devices in each tapped circuit shall have a pole in each ungrounded conductor.

215-8. Means of Identifying Conductor with the Higher Voltage to Ground. On a 4-wire, delta-connected secondary where the midpoint of one phase is grounded to supply lighting and similar loads, the phase conductor having the higher voltage to ground shall be identified by an outer finish that is orange in color or by tagging or other effective means. Such identification shall be placed at any point where a connection is made if the neutral conductor is also present.

215-9. Ground-Fault Personnel Protection. Feeders supplying 15- and 20-ampere receptacle branch circuits may be protected by a ground-fault circuit-interrupter approved for the purpose in lieu of the provisions for such interrupters as specified in Section 210-8.

ARTICLE 220 — BRANCH-CIRCUIT AND FEEDER CALCULATIONS

A. General

220-1. Scope. This Article provides requirements for determining the number of branch circuits required and for computing branch-circuit and feeder loads.

220-2. Computation of Branch Circuits. Branch-circuit loads shall be computed as shown in (a) through (d) below.

(a) Continuous Loads. The continuous load supplied by a branch circuit shall not exceed 80 percent of the branch-circuit rating.

Exception No. 1: Where branch-circuit conductors have been derated in accordance with Note 8 to Tables 310-16 through 310-19:

Exception No. 2: Where the assembly, including overcurrent devices, is listed for continuous operation of 100 percent of its rating.

(b) Lighting Load for Listed Occupancies. A unit load of not less than that specified in Table 220-2(b) for occupancies listed therein shall constitute the minimum lighting load for each square foot of floor area. The floor area for each floor shall be computed from the outside dimensions of the building, apartment, or other area involved. For dwelling occupancies, the computed floor area shall not include open porches, garages, or unused or unfinished spaces not adaptable for future use.

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

(c) Other Loads — Occupancies Not Listed. For lighting and appliance loads not covered in (b) above and not used for general illumination or for general-use receptacles in the occupancies listed in Table 220-2(b), a unit load of not less than the following shall constitute the minimum load for each outlet, the loads shown being based on nominal branch-circuit voltages.

- (1) Outlet for a specific appliance or other load except for a motor load Ampere rating of appliance or load served
- (2) Outlet for motor load See Sections 430-22 and 430-24 and Article 440.
- (3) Outlet for heavy-duty lampholder 600 volt-amperes
- (4) *Other outlets 180 volt-amperes per outlet.

For receptacle outlets, each single or multiple receptacle shall be considered at not less than 180 volt-amperes.

* This provision shall not be applicable to receptacle outlets connected to the circuit specified in Section 220-3(b) nor to receptacle outlets provided for the connection of stationary equipment as provided for in Section 400-7.

Exception No. 1: Where fixed multioutlet assemblies are employed, each 5 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 shall not apply to dwellings or the guest rooms of hotels or motels.

Exception No. 2: Table 220-19 shall be considered as an acceptable method of computing the load for a household electric range.

Exception No. 3: A load of not less than 200 watts per linear foot of show window, measured horizontally along its base, shall be permitted instead of the specified unit load per outlet.

Exception No. 4: The loads of outlets serving switchboards and switching frames in telephone exchanges shall be waived from the computations.

(d) Loads for Additions to Existing Installations.

(1) Dwelling Occupancies. Loads for structural additions to an existing dwelling occupancy or to a previously unwired portion of an

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

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

* All receptacle outlets of 20-ampere or less rating in single-family and multifamily dwellings and in guest rooms of hotels and motels [except those connected to the receptacle circuits specified in Section 220-3(b)] shall be considered as outlets for general illumination, and no additional load calculations shall be required for such outlets.

existing dwelling occupancy, either of which exceeds 500 square feet, shall be computed in accordance with (b) above. Loads for new circuits or extended circuits in previously wired dwelling occupancies shall be computed in accordance with either (b) or (c) above.

(2) Other Than Dwelling Occupancies. Loads for new circuits or extended circuits in other than dwelling occupancies shall be computed in accordance with either (b) or (c) above.

220-3. Branch Circuits Required. Branch circuits for lighting and for appliances, including motor-operated appliances, shall be provided to supply the loads computed in accordance with Section 220-2. In addition, branch circuits shall be provided for specific loads not covered by Section 220-2 where required elsewhere in this Code; for small appliance loads as specified in (b) below; and for laundry loads as specified in (c) below.

(a) Number of Branch Circuits. The minimum number of branch circuits shall be determined from the total computed load and the size or rating of the circuits used. In all installations the number of circuits shall be sufficient to supply the load served. In no case shall the load on any circuit exceed the maximum specified by Section 210-22.

(b) Small Appliance Branch Circuits — Dwelling Occupancies.

(1) In addition to the number of branch circuits determined in accordance with (a) above, two or more 20-ampere small appliance branch circuits shall be provided for all receptacle outlets specified by Section 210-25(b) for the small appliance loads, including refrigeration equipment, in the kitchen, pantry, breakfast room, dining room, and family room of dwelling occupancies. Such circuits, whether two or more are used, shall have no other outlets.

Exception: A receptacle installed solely for the electric supply to and support of an electric clock in any of these stipulated rooms or outdoor receptacle outlets shall be supplied either by a small appliance branch circuit or by a general purpose branch circuit.

(2) Receptacle outlets installed in the kitchen shall be supplied by not less than two small appliance branch circuits, either or both of which shall also be permitted to supply receptacle outlets in the other rooms specified in (1) above. Additional small appliance branch circuits shall be permitted to supply receptacle outlets in such other rooms.

(c) Laundry Branch Circuits — Dwelling Occupancies. In addition to the number of branch circuits determined in accordance with (a) and (b) above, at least one additional 20-ampere branch circuit shall be provided to supply the laundry receptacle(s) required by Section 210-25(b).

(d) Load Evenly Proportioned Among Branch Circuits. Where the load is computed on a watts-per-square-foot basis, the load, insofar as practical, shall be evenly proportioned among the branch circuits according to their capacities.

See Examples 1, 1(a), 1(b), 1(c), and 4, Chapter 9.

B. Feeders

220-10. General.

(a) Ampacity and Computed Loads. Feeder conductors shall have sufficient ampacity to supply the load served. In no case shall the computed load of a feeder be less than the sum of the loads on the branch circuits supplied as determined by Part A of this Article after any applicable demand factors permitted by Parts B, C, or D have been applied.

See Examples 1 through 8, Chapter 9. See Section 210-22(b) for maximum load in amperes permitted for lighting units operating at less than 100 percent power factor.

(b) Continuous and Noncontinuous Loads. Where a feeder supplies continuous loads or any combination of continuous and noncontinuous load, neither the ampere rating of the overcurrent device nor the ampacity of the feeder conductors shall be less than the noncontinuous load plus 125 percent of the continuous load.

Exception: Where the assembly including the overcurrent devices protecting the feeder(s) are listed for operation at 100 percent of their rating, neither the ampere rating of the overcurrent device nor the ampacity of the feeder conductors shall be less than the sum of the continuous load plus the noncontinuous load.

220-11. General Lighting. The demand factors listed in Table 220-11 shall apply to that portion of the total branch-circuit load computed for general illumination. They shall not be applied in determining the number of branch circuits for general illumination.

See Sections 220-16 for application of demand factors to small appliance and laundry loads in dwellings.

Table 220-11. Lighting Load Feeder Demand Factors

Type of Occupancy	Portion of Lighting Load to Which Demand Factor Applies (wattage)	Demand Factor Percent
Dwelling — Other Than Hotels	First 3000 or less at	100
	Next 3001 to 120,000 at	35
	Remainder over 120,000 at	25
*Hospitals	First 50,000 or less at	40
	Remainder over 50,000 at	20
*Hotels and Motels — Including Apartment Houses without Provision for Cooking by Tenants	First 20,000 or less at	50
	Next 20,001 to 100,000 at	40
	Remainder over 100,000 at	30
Warehouses (Storage)	First 12,500 or less at	100
	Remainder over 12,500 at	50
All Others	Total Wattage	100

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

220-12. Show-Window Lighting. For show-window lighting, a load of not less than 200 watts shall be included for each linear foot of show window, measured horizontally along its base.

See Section 220-2(c), Exception No. 3 for branch circuits supplying show windows.

220-13. Receptacle Loads — Nondwelling Occupancies. In other than dwelling occupancies, the use of the demand factors for lighting loads in Table 220-11 shall be permitted for receptacle loads computed at not more than 180 volt-amperes per outlet in accordance with Section 220-2 (c) (4).

220-14. Motors. Motor loads shall be computed in accordance with Sections 430-24, 430-25, and 430-26.

220-15. Fixed Electric Space Heating. Fixed electric space heating loads shall be computed at 100 percent of the total connected load.

Exception No. 1: Where reduced loading of the conductors results from units operating on duty-cycle, intermittently, or from all units not operating at one time, the authority having jurisdiction may grant permission for feeder conductors to have an ampacity less than 100 percent, provided the conductors have an ampacity for the load so determined.

Exception No. 2: The use of the optional calculations in Sections 220-30 and 220-31 shall be permitted for fixed electric space heating loads in a single-family dwelling or an individual apartment of a multifamily dwelling. In a multifamily dwelling the use of the optional calculation in Section 220-32 shall be permitted.

220-16. Small Appliance and Laundry Loads — Dwellings.

(a) Small Appliance Circuit Load. In each single-family dwelling, each apartment of multifamily dwellings having cooking facilities, and each hotel or motel suite having cooking facilities or a serving pantry, the feeder load shall be computed at 1500 watts for each 2-wire small appliance branch circuit required by Section 220-3(b) for portable appliances supplied by 15- or 20-ampere receptacles on 20-ampere branch circuits in the kitchen, pantry, dining room, breakfast room, and family room. Where the load is subdivided through two or more feeders, the computed load for each shall include not less than 1500 watts for each 2-wire branch circuit for small appliances. These loads shall be permitted for the general lighting load and subjected to the demand factors permitted in Table 220-11 for the general lighting load.

(b) Laundry Circuit Load. A feeder load of not less than 1500 watts shall be included for each 2-wire laundry branch circuit installed as required by Section 220-3(c). It shall be permissible to include this load with the general lighting load and subjected to the demand factors provided in Section 220-11.

220-17. Fixed Appliance Load — Dwelling. It shall be permissible to apply a demand factor of 75 percent to the nameplate-rating load of four or more fixed appliances served by the same feeder in a single-family or multifamily dwelling.

Exception: This demand factor shall not be applied to electric ranges, clothes dryers, space heating equipment, or air conditioning equipment.

220-18. Electric Clothes Dryers — Dwellings. The load for household electric clothes dryers in dwellings shall be 5000 watts or the nameplate rating, whichever is larger, for each dryer served. The use of the demand factors in Table 220-18 shall be permitted.

Table 220-18
Demand Factors for Household Electric Clothes Dryers

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

220-19. Electric Ranges and Other Cooking Appliances — Dwellings.

The feeder demand load for household electric ranges, wall-mounted ovens, counter-mounted cooking units, and other household cooking appliances individually rated in excess of 1¾ kW shall be permitted to be computed in accordance with Table 220-19. Where two or more single-phase ranges are supplied by a 3-phase 4-wire feeder, the total load shall be computed on the basis of twice the maximum number connected between any two phases.

See Example 7, Chapter 9.

220-20. Kitchen Equipment — Other Than Dwelling. It shall be permissible to compute the load for commercial electric cooking equipment, dishwasher booster heaters, water heaters, and other kitchen equipment in accordance with Table 220-20.

220-21. Noncoincident Loads. Where it is unlikely that two dissimilar loads will be in use simultaneously, it shall be permissible to omit the smaller of the two in computing the total load of a feeder.

220-22. Feeder Neutral Load. The feeder neutral load shall be the maximum unbalance of the load determined by this Article. 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 percent for 5-wire, 2-phase systems. For a feeder supplying household electric ranges, wall-mounted ovens, and counter-mounted cooking units, the maximum unbalanced load shall be considered as 70 percent of the load on the ungrounded conductors, as determined in accordance with Table 220-19. For 3-wire dc or single-phase ac, 4-wire, 3-phase, and 5-wire, 2-phase systems, a further demand factor of 70 percent shall be permitted for that portion of the unbalanced load in excess of 200 amperes. There shall be no re-

duction of the neutral capacity for that portion of the load which consists of electric-discharge lighting.

See Examples 1, 1a, 1b, 1c, 2, 3, 4, and 5, Chapter 9.

Table 220-19. Demand Loads for Household Electric Ranges, Wall-Mounted Ovens, Counter-Mounted Cooking Units, and Other Household Cooking Appliances over 1¼ kW Rating. Column A to be used in all cases except as otherwise permitted in Note 3 below.

NUMBER OF APPLIANCES	Maximum Demand (See Notes)	Demand Factors Percent (See Note 3)	
	COLUMN A (Not over 12 kW Rating)	COLUMN B (Less than 3½ kW Rating)	COLUMN C (3½ kW to 8¾ kW Rating)
1	8 kW	80%	80%
2	11 kW	75%	65%
3	14 kW	70%	55%
4	17 kW	66%	50%
5	20 kW	62%	45%
6	21 kW	59%	43%
7	22 kW	56%	40%
8	23 kW	53%	36%
9	24 kW	51%	35%
10	25 kW	49%	34%
11	26 kW	47%	32%
12	27 kW	45%	32%
13	28 kW	43%	32%
14	29 kW	41%	32%
15	30 kW	40%	32%
16	31 kW	39%	28%
17	32 kW	38%	28%
18	33 kW	37%	28%
19	34 kW	36%	28%
20	35 kW	35%	28%
21	36 kW	34%	26%
22	37 kW	33%	26%
23	38 kW	32%	26%
24	39 kW	31%	26%
25	40 kW	30%	26%
26-30	{ 15 kW plus 1 kW }	30%	24%
31-40	{ for each range }	30%	22%
41-50	{ 25 kW plus ¾ }	30%	20%
51-60	{ kW for each }	30%	18%
61 & over	{ range }	30%	16%

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

Note 2. Over 12 kW through 27 kW ranges of unequal ratings. For ranges individually rated more than 12 kW and of different ratings but none exceeding 27 kW an average value of rating shall be computed by adding together the ratings of all ranges to obtain the total connected

load (using 12 kW for any range rated less than 12 kW) and dividing by the total number of ranges; and then the maximum demand in Column A shall be increased 5 percent for each kW or major fraction thereof by which this average value exceeds 12 kW.

Note 3. Over 1¾ kW through 8¾ kW. In lieu of the method provided in Column A, it shall be permissible to add the nameplate ratings of all ranges rated more than 1¾ kW but not more than 8¾ kW and multiply the sum by the demand factors specified in Column B or C for the given number of appliances.

Note 4. Branch-Circuit Load. It shall be permissible to compute the branch-circuit load for one range in accordance with Table 220-19. The branch-circuit load for one wall-mounted oven or one counter-mounted cooking unit shall be the nameplate rating of the appliance. The branch-circuit load for a counter-mounted cooking unit and not more than two wall-mounted ovens, all supplied from a single branch circuit and located in the same room, shall be computed by adding the nameplate rating of the individual appliances and treating this total as equivalent to one range.

Note 5. This table also applies to household cooking appliances rated over 1¾ kW and used in instructional programs.

See Table 220-20 for commercial cooking equipment.

Table 220-20

**Feeder Demand Factors for Commercial Electric Cooking Equipment;
Including Dishwasher Booster Heaters, Water Heaters,
and Other Kitchen Equipment**

Number of Units of Equipment	Demand Factors Percent
1	100
2	100
3	90
4	80
5	70
6 & over	65

C. Optional Calculations for Computing Feeder and Service Loads

220-30. Optional Calculation — Single-Family Dwelling or Individual Apartment in Multifamily Dwellings. For a single-family dwelling or an individual apartment in a multifamily dwelling having the total connected load served by a single 3-wire 115/230-volt or 120/208 volt set of service-entrance or feeder conductors with an ampacity of 100 or greater, it shall be permissible to compute the feeder and service loads in accordance with Table 220-30 instead of the method specified in Part B of this Article. Feeder and service-entrance conductors whose demand load is determined by this optional calculation shall be permitted to have the neutral load determined by Section 220-22. The loads identified in Table 220-30 as "other load" and as "Remainder of other load" shall include the following:

(1) 1500 watts for each 2-wire, 20-ampere small appliance branch circuit and each laundry branch circuit specified in Section 220-16.

(2) 3 watts per square foot for general lighting and general-use receptacles.

(3) The nameplate rating of all fixed appliances, ranges, wall-mounted ovens, counter-mounted cooking units, and including four or more separately controlled space heating units.

(4) The nameplate ampere or kVA rating of all motors and of all low-power-factor loads.

(5) When applying Section 220-21 use the largest of the following: (1) Air-conditioning load; (2) The 65 percent diversified demand of the central electric space heating load; (3) The 65 percent diversified demand of the load of less than four separately-controlled electric space heating units; (4) The connected load of four or more separately-controlled electric space heating units.

Table 220-30

Optional Calculation for Single-Family Dwelling or Individual Apartment of Multifamily Dwelling

Load (in kW or kVA)	Demand Factor Percent
Air conditioning and cooling, including heat pump compressors	100
Central electric space heating	65
Less than four separately controlled electric space heating units	65
First 10 kW of all other load	100
Remainder of other load	40

220-31. Optional Calculation for Additional Loads in Existing Single-Family Dwelling Occupancy. For an existing single-family dwelling occupancy presently being served by an existing 115/230 volt or 120/208, 3-wire, 60-ampere service, it shall be permissible to compute load calculations as follows:

Load (in kW or kVA)	Percent of Load
First 8 kW of load at	100%
Remainder of load at	40%

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

If air conditioning equipment or electric space heating equipment is to be installed the following formula shall be applied to determine if the existing service is of sufficient size.

Air conditioning equipment*	100%
Central electric space heating*	100%

Less than four separately controlled space heating units*	100%
First 8 kW of all other load	100%
Remainder of all other load	40%

Other loads shall include:

1500 watts for each 20-ampere appliance circuit.

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

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

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

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

220-32. Optional Calculation — Three or More Multifamily Dwelling Units.

(a) It shall be permissible to compute the feeder or service load of a multifamily dwelling having three or more units in accordance with Table 220-32 instead of Part B of this Article where all the following conditions are met:

(1) No individual dwelling unit is supplied by more than one feeder.

(2) Each dwelling unit is equipped with electric cooking equipment.

Exception: When the computed load for multifamily dwellings under this Section without electric cooking exceeds that computed under this Section for the identical load plus electric cooking (based on 8 kW per unit), the lesser of the two loads may be used.

(3) Each dwelling unit is equipped with either electric space heating or air conditioning or both.

Feeders and service-entrance conductors whose demand load is determined by this optional calculation shall be permitted to have the neutral load determined by Section 220-22.

(b) House loads shall be computed in accordance with Part B of this Article and shall be in addition to the dwelling unit loads computed in accordance with Table 220-32.

(c) The connected load to which the demand factors of Table 220-32 apply shall include the following:

(1) 1500 watts for each 2-wire 20-ampere small appliance branch circuit and each laundry branch circuit specified in Section 220-16.

(2) 3 watts per square foot for general lighting and general-use receptacles.

(3) The nameplate rating of all fixed and stationary appliances, ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, water heaters, and space heaters.

If water heater elements are so interlocked that all elements cannot be used at the same time, the maximum possible load shall be considered the nameplate load.

(4) The nameplate ampere or kVA rating of all motors and of all low-power-factor loads.

(5) The larger of the air conditioning load or the space heating load.

Table 220-32
Optional Calculation — Demand Factors for Three or More
Multifamily Dwelling Units

Number of Dwelling Units	Demand Factor Percent
3-5	45
6-7	44
8-10	43
11	42
12-13	41
14-15	40
16-17	39
18-20	38
21	37
22-23	36
24-25	35
26-27	34
28-30	33
31	32
32-33	31
34-36	30
37-38	29
39-42	28
43-45	27
46-50	26
51-55	25
56-61	24
62 & over	23

220-33. Optional Method — Schools. The calculation of a feeder or service load for schools shall be permitted in accordance with Table 220-33 in lieu of Part B of this Article where equipped with electric space heating, or air conditioning, or both. The connected load to which the demand factors of Table 220-33 apply shall include interior and outdoor lighting, power, water heating, cooking, other loads, and the larger of the air conditioning load or space heating load.

Feeders and service entrance conductors whose demand load is determined by this optional calculation shall be permitted to have the neutral load determined by Section 220-22.

Table 220-33
Optional Method — Demand Factors for Feeders
and Service-Entrance Conductors for Schools

Connected Load Watts Per Sq. Ft.	Demand Factors Percent
Connected load up to and including 3, plus	100
Connected load over 3 and including 20, plus	75
Connected load over 20 at	25

D. Method for Computing Farm Loads**220-40. Farm Loads — Buildings and Other Loads.**

(a) **Dwellings.** The feeder or service load of a farm dwelling shall be computed in accordance with the provisions for dwellings in Part B or C of this Article.

(b) **Other Than Dwellings.** For each farm building or load supplied by two or more branch circuits the load for feeders, service-entrance conductors, and service equipment shall be computed in accordance with demand factors not less than indicated in Table 220-40.

See Section 230-21 for overhead conductors from a pole to a building or other structure.

Table 220-40**Method for Computing Farm Loads for Other Than Dwellings**

Ampere Load At 230 Volts	Demand Factor Percent
Loads expected to operate without diversity, but not less than 125 percent full-load current of the largest motor and not less than the first 60 amperes of load . .	100
Next 60 amperes of all other loads	50
Remainder of other load	25

220-41. Farm Loads — Total. The total load of the farm for service-entrance conductors and service equipment shall be computed in accordance with the farm dwelling load and demand factors specified in Table 220-41. Where there is equipment in two or more farm equipment buildings or for loads having the same function, such loads shall be computed in accordance with Table 220-40 and may be combined as a single load in Table 220-41 for computing the total load.

See Section 230-21 for overhead conductors from a pole to a building or other structure.

Table 220-41**Method for Computing Total Farm Load**

Individual Loads Computed in Accordance with Table 220-40	Demand Factor Percent
Largest load	100
Second largest load	75
Third largest load	65
Remaining loads	50

To this total load, add the load of the farm dwelling computed in accordance with Part B or C of this Article.

ARTICLE 225 — OUTSIDE BRANCH CIRCUITS AND FEEDERS

225-1. Scope. This Article covers electric equipment and wiring for the supply of utilization equipment located on or attached to the outside of public and private buildings, or run between buildings, other structures or poles on other premises served.

For additional information on wiring over 600 volts, see the National Electrical Safety Code (ANSI C2-1973).

225-2. Other Articles. Application of other Articles, including additional requirements to specific cases of equipment and conductors, are as follows:

	Article
Branch Circuits	210
Class 1, Class 2, and Class 3 Remote Control, Signaling, and Power Limited Circuits	725
Communication Circuits	800
Community Antenna Television and Radio Distribution Systems	820
Conductors	310
Electrically Driven or Controlled Irrigation Machines	675
Electric Signs and Outline Lighting	600
Feeders	215
Fire Protective Signaling Systems	760
Fixed Outdoor Electric De-icing and Snow-Melting Equipment	426
Fixtures	410
Grounding	250
Hazardous Locations	500
Hazardous Locations, Specific	510
Marinas and Boatyards	555
Over 600 Volts, General	710
Overcurrent Protection	240
Radio and Television Equipment	810
Services	230
Swimming Pools, Fountains and Similar Installations	680
Use and Identification of Grounded Conductors	200

225-3. Calculation of Load.

(a) **Branch Circuits.** The load on outdoor branch circuits shall be as determined by Section 220-2.

(b) **Feeders.** The load on outdoor feeders shall be as determined by Part B of Article 220.

225-4. Conductor Covering. Where within 10 feet of any building or other structure, open wiring on insulators shall be insulated or covered. 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 Section 310-7. Conductors for festoon lighting shall be of the rubber-covered or thermoplastic type.

225-5. Size of Conductors. The ampacity of outdoor branch-circuit

and feeder conductors shall be in accordance with Tables 310-16 through 310-19 based on loads as determined under Section 220-2 and Part B of Article 220.

225-6. Minimum Size of Conductor.

(a) **Overhead Spans.** Overhead conductors shall not be smaller than the following: (1) for 600 volts or less, No. 10 for spans up to 50 feet in length and No. 8 for longer spans; (2) for over 600 volts, No. 6 where open individual conductors and No. 8 where in cable.

(b) **Festoon Lighting.** Overhead conductors for festoon lighting shall not be smaller than No. 12.

Exception: Where supported by messenger wires.

See Section 225-25 for outdoor lampholders.

DEFINITION: Festoon lighting is a string of outdoor lights suspended between two points more than 15 feet apart.

225-7. Lighting Equipment on Poles or Other Structures.

(a) **General.** For the supply of lighting equipment installed on a single pole or structure, the branch circuits shall comply with Article 210 and (c) below.

(b) **Common Neutral.** It shall be permissible to use a multiwire branch circuit consisting of the neutral and not more than 8 ungrounded conductors. The ampacity of the neutral conductor shall not be less than the calculated sum of the currents in all ungrounded conductors connected to any one phase of the circuit.

(c) **Voltage to Ground.** Branch circuits supplying lamp holders or lighting fixtures mounted on the outside of buildings or on poles or structures for area illumination of residential, commercial, or industrial property shall not exceed 150 volts to ground.

Exception: The voltage shall not exceed 300 volts to ground on branch circuits supplying lighting fixtures for illumination of outdoor areas of industrial establishments, office buildings, schools, stores, and other commercial or public buildings where all of the following conditions are met:

1. *The fixtures are mounted on the outside of buildings or out-of-doors on poles or other structures.*

2. *The fixtures are not less than 8 feet above grade or other surface accessible to individuals other than those charged with fixture maintenance and supervision.*

3. *The fixtures are not less than 3 feet from windows, platforms, fire escapes, and the like.*

(d) **Voltage Between Conductors.** The voltage between conductors on branch circuits supplying only the ballast for permanently installed electric-discharge fixtures for area illumination shall be in accordance with Section 210-6(b).

225-8. Disconnection. The disconnecting means for branch-circuit and feeder fuses shall be in accordance with Section 240-40.

225-9. Overcurrent Protection. Overcurrent protection shall be in accordance with Section 210-20 for branch circuits and Part A of Article 240 for feeders.

225-10. Wiring on Buildings. The installation of outside wiring on surfaces of buildings shall be permitted for circuits of not over 600 volts as open wiring on insulators, as multiconductor cable approved for the purpose, as aluminum-sheathed cable, as Type MI cable, in rigid metal conduit, in intermediate metal conduit, in busways as provided in Article 364, or in electrical metallic tubing. Circuits of over 600 volts shall be installed as provided for services in Section 230-202. Circuits for sign and outline lighting shall be installed in accordance with Article 600.

225-11. Circuit Exits and Entrances. Where outside branch and feeder circuits leave or enter a building, the requirements of Section 230-43, 230-52 and 230-54 shall apply.

225-12. Open-Conductor Supports. Open conductors shall be supported on glass or porcelain-knobs, racks, brackets, or strain insulators.

225-13. Festoon Supports. In spans exceeding 40 feet, the conductors shall be supported by a messenger wire; and the messenger wire shall be supported by strain insulators. Conductors or messenger wires shall not be attached to any fire escape, downspout, or plumbing equipment.

225-14. Open-Conductor Spacings.

(a) **600 Volts or Less.** Conductors of 600 volts or less shall comply with the spacings provided in Table 230-51(c).

(b) **Over 600 Volts.** Conductors of over 600 volts shall comply with the spacings provided in Part D of Article 710.

(c) **Separation From Other Circuits.** Open conductors shall be separated from open conductors of other circuits or systems by not less than 4 inches.

(d) **Conductors on Poles.** Conductors on poles shall have a separation of not less than one foot where not placed on racks or brackets. Conductors supported on poles shall provide a horizontal climbing space not less than the following:

Power conductors, below communication conductors	30 inches
Power conductors alone or above communication conductors:	
300 volts or less	24 inches
Over 300 volts	30 inches
Communication conductors below power conductors	same as power conductors
Communication conductors alone	no requirement

225-15. Supports Over Buildings. Supports over a building shall be in accordance with Section 230-29.

225-16. Point of Attachment to Buildings. The point of attachment to a building shall be in accordance with Section 230-26.

225-17. Means of Attachment to Buildings. The means of attachment to a building shall be in accordance with Section 230-27.

225-18. Clearance From Ground. Open conductors of not over 600 volts shall conform to the following:

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

12 feet — over residential driveways and commercial areas such as parking lots and drive-in establishments not subject to truck traffic.

15 feet — over commercial areas, parking lots, or agricultural or other areas subject to truck traffic.

18 feet — over public streets, alleys, roads, and driveways on other than residential property.

Note: For clearance of conductors of over 600 volts, see National Electrical Safety Code (ANSI C2-1973).

225-19. Clearances From Buildings for Conductors of Not Over 600 Volts.

(a) **Over Roofs.** Open conductors shall have a clearance of not less than 8 feet from the highest point of roofs over which they pass.

Exception No. 1: Where the voltage between conductors does not exceed 300 and the roof has a slope of not less than 4 inches in 12 inches, a reduction in clearance to 3 feet shall be permitted.

Exception No. 2: Where the voltage between conductors does not exceed 300, a reduction in clearance over the roof to 18 inches shall be permitted if:

a. They do not pass over more than 4 feet of the overhang portion of the roof; and

b. They are terminated at a (through-the-roof) raceway or approved support.

(b) **Horizontal Clearances.** Open conductors not attached to a building shall have a minimum horizontal clearance of 3 feet.

(c) **Final Spans.** Final spans of feeders or branch circuits to a building they supply or from which they are fed shall be permitted to be attached to the building, but they shall be kept 3 feet from windows, doors, porches, fire escapes, or similar locations.

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

(d) **Zone for Fire Ladders.** Where buildings exceed three 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.

Note: For clearance of conductors over 600 volts, see National Electrical Safety Code (ANSI C2-1973).

225-20. Mechanical Protection of Conductors. Mechanical protection of conductors on buildings, structures, or poles shall be as provided for services in Section 230-50.

225-21. Multiconductor Cables on Exterior Surfaces of Buildings. Multiconductor cables on exterior surfaces of buildings shall be as provided for service cable in Section 230-51.

225-22. Raceways on Exterior Surfaces of Buildings. Raceways on exterior surfaces of buildings shall be made raintight and suitably drained.

225-23. Underground Circuits. Underground circuits shall meet the requirements of Section 300-5.

225-24. Outdoor Lampholders. Where outdoor lampholders are attached as pendants, the connections to the circuit wires shall be staggered. Where such lampholders have terminals of a type that puncture the insulation and make contact with the conductors, they shall be attached only to conductors of the stranded type.

225-25. Location of Outdoor Lamps. Locations of lamps for outdoor lighting shall be below all live conductors, transformers, or other electrical equipment:

Exception No. 1: Where clearances or other safeguards are provided for relamping operations.

Exception No. 2: Where equipment is controlled by a disconnecting means that can be locked in the open position.

ARTICLE 230 — SERVICES

A. General

230-1. Scope. This Article covers service conductors and equipment for control and protection of services; the number, types, and sizes of services and service equipment; and the installation requirements.

230-2. Number of Services. A building or other structure served shall be supplied by only one set of service drop or service lateral conductors.

Exception No. 1: For fire pumps where a separate service is required.

Exception No. 2: For emergency electrical systems where a separate service is required.

Exception No. 3: Multiple-Occupancy Buildings.

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

b. Buildings of multiple occupancy shall be permitted to have two or more separate sets of service-entrance conductors which are tapped from one service drop or lateral, or two or more sub-sets of service-entrance conductors shall be permitted to be tapped from a single set of main service-entrance conductors.

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

Exception No. 4: Capacity Requirements. Two or more services shall be permitted:

a. Where the capacity requirements are in excess of 3000 amperes at a supply voltage of 600 volts or less; or

b. Where the load requirements of a single-phase installation are greater than the serving agency normally supplies through one service; or

c. By special permission.

Exception No. 5: Buildings of Large Area. By special permission, for a single building or other structure sufficiently large to make two or more services necessary.

Exception No. 6: For different characteristics, such as for different voltages, frequencies, or phases, or for different uses, such as for different rate schedules.

230-3. One Building or Other Structure Not to Be Supplied Through Another. Service conductors supplying a building or other structure shall not pass through the interior of another building or other structure.

Exception: Where the buildings or other structures served are under single occupancy or management.

See Section 230-44 for masonry-encased conductors considered outside of a building.

B. Insulation and Size of Service Conductors

230-4. Insulation of Service Conductors. Service conductors shall normally withstand exposure to atmospheric and other conditions of use without detrimental leakage of current.

For Service Drops — See Section 230-22.

For Underground Services — See Section 230-30.

For Service-Entrance Conductors — See Section 230-40.

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

Minimum sizes are given in the following references:

For Service Drops — See Section 230-23.

For Underground Service Conductors — See Section 230-31.

For Service-Entrance Conductors — See Section 230-41.

For Farmstead Service Conductors — See Part D of Article 220.

C. Overhead Services

230-21. Overhead Supply. Overhead conductors to a building or other structure from another building or other structure (such as a pole) on which a meter or disconnecting means is installed shall be considered as a service drop and installed accordingly.

Example: Farm loads in Part D of Article 220.

230-22. Insulation or Covering.

(a) **Cable.** Individual conductors of multiconductor cable shall be insulated or covered with thermoplastic, rubber or other vulcanizable material.

Exception: A grounded conductor shall be permitted to be bare.

(b) **Open Wiring.** Individual conductors shall be insulated or covered.

Service-drop conductors with an extruded covering have an ampacity equal to that of covered conductors of the same size as listed in Tables 310-17 and 310-19.

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

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

The grounded conductor shall not be less than the minimum size required by Section 250-23(b).

230-24. Clearances. Service-drop conductors shall not be readily accessible and shall comply with (a) through (c) below for services not over 600 volts.

(a) Over Roofs. Conductors shall have a clearance of not less than 8 feet from the highest point of roofs over which they pass.

Exception No. 1: Where the voltage between conductors does not exceed 300 and the roof has a slope of not less than 4 inches in 12 inches, a reduction in clearance to 3 feet shall be permitted.

Exception No. 2: Where the voltage between conductors does not exceed 300, a reduction in clearance over the roof to not less than 18 inches shall be permitted if (1) they do not pass over more than 4 feet of the overhang portion of the roof, and (2) they are terminated at a through-the-roof raceway or approved support.

See Section 230-28 for mast supports.

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

- 10 feet — above finished grade, sidewalks or from any platform or projection from which they might be reached;
- 12 feet — over residential driveways and commercial areas such as parking lots and drive-in establishments not subject to truck traffic;
- 15 feet — over commercial areas, parking lots, agricultural or other areas subject to truck traffic;
- 18 feet — over public streets, alleys, roads and driveways on other than residential property.

(c) Clearance from Building Openings. Conductors shall have a clearance of not less than 3 feet from windows, doors, porches, fire escapes, or similar locations.

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

230-26. Point of Attachment. The point of attachment of conductors to a building or other structure shall provide the minimum clearances as specified in Section 230-24. In no case shall this point of attachment be less than 10 feet above finished grade.

230-27. Means of Attachment. Multiconductor cables used for service drops shall be attached to buildings or other structures by fittings approved for the purpose. Open conductors shall be attached to fittings

approved for the purpose or to noncombustible, nonabsorbent insulators securely attached to the building or other structure.

230-28. Service Masts As Supports. Where a service mast is used for the support of service-drop conductors, it shall be of adequate strength or be supported by braces or guys to withstand safely the strain imposed by the service drop. Where raceway-type service masts are used, all raceway fittings shall be approved for the purpose.

230-29. Supports Over Buildings. Service-drop conductors passing over a roof shall be securely supported by substantial structures. Where practicable, such supports shall be independent of the building.

D. Underground Services

230-30. Insulation. Service lateral conductors shall be insulated for the applied voltage.

Exception: A grounded conductor shall be permitted as follows:

1. Bare copper used in a raceway.
2. Bare copper for direct burial where bare copper is judged to be suitable for the soil conditions.
3. Bare copper for direct burial without regard to soil conditions where part of an approved cable assembly with a moisture- and fungus-resistant outer covering.
4. Aluminum or copper-clad aluminum without individual insulation or covering used in a raceway or for direct burial when part of a cable assembly approved for the purpose and having a moisture- and fungus-resistant outer covering.

230-31. Size and Rating. Conductors shall have sufficient ampacity to carry the load. They shall not be smaller than No. 8 copper or No. 6 aluminum or copper-clad aluminum. The grounded conductor shall not be less than the minimum size required by Section 250-23(b).

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

E. Service-Entrance Conductors

230-40. Insulation of Service-Entrance Conductors.

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

Exception: A grounded conductor shall be permitted as follows:

1. Bare copper used in a raceway or part of a service cable assembly.
2. Bare copper for direct burial where bare copper is judged to be suitable for the soil conditions.
3. Bare copper for direct burial without regard to soil conditions where part of an approved cable assembly with a moisture- and fungus-resistant outer covering.
4. Aluminum or copper-clad aluminum without individual insula-

tion or covering used in a raceway or for direct burial when part of a cable assembly approved for the purpose and having a moisture- and fungus-resistant outer covering.

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

230-41. Size and Rating.

(a) **General.** Conductors shall be of sufficient size to carry the loads as computed in accordance with Article 220. Ampacity shall be determined from Tables 310-16 through 310-19 and all applicable notes to these Tables.

(b) **Ungrounded Conductors.** Ungrounded conductors shall not be smaller than:

(1) 100-ampere, 3-wire, for a single-family dwelling with six or more 2-wire branch circuits.

(2) 100-ampere, 3-wire, for a single-family dwelling with an initial computed load of 10 kW or more.

(3) 60 amperes for other loads.

Exception No. 1: For loads consisting of not more than two 2-wire branch circuits, No. 8 copper or No. 6 aluminum or copper-clad aluminum.

Exception No. 2: By special permission, for loads limited by demand or by the source of supply, No. 8 copper or No. 6 aluminum or copper-clad aluminum.

Exception No. 3: For limited loads of a single branch circuit, No. 12 copper or No. 10 aluminum or copper-clad aluminum, but in no case smaller than the branch-circuit conductors.

(c) **Grounded Conductors.** The grounded (neutral) conductor shall not be less than the minimum size as required by Section 250-23(b).

F. Installation of Service Conductors

230-43. Wiring Methods for 600 Volts or Less. Service-entrance conductors shall be installed in accordance with the applicable requirements of this Code covering the type of wiring method used and limited to the following methods: (1) open wiring on insulators; (2) rigid metal conduit; (3) electrical metallic tubing; (4) service-entrance cables; (5) wireways; (6) busways; (7) auxiliary gutters; (8) rigid nonmetallic conduit; (9) cablebus; or (10) mineral-insulated metal-sheathed cable.

230-44. Conductors Considered Outside of Building. Conductors shall be considered outside of a building or other structure under any of the following conditions: (1) where installed under not less than 2 inches of concrete beneath a building or other structure, or (2) where installed within a building or other structure in a raceway that is enclosed by concrete or brick not less than 2 inches thick.

230-45. Separate Enclosures. Where two to six service disconnecting means in separate enclosures supply separate loads from one service drop or lateral, one set of service-entrance conductors shall be permitted to supply each or several such service equipment enclosures.

230-46. Unspliced Conductors. Service-entrance conductors shall not be spliced.

Exception No. 1: Clamped or bolted connections in metering equipment enclosures shall be permitted.

Exception No. 2: Where service-entrance conductors are tapped to supply two to six disconnecting means grouped at a common location.

Exception No. 3: At a properly enclosed junction point where an underground wiring method is changed to another type of wiring method.

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

230-47. Other Conductors in Raceway or Cable. Conductors other than service conductors shall not be installed in the same service raceway or service-entrance cable.

Exception No. 1: Grounding conductors.

Exception No. 2: Time switch conductors having overcurrent protection.

230-48. Raceway Seal. Where a service raceway enters from an underground distribution system, it shall be sealed in accordance with Section 300-5. Spare or unused raceways shall also be sealed.

230-49. Protection Against Damage — Underground. Underground service conductors shall be protected against physical damage in accordance with Section 300-5.

230-50. Protection of Open Conductors and Cables Against Damage — Above Ground. Service-entrance conductors installed above ground shall be protected against physical damage as specified in (a) or (b) below.

(a) **Service-Entrance Cables.** Service-entrance cables, where subject to physical damage, such as where installed in exposed places near driveways or coal chutes, or where subject to contact with awnings, shutters, swinging signs, or similar objects, shall be protected in any of the following ways: (1) by rigid metal conduit; (2) by rigid non-metallic conduit suitable for the location; (3) by electrical metallic tubing; or (4) by other approved means.

(b) **Other Than Service-Entrance Cable.** Individual open conductors and cables other than service-entrance cables shall not be installed within 8 feet of grade level or where exposed to physical damage.

230-51. Mounting Supports. Cables or individual open service conductors shall be supported as specified in (a), (b), or (c) below.

(a) **Service-Entrance Cables.** Service-entrance cables shall be supported by straps or other approved means within 12 inches of every service head, gooseneck, or connection to a raceway or enclosure and at intervals not exceeding 4½ feet.

(b) **Other Cables.** Cables that are not approved for mounting in contact with a building or other structure shall be mounted on insulating supports installed at intervals not exceeding 15 feet and in a manner

that will maintain a clearance of not less than 2 inches from the surface over which they pass.

(c) **Individual Open Conductors.** Individual open conductors shall be installed in accordance with Table 230-51(c). Where exposed to the weather, the conductors shall be mounted on insulators or on insulating supports attached to racks, brackets, or other approved means. Where not exposed to the weather, the conductors shall be mounted on glass or porcelain knobs.

Table 230-51(c). Supports and Clearances for Individual Open Service Conductors

Maximum Volts	Maximum Distance In Feet Between Supports	Minimum Clearances In Inches	
		Between Conductors	From Surface
600	9	6	2
600	15	12	2
300	4½	3	2
600*	4½ *	2½ *	1 *

* Where not exposed to weather.

230-52. Individual Conductors Entering Buildings or Other Structures. Where individual open conductors enter a building or other structure, they shall enter through roof bushings or through the wall in an upward slant through individual, noncombustible, nonabsorbent insulating tubes. Drip loops shall be formed on the conductors before they enter the tubes.

230-53. Raceways to Drain. Where exposed to the weather, raceways enclosing service-entrance conductors shall be raintight and arranged to drain. Where embedded in masonry, raceways shall be arranged to drain.

230-54. Connections at Service Head.

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

(b) Service cables, either (1) unless continuous from pole to service equipment or meter, shall be equipped with a raintight service head, or (2) formed in a gooseneck and taped and painted or taped with a self-sealing weather-resistant thermoplastic.

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

Exception: Where it is impracticable to locate the service head above the point of attachment, the service head location shall be permitted not farther than 24 inches from the point of attachment.

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

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

(f) Drip loops shall be formed on individual conductors. To prevent the entrance of moisture, service-entrance conductors shall be connected to the service-drop conductors either (1) below the level of the service head, or (2) below the level of the termination of the service-entrance cable sheath.

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

230-55. Termination at Service Equipment. Any service raceway or cable shall terminate at the inner end in a box, cabinet, or equivalent fitting that effectively encloses all live metal parts.

Exception: Where the service disconnecting means is mounted on a switchboard having exposed busbars on the back, a raceway shall be permitted to terminate at a bushing.

G. Service Equipment — Guarding and Grounding

230-62. Service Equipment — Enclosed or Guarded. Live parts of service equipment shall be enclosed as specified in (a) below, or guarded as specified in (b) below.

(a) **Enclosed.** Live parts shall be enclosed so that they will not be exposed to accidental contact or guarded as in (b) below.

(b) **Guarded.** Live parts that are not enclosed shall be installed on a switchboard, panelboard, or control board and guarded in accordance with Sections 110-17 and 110-18. Such an enclosure shall be provided with means for locking or sealing doors giving access to live parts.

230-63. Grounding and Bonding. Service equipment, raceways, cable armor, cable sheaths, etc., and any service conductor that is to be grounded shall be grounded in accordance with the following parts of Article 250.

Part B. Circuit and System Grounding.

Part C. Location of System Grounding Connections.

Part D. Enclosure Grounding.

Part F. Methods of Grounding.

Part G. Bonding.

Part H. Grounding Electrodes.

Part J. Grounding Conductors.

Exception: Service equipment shall not be required to be grounded where the voltage does not exceed 150 volts to ground and such enclosures are (1) isolated from conducting surfaces, and (2) unexposed to contact by persons or materials that could also be in contact with other conducting surfaces.

H. Service Equipment — Disconnecting Means

230-70. General. Means shall be provided to disconnect all conductors in a building or other structure from the service-entrance conductors. Each such disconnecting device shall be permanently marked to identify it as a service disconnecting means and shall be of a type that is suitable for use as service equipment under prevailing conditions.

Service equipment installed in hazardous locations shall comply with the requirements of Articles 500 through 517.

230-71. Maximum Number of Disconnects.

(a) **General.** The service disconnecting means for each set or for each sub-set of service-entrance conductors shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard.

(b) **Single-Pole Units.** Two or three single-pole switches or breakers, capable of individual operation, shall be permitted on multiwire circuits, one pole for each ungrounded conductor, as one multipole disconnect provided they are equipped with "handle ties" or a "master handle" to disconnect all conductors of the service with no more than six operations of the hand.

See Section 384-16(a) for service equipment in panelboards.

230-72. Grouping of Disconnects.

(a) **Sets of Disconnects.** Where supplied by one service drop or service lateral, the two to six service disconnecting means permitted in Section 230-71 shall be grouped and each marked to indicate the load it serves.

Exception: Services as permitted in Section 230-2.

(b) **Emergency or Fire Pump Services.** The one or more additional service disconnecting means for fire pumps or for emergency services shall be installed sufficiently remote from the one to six service disconnecting means for normal services to minimize the possibility of simultaneous interruption of supply.

See Sections 700-6(c) and 700-6(d) for emergency system services.

(c) **Location.** The service disconnecting means shall be installed either inside or outside of a building or other structure at a readily accessible location nearest the point of entrance of the service-entrance conductors.

(d) 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 location.

The disconnecting means shall consist of not more than six switches or six circuit breakers.

Multiple-occupancy buildings that do not have individual occupancy above the second floor shall be permitted to have service conductors run to each occupancy in accordance with Section 230-2, Exception No. 3 and each such service may have not more than six switches or six circuit breakers.

230-73. Working Space. Sufficient working space shall be provided in the vicinity of the service disconnecting means to permit safe operation, inspection, and repairs. In no case shall this be less than that specified by Section 110-16.

230-74. Simultaneous Opening of Poles. Each disconnecting means shall simultaneously disconnect all ungrounded conductors.

230-75. Disconnection of Grounded Conductor. Where the service disconnecting means does not disconnect the grounded conductor from the premises wiring, other means shall be provided for this purpose in the service equipment. A terminal or bus to which all grounded conductors can be attached by means of pressure connectors shall be permitted for this purpose.

230-76. Manually or Power Operable. The disconnecting means for ungrounded conductors shall consist of either (1) a manually operable switch or circuit breaker equipped with a handle or other suitable operating means, or (2) a power-operated switch or circuit breaker provided the switch or circuit breaker can be opened by hand in the event of a power supply failure.

230-77. Indicating. The disconnecting means shall plainly indicate whether it is in the open or closed position.

230-78. Externally Operable. An enclosed service disconnecting means shall be externally operable without exposing the operator to contact with live parts.

Exception: A power-operated switch or circuit breaker shall not be required to be externally operable by hand to the closed position.

230-79. Rating of Disconnect. The service disconnecting means shall have a rating not less than the load to be carried, determined in accordance with Article 220. In no case shall the rating be lower than specified in (a), (b), (c) or (d) below.

(a) **One-Circuit Installation.** For installations to supply only limited loads of a single branch circuit, the service disconnecting means shall have a rating of not less than 15 amperes.

(b) **Two-Circuit Installations.** For installations consisting of not more than two 2-wire branch circuits, the service disconnecting means shall have a rating of not less than 30 amperes.

(c) **Single-Family Dwelling.** For a single-family dwelling, the service disconnecting means shall have a rating of not less than 100 amperes, 3-wire under either of the following conditions: (1) where the initial computed load is 10 kW or more, or (2) where the initial installation consists of six or more 2-wire branch circuits.

(d) **All Others.** For all other installations the service disconnecting means shall have a rating of not less than 60 amperes.

230-80. Combined Rating of Disconnects. Where the service disconnecting means consists of more than one switch or circuit breaker, as permitted by Section 230-71, the combined ratings of all the switches or circuit breakers used shall not be less than the rating required for a single switch or circuit breaker.

230-81. Connection to Terminals. The service conductors shall be connected to the service disconnecting means by pressure connectors, clamps, or other approved means. Connections that depend upon solder shall not be used.

230-82. Equipment Connected to the Supply Side of Service Disconnect. Equipment shall not be connected to the supply side of the service disconnecting means.

Exception No. 1: Service fuses.

Exception No. 2: Fuses and disconnecting means or circuit breakers, in meter pedestals, connected in series with the ungrounded service conductors and located away from the building supplied.

Exception No. 3: Meters nominally rated not in excess of 600 volts, provided all metal housings and service enclosures are grounded in accordance with Article 250.

Exception No. 4: Instrument transformers (current and potential), high-impedance shunts, surge-protective capacitors, time switches, and lightning arresters.

Exception No. 5: Taps used only to supply time switches, circuits for emergency systems, stand-by power systems, fire pump equipment, and fire and sprinkler alarms if provided with service equipment and installed in accordance with requirements for service-entrance conductors.

230-83. Emergency Transfer Equipment. Where an emergency source is used as an alternate supply to the same load conductors supplied by the normal source, transfer equipment for shifting from one source to the other shall open all ungrounded conductors of one source before connection is made to the other.

Exception: Where parallel operation is used and suitable automatic control equipment is provided.

230-84. More Than One Building or Other Structure.

(a) Disconnect Required for Each. Where more than one building or other structure is on the same property and under single management, each building or other structure served shall be provided with means for disconnecting all ungrounded conductors.

See Sections 230-72(c) and (d) for location.

(b) Suitable for Service Equipment. The disconnecting means specified in (a) above shall be suitable for use as service equipment.

Exception: For garages and outbuildings on residential property, a snap switch or a set of 3-way or 4-way snap switches suitable for use on branch circuits shall be permitted as the disconnecting means.

J. Service Equipment — Overcurrent Protection

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

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

Exception No. 1: For motor-starting currents, ratings in conformity with Sections 430-52, 430-62, or 430-63 shall be permitted.

Exception No. 2: Fuses and circuit breakers with a rating or setting in conformity with Section 240-3, Exception No. 1, and Section 240-6.

Exception No. 3: Not more than six circuit breakers or six sets of fuses shall be considered as the overcurrent device.

Exception No. 4: In a multiple-occupancy building each occupant shall have access to his overcurrent protective devices. A multiple-occupancy building having individual occupancy above the second floor shall have service equipment grouped in a common accessible location. The overcurrent protection shall consist 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 shall be permitted to have service conductors run to each occupancy and each such service shall not have more than six circuit breakers or six sets of fuses.

Exception No. 5: Fire Pumps. Where the service to the fire pump room is judged to be outside of buildings, these provisions shall not apply. Service equipment for fire pump services shall be selected or set to carry locked-rotor current of the motor(s) indefinitely (See NFPA No. 20—1972, Standard for Centrifugal Fire Pumps).

A set of fuses shall be considered all the fuses required to protect all the ungrounded conductors of a circuit. Single-pole circuit breakers, grouped in accordance with Section 230-71(b), shall be considered as one protective device.

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

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

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

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

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

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

Exception No. 1: The service switch shall be permitted on the supply side.

Exception No. 2: High-impedance shunt circuits, lightning arresters, surge protective capacitors, instrument transformers (current and potential), shall be permitted to be connected and installed on the supply side of the service disconnecting means as permitted in Section 230-82.

Exception No. 3: Circuits for emergency supply and time switches shall be permitted to be connected on the supply side of the service overcurrent device where separately provided with overcurrent protection.

Exception No. 4: Circuits used only for the operation of fire alarm, other protective signaling systems, or the supply to fire pump equipment shall be permitted to be connected on the supply side of the service overcurrent device where separately provided with overcurrent protection.

Exception No. 5: Meters nominally rated not in excess of 600 volts, provided all metal housings and service enclosures are grounded in accordance with Article 250.

Exception No. 6: Where service equipment is power operable, the control circuit shall be permitted to be connected ahead of the service equipment if suitable overcurrent protection and disconnecting means are provided.

230-95. Ground-Fault Protection of Equipment. Ground-fault protection of equipment shall be provided for solidly grounded wye electrical services of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase for each service disconnecting means rated 1000 amperes or more.

(a) The ground-fault protection shall operate to cause the service disconnecting means to open all ungrounded conductors of the faulted circuit. The maximum setting of the ground-fault protection shall be 1200 amperes.

(b) If a switch and fuse combination is used, the fuses employed shall be capable of interrupting any current higher than the interrupting capacity of the switch during a time when the ground-fault protective system will not cause the switch to open.

As used in this Section, the rating of the Service Disconnecting Means is considered to be the rating of the largest fuse that can be installed or the highest trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted.

It is recognized that ground-fault protection is desirable for service disconnecting means rated less than 1000 amperes on solidly grounded systems having more than 150 volts to ground, not exceeding 600 volts phase-to-phase.

As used in this Section, solidly grounded means that the grounded conductor (neutral) is grounded without inserting any resistor or impedance device.

Ground-fault protection that functions to open the service disconnecting means will not protect service conductors or the service disconnecting means but will limit the damage to conductors and equipment on the load side of the ground-fault protection.

This added protective equipment at the service equipment will make it necessary to review the overall wiring system for proper selective overcurrent protection coordination. Additional installations of ground-fault protective equipment will be needed on feeders and branch circuits where maximum continuity of electrical service is necessary.

230-96. Working Space. Sufficient working space shall be provided in the vicinity of the service overcurrent devices to permit safe operation, replacements, inspection, and repairs. In no case shall this be less than that specified by Section 110-16.

230-98. Available Short-Circuit Current. Service equipment shall be suitable for the short circuit current available at its supply terminals.

K. Services Exceeding 600 Volts, Nominal

230-200. General. Service conductors and equipment used on circuits exceeding 600 volts shall comply with all applicable provisions of the preceding Sections of this Article and with the following Sections, which supplement or modify the preceding Sections. In no case shall the provisions of this Article apply to equipment on the supply side of the service conductors.

230-201. Classification of Service Conductors.

(a) **Secondary Conductors.** The secondary conductors shall constitute the service conductors where the step-down transformers are located as follows: (1) outdoors; (2) in a separate building from the building or other structure served; (3) inside the building or other structure served where in a vault complying with Part C of Article 450; or (4) inside the building or other structure served where in a locked room or other locked enclosure and accessible to qualified persons only.

(b) **Primary Conductors.** In all other cases, the primary conductors shall be considered the service conductors.

230-202. Service-Entrance Conductors. Service entrance conductors to buildings or enclosures shall be installed to conform to the following:

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

(b) **Wiring Methods.** Service-entrance conductors shall be installed by means of one of the following wiring methods: (1) in rigid metal conduit; (2) in rigid nonmetallic conduit where encased in not less than 2 inches of concrete; (3) as multiconductor cable approved for the purpose; (4) as open conductors where supported on insulators approved for the purpose and where either accessible only to qualified persons or where effectively guarded against accidental contact; or (5) in cablebus. Underground service-entrance conductors shall conform to Section 300-5.

See Section 310-51 for shielding of solid dielectric insulated conductors.

(c) **Open Work.** Open wire services over 600 volts shall be installed in accordance with the provisions of Article 710, Part C.

(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 to make them accessible only to qualified persons.

(f) **Service Cable.** Where cable conductors emerge from a metal sheath or raceway, the insulation of the conductors shall be protected from moisture and physical damage by a pothead or other approved means.

(g) **Draining Raceways.** Unless conductors specifically approved for

the purpose are used, raceways embedded in masonry, or exposed to the weather, or in wet locations shall be arranged to drain.

(h) **Over 15,000 Volts.** Where the voltage exceeds 15,000 volts between conductors they shall enter either metal-enclosed switchgear or a transformer vault conforming to the requirements of Sections 450-41 through 450-48.

(i) **Conductor Considered Outside Building.** Conductors placed under at least 2 inches of concrete beneath a building, or conductors within a building in conduit or duct and enclosed by concrete or brick not less than 2 inches thick shall be considered outside the building.

230-203. Warning Signs. High-voltage signs with the words "High Voltage" shall be posted where unauthorized persons might come in contact with live parts.

230-204. Isolating Switches.

(a) **Where Required.** Where oil switches or air or oil circuit breakers constitute the service disconnecting means, an air-break isolating switch shall be installed on the supply side of the disconnecting means and all associated service equipment.

Exception: Where such equipment is mounted on removable truck panels or metal-enclosed switchgear units, which cannot be opened unless the circuit is disconnected, and which, when removed from the normal operating position, automatically disconnect the circuit breaker or switch from all live parts.

(b) **Fuses As Isolating Switch.** Where fuses are of the type that can be operated as a disconnecting switch, a set of such fuses shall be permitted as the isolating switch where: (1) the oil disconnecting means is a nonautomatic switch, and (2) the set of fuses disconnect the oil switch and all associated service equipment from the service-entrance conductors.

(c) **Accessible to Qualified Persons Only.** The isolating switch shall be accessible to qualified persons only.

(d) **Grounding Connection.** Isolating switches shall be provided with a means for readily connecting the load side conductors to ground when disconnected from the source of supply.

A means for grounding the load side conductors need not be provided for any duplicate isolating switch installed and maintained by the electric supply company.

230-205. Disconnecting Means. The service disconnecting means shall simultaneously disconnect all ungrounded conductors and shall be capable of being closed on a fault within the maximum interrupting rating of the overcurrent protection.

230-206. Overcurrent Devices As Disconnecting Means. Where the circuit-breaker or alternative for it specified in Section 230-208 for service overcurrent devices meets the requirements specified in Section 230-205, they shall constitute the service disconnecting means.

230-207. Equipment in Secondaries. Where the primary service equipment supplies one or more transformers whose secondary windings connect to a single set of mains, and the primary load-interrupter switch

or circuit breaker is capable of being opened and closed from a point outside the transformer vault, the disconnecting means and overcurrent protection shall not be required in the secondary circuit if the primary fuse or circuit breaker is rated or set to protect the secondary circuit.

230-208. Overcurrent Protection Requirements. Service-entrance conductors shall have a short circuit protective device in each ungrounded conductor, on the load side of, or as an integral part of the service-entrance switch. The protective device shall be capable of detecting and interrupting all values of current in excess of its trip setting or melting point, which can occur at its location. A fuse rated in continuous amperes not to exceed three times the ampacity of the conductor, or a circuit breaker with a trip setting of not more than six times the ampacity of the conductors shall be considered as providing the required short circuit protection.

See Tables 310-39 through 310-50 for ampacity of high voltage conductors.

Overcurrent devices shall conform to the following:

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

(1) A nonautomatic oil switch, oil fuse cutout, air load-interrupter switch, or other switch approved for the purpose shall be permitted with suitable fuses. The interrupting rating of this switch shall equal or exceed the continuous current rating of the fuse.

(2) An automatic trip circuit breaker of suitable current-carrying and interrupting capacity.

(3) A switch capable of interrupting the no-load current of the transformer supplied through the switch and suitable fuses shall be permitted provided the switch is interlocked with a single switch or circuit breaker on the secondary circuit of the transformer so that the primary switch cannot be opened when the secondary circuit is closed.

(b) Not in Vault or Not Consisting of Metal-Enclosed Switchgear. Where the service equipment is not in a vault or metal-enclosed switchgear, the overcurrent protection and disconnecting means shall be either of the following:

(1) An air load-interrupter switch or other switch approved for the purpose capable of interrupting the rated circuit load shall be permitted with suitable fuses on a pole or elevated structure outside the building provided the switch is operable by persons using the building.

(2) An automatic-trip circuit breaker of suitable ampacity and interrupting capacity. The circuit breaker shall be located outside the building as near as practicable to where the service conductors enter the building. The location shall be permitted on a pole, roof, foundation or other structure.

(c) Fuses. Fuses shall have an interrupting rating no less than the maximum available short-circuit current in the circuit at their supply terminals.

(d) Circuit Breakers. Circuit breakers shall be free to open in case

the circuit is closed on an overload. This can be accomplished by means such as trip-free circuit breakers. A service circuit breaker shall indicate clearly whether it is open or closed, and shall have an interrupting rating no less than the maximum available short-circuit current at its supply terminals.

Overcurrent relays shall be furnished in connection with current transformers in one of the following combinations:

(1) Three overcurrent relays operated from current transformers in each phase.

(2) Two overcurrent relays operated by current from current transformers in any two phases and one overcurrent relay sensitive to ground-fault current that is operated by the sum of the currents from current transformers in each phase.

(3) Two overcurrent relays operated by current from current transformers in any two phases and one overcurrent relay sensitive to ground-fault current that is operated from a current transformer which links all three phase conductors and the grounded circuit conductor (neutral), if provided.

(e) **Enclosed Overcurrent Devices.** The restriction to 80 percent of rating for an enclosed overcurrent device on continuous loads shall not apply to overcurrent devices installed in services operating at over 600 volts.

230-209. Surge Arresters (Lightning Arresters). Surge arresters installed in accordance with the requirements of Article 280 shall be placed on each ungrounded overhead service conductor on the supply side of the service equipment, when called for by the authority having jurisdiction.

230-210. Service Equipment-General Provisions. Service equipment including instrument transformers shall conform to Article 710, Part B.

230-211. Metal-Enclosed Switchgear. Metal-enclosed switchgear shall consist of a substantial metal structure and a sheet metal enclosure. Where installed over a wood floor, suitable protection thereto shall be provided.

ARTICLE 240 — OVERCURRENT PROTECTION

240-1. Scope. Parts A through G of this Article provide the general requirements for overcurrent protection and overcurrent protective devices not more than 600 volts, nominal. Part H covers overcurrent protection over 600 volts, nominal.

Overcurrent protection for conductors and equipment is provided to open the circuit if the current reaches a value that will cause an excessive or dangerous temperature in conductors or conductor insulation. See also Sections 110-9 and 110-10 for requirements for interrupting capacity and protection against fault currents.

A. General

240-2. Protection of Equipment. Equipment shall be protected against overcurrent in accordance with the Article in this Code covering the type of equipment as specified in the following list.

Equipment	Article No.
Air-Conditioning and Refrigerating Equipment	440
Appliances	422
Branch Circuits	210
Capacitors	460
Class 1, Class 2, and Class 3 Remote Control, Signaling, and Power Limited Circuits	725
Cranes and Hoists	610
Electrical Floor Assemblies	366
Electric Signs and Outline Lighting	600
Electric Welders	630
Elevators, Dumbwaiters, Escalators, and Moving Walks ...	620
Emergency Systems	700
Fire Protective Signaling Systems	760
Fixed Electric Heating Equipment for Pipelines and Vessels	427
Fixed Electric Space Heating Equipment	424
Fixed Outdoor Electric De-Icing and Snow Melting Equipment	426
Generators	445
Induction and Dielectric Heating Equipment	665
Metalworking Machine Tools	670
Motion Picture Studios and Similar Locations	530
Motors, Motor Circuits, and Controllers	430
Organs	650
Over 600 Volts, Nominal — General	710
Places of Assembly	518
Services	230
Sound-Recording and Similar Equipment	640
Switchboards and Panelboards	384
Theaters and Similar Locations	520
Transformers and Transformer Vaults	450
X-ray Equipment	660

240-3. Protection of Conductors — Other Than Flexible Cords and Fixture Wires. Conductors, other than flexible cords and fixture wires, shall be protected against overcurrent in accordance with their ampacities as specified in Tables 310-16 through 310-19 and all applicable notes to these Tables.

Exception No. 1: Next Higher Overcurrent Protective Device Rating. Where the ampacity of the conductor does not correspond with the standard ampere rating of a fuse or a circuit breaker without overload trip adjustment above its rating (but which may have other trip or rating adjustments), the next higher standard device rating shall be permitted only if this rating does not exceed 800 amperes.

Exception No. 2: Tap Conductors. Tap conductors as permitted in Sections 210-19(c); 240-21, Exception Nos. 2, 3, 5, and 8; 364-9 and 364-10; and Part D of Article 430.

Exception No. 3: Motor and Motor-Control Circuits. Motor and motor-control circuit conductors protected in accordance with Parts C, D, E, and F of Article 430. Motor-operated appliance circuit conductors protected in accordance with Parts B and D of Article 422. Air-conditioning and refrigerating equipment circuit conductors protected in accordance with Parts C and F of Article 440.

Exception No. 4: Remote-Control Circuits. Where not in the same cable with communication circuits, as provided in Section 725-5, conductors of remote-control circuits other than motor-control circuits shall be considered as protected by overcurrent devices that are rated or set at not more than 300 percent of the ampacity of the remote-control conductors.

Exception No. 5: Transformer Secondary Conductors. Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary shall be considered as protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with Section 450-3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the secondary-to-primary transformer voltage ratio.

240-4. Protection of Fixture Wires and Cords. Fixture wire or flexible cord, size No. 16 or No. 18, and tinsel cord shall be considered as protected by 20-ampere overcurrent devices. Fixture wires of the sizes permitted for taps in Section 210-19(c) shall be considered as protected by the overcurrent protection of the 30-, 40-, and 50-ampere branch circuits of Article 210. Flexible cord approved for use with specific appliances shall be considered as protected by the overcurrent device of the branch circuit of Article 210 when conforming to the following:

- 20-ampere circuits, No. 18 cord and larger.
- 30-ampere circuits, cord of 10-ampere capacity and over.
- 40-ampere circuits, cord of 20-ampere capacity and over.
- 50-ampere circuits, cord of 20-ampere capacity and over.

240-6. Standard Ampere Ratings. The standard ampere ratings for fuses and inverse time circuit breakers shall be considered 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000.

240-8. Fuses or Circuit Breakers in Parallel. Fuses, circuit breakers, or combinations thereof shall not be connected in parallel.

Exception: Circuit breakers assembled in parallel that are tested and approved for the purpose.

240-9. Thermal Devices. Thermal cutouts, thermal relays, and other devices not designed to open short circuits shall not be used for the protection of conductors against overcurrent due to short circuits or

grounds but the use of such devices shall be permitted to protect motor-branch-circuit conductors from overload if protected in accordance with Section 430-40.

240-10. Supplementary Overcurrent Protection. Where supplementary overcurrent protection is used for lighting fixtures, appliances, and other equipment or for internal circuits and components of equipment, it shall not be used as a substitute for branch-circuit overcurrent devices or in place of the branch-circuit protection specified in Article 210. Supplementary overcurrent devices shall not be required to be readily accessible.

240-11. Definition of Current-Limiting Overcurrent Protective Device. A current-limiting overcurrent protective device is a device which, when interrupting currents in its current-limiting range, will reduce the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device were replaced with a solid conductor having comparable impedance.

B. Location

240-20. Ungrounded Conductors.

(a) **Overcurrent Device Required.** A fuse or an overcurrent trip unit of a circuit breaker shall be connected in series with each ungrounded conductor. A combination of a current transformer and overcurrent relay shall be considered equivalent to an overcurrent trip unit.

For motor circuits, see Parts C, D, F, and J of Article 430.

(b) **Circuit Breaker As Overcurrent Device.** Circuit breakers shall open all ungrounded conductors of the circuit.

Exception: Individual single-pole circuit breakers shall be acceptable as the protection for 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 3-phase systems or 5-wire 2-phase systems, provided such lighting or appliance circuits are supplied from a system having a grounded neutral and no conductor in such circuits operates at a voltage greater than permitted in Section 210-6.

240-21. Location in Circuit. An overcurrent device shall be connected at the point where the conductor to be protected receives its supply.

Exception No. 1: Smaller Conductor Protected. Where the overcurrent device protecting the larger conductor also protects the smaller conductor in accordance with Tables 310-16 through 310-19.

Exception No. 2: Feeder Taps Not Over 10 Feet Long. For conductors tapped to a feeder or transformer secondary where all of the following conditions are met:

a. *The length of the tap conductors does not exceed 10 feet.*

b. *The ampacity of the tap conductors is: (1) not less than the combined computed loads on the circuits supplied by the tap conductors, and (2) not less than the ampere rating of the switchboard, panelboard, or control device supplied by the tap conductors unless they are terminated in an overcurrent protective device not exceeding the ampacity of the tap conductors.*

c. The tap conductors do not extend beyond the switchboard, panelboard, or control devices they supply.

d. Except at the point of connection to the feeder, the tap conductors are enclosed in a raceway, which shall extend from the tap to the enclosure of an enclosed switchboard, panelboard, or control devices, or to the back of an open switchboard.

See Section 384-16(a) for lighting and appliance branch-circuit panelboards.

Exception No. 3: Feeder Taps Not Over 25 Feet Long. For conductors tapped to a feeder where all of the following conditions are met:

a. The length of the tap conductors does not exceed 25 feet.

b. The ampacity of the tap conductors is not less than $1/3$ that of the feeder conductors from which they are supplied.

c. The tap conductors terminate with a single circuit breaker or a single set of fuses that will limit the load to the ampacity of the tap conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side.

d. The tap conductors are suitably protected from physical damage.

Exception No. 4: Service Conductors. For service-entrance conductors where protected in accordance with Section 230-91.

Exception No. 5: Branch-Circuit Taps. Taps to individual outlets and circuit conductors supplying a single household electric range shall be considered as protected by the branch-circuit overcurrent devices when in accordance with the requirements of Sections 210-19, 210-20, and 210-24.

Exception No. 6: Motor Circuit Taps. For motor-branch-circuit conductors where protected in accordance with Sections 430-28 and 430-53.

Exception No. 7: Busway Taps. For busways where protected in accordance with Sections 364-9 through 364-13.

Exception No. 8: Transformer Feeder Taps with Primary Plus Secondary Not Over 25 Feet Long. Where all of the following conditions are met:

a. The conductors supplying the primary of a transformer have an ampacity at least $1/3$ that of the conductors or overcurrent protection from which they are tapped, and

b. The conductors supplied by the secondary of the transformer have an ampacity that, when multiplied by the ratio of the secondary-to-primary voltage, is at least $1/3$ the ampacity of the conductors or overcurrent protection from which the primary conductors are tapped, and

c. The total length of one primary plus one secondary conductor, excluding any portion of the primary conductor that is protected at its ampacity, is not over 25 feet, and

d. The primary and secondary conductors are suitably protected from physical damage, and

e. The secondary conductors terminate in a single circuit breaker or set of fuses which will limit the load to that allowed in Tables 310-16 through 310-19.

240-22. Grounded Conductors. No overcurrent device shall be connected in series with any conductor that is intentionally grounded.

Exception No. 1: Where the overcurrent device opens all conductors of the circuit, including the grounded conductor, and is so designed that no pole can operate independently.

Exception No. 2: Where required by Sections 430-36 and 430-37 for motor running (overload) protection.

240-23. Change in Size of Grounded Conductor. Where a change occurs in the size of the ungrounded conductor, a similar change may be made in the size of the grounded conductor.

240-24. Location in or on Premises.

(a) Readily Accessible. Overcurrent devices shall be readily accessible.

Exception No. 1: For services as provided in Section 230-91.

Exception No. 2: For busways as provided in Section 364-11.

Exception No. 3: For supplementary overcurrent protection as described in Section 240-10.

(b) Occupant to Have Ready Access. Each occupant shall have ready access to all overcurrent devices protecting the conductors supplying his occupancy.

Exception: In a multiple-occupancy building where electric service and electrical maintenance are provided by the building management and where these are under continuous building management supervision, the service overcurrent devices and feeder overcurrent devices supplying more than one occupancy shall be permitted to be accessible to authorized management personnel only.

(c) Not Exposed to Damage. Overcurrent devices shall be located where they will not be exposed to physical damage.

(d) Not in Vicinity of Easily Ignitable Material. Overcurrent devices shall not be located in the vicinity of easily ignitable material.

C. Enclosures

240-30. General. Overcurrent devices shall be enclosed in cabinets or cutout boxes.

Exception No. 1: Where a part of an assembly that provides equivalent protection.

Exception No. 2: Where mounted on open-type switchboards, panelboards, or control boards that are in rooms or enclosures free from dampness and easily ignitable material and accessible only to qualified personnel.

Exception No. 3: The operating handle of a circuit breaker shall be permitted to be accessible without opening a door or cover.

240-32. Damp or Wet Locations. Enclosures for overcurrent devices in damp or wet locations shall be of a type approved for the purpose and shall be mounted so there is at least $\frac{1}{4}$ -inch air space between the enclosure and the wall or other supporting surface.

240-33. Vertical Position. Enclosures for overcurrent devices shall be mounted in a vertical position unless in individual instances this is shown to be impracticable.

D. Disconnecting and Guarding

240-40. Disconnecting Means for Fuses and Thermal Cutouts. Disconnecting means shall be provided on the supply side of all fuses or thermal cutouts in circuits of over 150 volts to ground and cartridge fuses in circuits of any voltage, where accessible to other than qualified persons, so that each individual circuit containing fuses or thermal cutouts can be independently disconnected from the source of electric energy.

Exception No. 1: Where fuses are permitted on the supply side of the service disconnecting means as provided by Section 230-82.

Exception No. 2: A single disconnecting means shall be permitted on the supply side of more than one set of fuses as provided by Section 430-112 for group operation of motors and in Section 424-22 for fixed electric space heating equipment.

240-41. Arcing or Suddenly Moving Parts. Arcing or suddenly moving parts shall comply with (a) and (b) below.

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

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

E. Plug Fuses, Fuseholders, and Adapters

240-50. General.

(a) **Maximum Voltage.** Plug fuses and fuseholders shall not be used in circuits exceeding 125 volts between conductors.

Exception: In circuits supplied by a system having a grounded neutral and having no conductor at over 150 volts to ground.

(b) **Marking.** Each fuse, fuseholder, and adapter shall be marked with its ampere rating.

(c) **Hexagonal Configuration.** Plug fuses of 15-ampere and lower rating shall be identified by a hexagonal configuration of the window, cap, or other prominent part to distinguish them from fuses of higher ampere ratings.

(d) **No Live Parts.** Plug fuses, fuseholders, and adapters shall have no exposed live parts after fuses or fuses and adapters have been installed.

(e) **Screw-Shell.** The screw-shell of a plug-type fuseholder shall be connected to the load side of the circuit.

240-51. Edison-Base Fuses.

(a) **Classification.** Plug fuses of the Edison-base type shall be classified at not over 125 volts and 0 to 30 amperes.

(b) **Replacement Only.** Plug fuses of the Edison-base type shall be used only for replacements in existing installations where there is no evidence of overfusing or tampering.

240-52. Edison-Base Fuseholders. Fuseholders of the Edison-base type shall be installed only where they are made to accept Type S fuses by the use of adapters approved for the purpose.

240-53 Type S Fuses. Type S fuses shall be of the plug type and shall comply with (a) and (b) below.

(a) **Classification.** Type S fuses shall be classified at not over 125 volts and 0 to 15 amperes, 16 to 20 amperes, and 21 to 30 amperes.

(b) **Noninterchangeable.** Type S fuses of an ampere classification as specified in (a) above shall not be interchangeable with a lower ampere classification. They shall be so designed that they cannot be used in any fuseholder other than a Type S fuseholder or a fuseholder with a Type S adapter inserted.

240-54. Type S Fuses, Adapters, and Fuseholders.

(a) **To Fit Edison-Base Fuseholders.** Type S adapters shall fit Edison-base fuseholders.

(b) **To Fit Type S Fuses Only.** Type S fuseholders and adapters shall be so designed that either the fuseholder itself or the fuseholder with a Type S adapter inserted cannot be used for any fuse other than a Type S fuse.

(c) **Nonremovable.** Type S adapters shall be so designed that once inserted in a fuseholder, they cannot be removed.

(d) **Nontamperable.** Type S fuses, fuseholders, and adapters shall be so designed that tampering or shunting (bridging) would be difficult.

(e) **Interchangeability.** Dimensions of Type S fuses, fuseholders, and adapters shall be standardized to permit interchangeability regardless of the manufacturer.

F. Cartridge Fuses and Fuseholders

240-60. General.

(a) **Maximum Voltage — 300-Volt Type.** Cartridge fuses and fuseholders of the 300-volt type shall not be used in circuits of over 300 volts between conductors.

Exception: In circuits supplied by a system having a grounded neutral and having no conductor at over 300 volts to ground.

(b) **Noninterchangeable — 0-6000 Ampere Cartridge Fuseholders.** Fuseholders shall be so designed that it will be difficult to put a fuse of any given class into a fuseholder that is designed for a current lower, or voltage higher, than that of the class to which it belongs. Fuseholders for current-limiting fuses shall not permit insertion of fuses that are not current limiting.

(c) **Marking.** Fuses shall be plainly marked, either by printing on the fuse barrel or by a label attached to the barrel, showing the following: (1) Ampere rating; (2) Voltage rating; (3) Interrupting rating where other than 10,000 amperes; (4) "Current Limiting" where applicable; (5) The name or trademark of the manufacturer.

Exception: Interrupting rating marking shall not be required on fuses used for supplementary protection.

240-61. Classification.

(a) **0 through 600 Amperes.** Cartridge fuses and fuseholders of 0 through 600 amperes shall be classified as follows:

Not over 250 Volts Amperes	Not over 300 Volts Amperes	Not over 600 Volts Amperes
0- 30	0-15	0- 30
31- 60	16-20	31- 60
61-100	21-30	61-100
101-200	31-60	101-200
201-400	-	201-400
401-600	-	401-600

(b) **601 through 6000 Amperes.** Cartridge fuses and fuseholders of 601 through 6000 amperes shall be classified as follows:

Not over 600 Volts Amperes		
601- 800	1601-2000	3001-4000
801-1200	2001-2500	4001-5000
1201-1600	2501-3000	5001-6000

There are no 250-volt fuses with current ratings over 600 amperes, but the use of 600-volt fuses and fuseholders shall be permitted for lower voltages.

G. Circuit Breakers

240-80. Method of Operation. Circuit breakers shall be trip free and capable of being closed and opened by manual operation. Their normal method of operation by other than manual means such as electrical or pneumatic shall be permitted if means for manual operation is also provided.

240-81. Indicating. Circuit breakers shall clearly indicate whether they are in the open (off) or closed (on) position.

Where circuit breaker handles on switchboards are operated vertically rather than rotationally or horizontally, the up position of the handle shall be the ON position.

240-82. Nontamperable. A circuit breaker shall be of such design that any alteration of its trip point (calibration) or the time required for its operation will require dismantling of the device or breaking of a seal for other than intended adjustments.

240-83. Marking.

(a) **Durable and Visible.** Circuit breakers shall be marked with their rating in a manner that will be durable and visible after installation. Such marking shall be required to be visible after removal of a trim or cover.

(b) **Location.** Circuit breakers rated at 100 amperes or less and 600 volts or less shall have the ampere rating molded, stamped, etched, or similarly marked into their handles or escutcheon areas.

(c) **Interrupting Rating.** Every circuit breaker having an interrupting

rating other than 5000 amperes shall have its interrupting rating shown on the circuit breaker.

Exception: Interrupting rating marking shall not be required on circuit breakers used for supplementary protection.

H. Overcurrent Protection Over 600 Volts, Nominal

240-100. Feeders. Feeders shall have a short circuit protective device in each ungrounded conductor. The protective device(s) shall be capable of detecting and interrupting all values of current which can occur at their location in excess of their trip setting or melting point. A fuse rated in continuous amperes not to exceed three times the ampacity of the conductor or a breaker having a trip setting of not more than six times the ampacity of the conductor shall be considered as providing the required short circuit protection. See Tables 310-39 through 310-50 for ampacities of high voltage conductors.

240-101. Branch Circuits. Branch circuits shall have a short circuit protective device in each ungrounded conductor. The protective device(s) shall be capable of detecting and interrupting all values of current which can occur at their location in excess of their trip setting or melting point. See Tables 310-39 through 310-50 for ampacities of high voltage conductors.

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ARTICLE 250 — GROUNDING

A. General

250-1. Scope. This Article covers general requirements for grounding and bonding of electrical installations, and specific requirements in (a) through (g) below.

(a) Systems, circuits, and equipment required, permitted, or not permitted to be grounded.

(b) Circuit conductor to be grounded on grounded systems.

(c) Location of grounding connections.

(d) Types and sizes of grounding and bonding conductors and electrodes.

(e) Methods of grounding and bonding.

(f) Conditions under which guards, isolation, or insulation may be substituted for grounding.

(g) Connections for lightning arresters.

Circuits are grounded to limit excessive voltages from lightning, line surges, or unintentional contact with higher voltage lines and to limit the voltage to ground during normal operation.

Conductive materials enclosing electric conductors or equipment, or forming part of such equipment, are grounded for the purpose of preventing a voltage above ground on these materials.

Circuits and enclosures are grounded to facilitate overcurrent device operation in case of insulation failure or ground faults. See Section 110-10.

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

	Article	Section
Appliances		422-16
Branch Circuits		210-5
		210-6
		210-7
		365-9
Cablebus		
Circuits and Equipment Operating at Less Than 50 Volts	720	
Class 1, Class 2, and Class 3 Circuits		725-20
		725-42
Communications Circuits	800	
Community Antenna Television and Radio Dis- tribution Systems		820-7
		820-22
		820-23
Conductors	310	
Conductors (Grounded)	200	
Cranes and Hoists	610	
Data Processing Systems		645-4
Electrically Driven or Controlled Irrigation Ma- chines		675-8
		675-9
		675-10
		675-11
		366-14
Electrical Floor Assemblies		
Electric Signs and Outline Lighting	600	
Elevators, Dumbwaiters, Escalators, and Moving Walks	620	
Fire Protective Signaling Systems		760-6
Fixed Electric Heating Equipment for Pipeline and Vessels		427-26
Fixed Electric Space Heating Equipment		424-14
Fixed Outdoor Electric De-Icing and Snow Melt- ing Equipment		426-28
Fixtures and Lighting Equipment		410-17
		410-18
		410-19
		410-20
		410-21
Flexible Cords		400-22
		400-23
Generators		445-8
Grounding-Type Receptacles (Outlets)		210-7
Hazardous Locations	500-517	
Health Care Facilities	517	
Induction and Dielectric Heating Equipment ...	665	

	Article	Section
Lighting Fixtures, Lampholders, Lamp Receptacles, and Rosettes	410	
Marinas and Boatyards		555-7
Metalworking Machine Tools	670	
Mobile Homes and Mobile Home Parks	550	
Motion Picture Studios and Similar Locations ..		530-20 530-66
Motors, Motor Circuits, and Controllers	430	
Organs	650	
Outlet, Switch and Junction Boxes, and Fittings		370-4 370-15 384-27
Panelboards		
Radio and Television Equipment	810	
Receptacles and Attachment Plugs		410-58
Recreational Vehicles and Recreational Vehicle Parks	551	
Services	230	
Service Equipment		230-63 640-4
Sound Recording and Similar Equipment		
Swimming Pools, Fountains and Similar Installations	680	
Switchboards and Panelboards		384-3(c) 384-11
Switches		380-1 380-12
Theaters and Similar Locations		520-81
Transformers and Transformer Vaults		450-9
X-ray Equipment	660	

B. Circuit and System Grounding

250-3. Direct-Current Systems.

(a) **Two-Wire Direct Current Systems.** Two-wire DC systems supplying premises wiring shall be grounded.

Exception No. 1: A system equipped with a ground detector and supplying only industrial equipment in limited areas.

Exception No. 2: A system operating at 50 volts or less between conductors.

Exception No. 3: A system operating at over 300 volts between conductors.

Exception No. 4: A rectifier derived DC system supplied from a grounded AC system.

Exception No. 5: DC Fire Protective Signaling Circuits having a maximum current of 0.030 amperes as specified in Article 760, Part C.

(b) **Three-Wire Direct-Current Systems.** The neutral conductor of all 3-wire DC systems supplying premises wiring shall be grounded.

250-5. Alternating-Current Circuits and Systems to Be Grounded. AC circuits and systems shall be grounded as provided for in (a), (b), (c), or (d) below. Other circuits and systems shall be permitted to be grounded.

(a) Alternating-Current Circuits of Less Than 50 Volts. AC circuits of less than 50 volts shall be grounded under any of the following conditions:

(1) Where supplied by transformers if the transformer supply system exceeds 150 volts to ground.

(2) Where supplied by transformers if the transformer supply system is ungrounded.

(3) Where installed as overhead conductors outside of buildings.

(b) Alternating-Current Systems of 50 Volts to 1000 V. AC systems of 50 volts to 1000 volts supplying premises wiring and premises wiring systems shall be grounded under any of the following conditions:

(1) Where the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts.

(2) Where the system is nominally rated 480Y/277-volt, 3-phase; 4-wire in which the neutral is used as a circuit conductor.

(3) Where the system is nominally rated 240/120-volt, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor.

(4) Where a service conductor is uninsulated in accordance with Section 230-4.

Exception No. 1: Electric systems used exclusively to supply industrial electric furnaces for melting, refining, tempering, and the like.

Exception No. 2: Separately derived systems used exclusively for rectifiers supplying only adjustable speed industrial drives.

The proper use of suitable ground detectors on ungrounded systems can provide additional protection.

(c) Alternating-Current Systems of 1 KV and Over. AC systems of 1 kV and over supplying portable equipment shall be grounded. Where supplying other than portable equipment, such systems shall be permitted to be grounded. Where such systems are grounded, they shall comply with the applicable provisions of this Article.

(d) Separately Derived Systems. A premises wiring system whose power is derived from generator, transformer, or converter windings that have no direct electrical connection to supply conductors originating in another supply system, if required to be grounded as in (a) or (b) above, shall be grounded as specified in Section 250-26.

250-6. Portable and Vehicle Mounted Generators.

(a) Portable Generators. The frame of a portable generator shall not be required to be grounded under the following conditions:

(1) The generator supplies only equipment mounted on the generator and/or cord and plug connected equipment through receptacles mounted on the generator, and

(2) The non-current carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame.

(b) Vehicle Mounted Generators. Under the following conditions the frame of a vehicle shall be permitted to serve as the grounding electrode for a system supplied by a generator located on the vehicle:

- (1) The frame of the generator is bonded to the vehicle frame, and
- (2) The generator supplies only equipment located on the vehicle and/or cord and plug connected equipment through receptacles mounted on the vehicle or on the generator, and
- (3) The system complies with all other provisions of this Article.

(c) **Neutral Conductor Bonding.** A neutral conductor shall be bonded to the generator frame. The bonding of any conductor other than a neutral within the generator to its frame shall not be required.

For grounding of portable generators supplying fixed wiring systems, see Section 250-5(d).

250-7. Circuits Not to Be Grounded. The following circuits shall not be grounded:

- (a) Circuits for electric cranes operating over combustible fibers in Class III locations, as provided in Section 503-13.
- (b) Circuits as provided in Article 517.

C. Location of System Grounding Connections

250-21. Objectionable Current over Grounding Conductors.

(a) **Arrangement to Prevent Objectionable Current.** The grounding of electric systems, circuit conductors, lightning arresters, and conductive noncurrent-carrying materials and equipment shall be installed and arranged in a manner that will prevent an objectionable flow of current over the grounding conductors or grounding paths.

(b) **Alterations to Stop Objectionable Current.** If the use of multiple grounding connections results in an objectionable flow of current, one or more of the following alterations shall be made:

- (1) Discontinue one or more such grounding connections.
- (2) Change the locations of the grounding connections.
- (3) Interrupt the continuity of the conductor or conductive path interconnecting the grounding connections.
- (4) Take other suitable remedial action satisfactory to the authority having jurisdiction.

(c) **Temporary Currents Not Classified As Objectionable Currents.** Temporary currents resulting from accidental conditions, such as ground-fault currents, that occur only while the grounding conductors are performing their intended protective functions shall not be classified as objectionable current for the purposes specified in (a) and (b) above.

250-22. Point of Connection for Direct-Current Systems. DC systems to be grounded shall have the grounding connection made at one or more supply stations. A grounding connection shall not be made at individual services nor at any point on premises wiring.

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

(a) An ac system that is grounded on the premises shall have a grounding electrode conductor connected to a grounding electrode at each service. Such supply systems that originate outside the building shall have at least one additional grounding connection made to a grounding electrode on the secondary side of the transformer supplying the system, either at the transformer or elsewhere. The grounding electrode conductor shall be connected to the ac system on the supply

side of the service disconnecting means at any convenient, accessible point on the premises, preferably within the enclosure for the service disconnecting means. Grounding connections shall not be made on the load side of the service disconnecting means.

Exception No. 1: A grounding conductor shall be connected to each separately derived system as provided in Section 250-26.

Exception No. 2: A grounding conductor connection shall be made at each separate building where required by Section 250-24.

Exception No. 3: For ranges, counter-mounted cooking units, wall-mounted ovens, clothes dryers and meter enclosures as permitted by Section 250-61.

Exception No. 4: For services that are dual fed (double ended) in a common enclosure or grouped together in separate enclosures and employing a secondary tie, a single grounding electrode connection to the tie point of the grounded circuit conductors from each power source shall be permitted.

(b) Grounded Conductor Brought to Service Equipment. Where an AC system operating at 1000 volts or less is grounded at any point, the grounded conductor shall be run to each service. This conductor shall be routed with the phase conductors and shall not be smaller than the required grounding electrode conductor specified in Table 250-94 and, in addition, for service phase conductors larger than 1100 MCM, the grounded conductor shall not be smaller than 12½ percent of the area of the largest phase conductor.

Exception: The grounded conductor shall not be required to be larger than the largest ungrounded service conductor.

250-24. Two or More Buildings Supplied from Single Service Equipment.

(a) Grounded Systems: Where two or more buildings are supplied by a grounded system from a single service equipment, each building shall have a grounding electrode connected to the AC system grounded circuit conductor on the supply side of the building disconnecting means.

(b) Ungrounded Systems: Where two or more buildings are supplied by an ungrounded system from a single service equipment, each building shall have a grounding electrode connected to the metal enclosure of the building disconnecting means.

Exception for (a) and (b) above: A grounding electrode at a separate building shall not be required where the conditions of either (1) or (2) below are met:

(1) Only one branch circuit is supplied and there is no equipment in the building that requires grounding.

(2) No livestock is housed in the building, an equipment grounding conductor is run with the circuit conductors for grounding any non-current carrying equipment, interior metal piping systems or building metal frames and the equipment grounding conductor is bonded to grounding electrodes described in Sections 250-81, 82, and 83 which exist at the building.

250-25. Conductor to Be Grounded — Alternating-Current Systems. For AC premises wiring systems, the conductor to be grounded shall be as specified in (a) through (e) below.

(a) Single-phase, 2-wire: the identified conductor.

(b) Single-phase, 3-wire: the identified neutral conductor.

(c) Multiphase systems having one wire common to all phases: the identified common conductor.

(d) Multiphase systems having one phase grounded: the identified conductor.

(e) Multiphase systems in which one phase is used as in (b) above: the identified neutral conductor.

See Article 200 for means of identification.

250-26. Grounding Separately Derived Alternating-Current Systems. A separately derived AC system that is required to be grounded by Section 250-5 shall be grounded as specified in (a) through (d) below.

(a) A bonding jumper, sized in accordance with Section 250-79(c) for the derived phase conductors, shall be used to connect the system noncurrent-carrying equipment enclosures to the system circuit conductor that is to be grounded. Except as permitted by Exception No. 4 of Section 250-23(a), this connection shall be made on the supply side of the separately derived system and ahead of any system disconnecting means or overcurrent device.

(b) A grounding conductor, sized in accordance with Section 250-94 for the derived phase conductors, shall be used to connect the circuit conductor of the system that is to be grounded to the grounding electrode as specified in (c) below. Except as permitted by Exception No. 4 of Section 250-23(a), this connection shall be made on the supply side of the separately derived system and ahead of any system disconnecting means or overcurrent device.

(c) The grounding electrode shall be as near as practicable to and preferably in the same area as the grounding conductor connection to the system. The grounding electrode shall be: (1) The nearest available effectively grounded structural metal member of the structure; or (2) The nearest available effectively grounded metal water pipe; or (3) Other electrodes as specified in Sections 250-82 and 250-83 where electrodes specified by (1) or (2) above are not available.

(d) In all other respects, grounding methods shall comply with requirements prescribed in other parts of this Code.

D. Enclosure Grounding

250-32. Service Raceways and Enclosures. Metal enclosures for service conductors and equipment shall be grounded.

250-33. Other Conductor Enclosures. Metal enclosures for other than service conductors shall be grounded.

Exception No. 1: Metal enclosures for conductors added to existing installations of open wire, knob and tube wiring, and nonmetallic-sheathed cable, if in runs of less than 25 feet, if free from probable contact with ground, grounded metal, metal lath, or other conductive

material; and if guarded against contact by persons shall not be required to be grounded.

Exception No. 2: Metal enclosures used to protect cable assemblies from physical damage shall not be required to be grounded.

E. Equipment Grounding

250-42. Fixed Equipment, General. Exposed noncurrent-carrying metal parts of fixed equipment likely to become energized under abnormal conditions shall be grounded under any of the conditions specified in (a) through (f) below.

(a) Where within 8 feet vertically or 5 feet horizontally of ground or grounded metal objects and subject to contact by persons.

(b) Where located in a wet or damp location and not isolated.

(c) Where in electrical contact with metal.

(d) Where in a hazardous location as covered by Articles 500 through 517.

(e) Where supplied by a metal-clad, metal-sheathed, or metal-raceway wiring method, except as permitted by Section 250-33 for short sections of raceway.

(f) Where equipment operates with any terminal at over 150 volts to ground.

Exception No. 1: Enclosures for switches or circuit breakers used for other than service equipment and accessible to qualified persons only.

Exception No. 2: Metal frames of electrically heated devices, exempted by special permission, in which case the frames shall be permanently and effectively insulated from ground.

Exception No. 3: Distribution apparatus, such as transformer and capacitor cases, mounted on wooden poles, at a height exceeding 8 feet above ground or grade level.

250-43. Fixed Equipment — Specific. Exposed, noncurrent-carrying metal parts of the kinds of equipment described in (a) through (i) below, regardless of voltage, shall be grounded:

(a) Switchboard frames and structures supporting switching equipment.

Exception: Frames of DC, single-polarity switchboards where effectively insulated.

(b) Generator and motor frames in an electrically operated organ.

Exception: Where the generator is effectively insulated from ground and from the motor driving it.

(c) Motor frames, as provided by Section 430-142.

(d) Enclosures for motor controllers.

Exception: Lined covers of snap switches.

(e) Electric equipment for elevators and cranes.

(f) Electric equipment in garages, theaters, and motion picture studios.

Exception: Pendant lampholders supplied by circuits not over 150 volts to ground.

(g) Electric signs and associated equipment.

Exception: Where insulated from ground and from other conductive objects and accessible only to authorized persons.

(h) Motion picture projection equipment.

(i) Equipment supplied by Class 1 and Class 2 remote-control and signaling circuits where required to be grounded by Part B of this Article.

250-44. Nonelectrical Equipment. The metal parts of nonelectrical equipment described in (a) through (e) below shall be grounded.

(a) Frames and tracks of electrically operated cranes.

(b) Frames of nonelectrically driven elevator cars to which electric conductors are attached.

(c) Hand-operated metal shifting ropes or cables of electric elevators.

(d) Metal partitions, grill work, and similar metal enclosures around equipment of over 750 volts between conductors except substations or vaults under the sole control of the supply company.

(e) Mobile homes and recreational vehicles as required in Articles 550 and 551.

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

250-45. Equipment Connected by Cord and Plug. Under any of the conditions described in (a) through (d) below, exposed noncurrent-carrying metal parts of cord- and plug-connected equipment likely to become energized, shall be grounded.

(a) In hazardous locations (see Articles 500 through 517).

(b) Where operated at over 150 volts to ground.

Exception No. 1: Motors, where guarded.

Exception No. 2: Metal frames of electrically heated appliances exempted by Section 422-16.

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

Exception: Listed portable tools and appliances protected by a system of double insulation, or its equivalent, shall not be required to be grounded. Where such a system is employed, the equipment shall be distinctively marked.

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

(d) In other than residential occupancies: (1) refrigerators, freezers, and air conditioners; (2) clothes-washing, clothes-drying, dish-washing machines, and sump pumps; (3) portable, hand-held, motor-operated tools and appliances of the following types: drills, hedge clippers, lawn mowers, wet scrubbers, sanders, and saws; (4) cord- and plug-connected 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 (5) portable tools likely to be used in wet and conductive locations.

Exception No. 1: Portable tools likely to be used in wet and conductive locations shall not be required to be grounded where supplied through an isolating transformer with an ungrounded secondary of not over 50 volts.

Exception No. 2: Listed portable tools and appliances protected by an approved system of double insulation, or its equivalent, shall not be required to be grounded. Where such a system is employed, the equipment shall be distinctively marked.

250-46. Spacing From Lightning Rods. Metal raceways, enclosures, frames, and other noncurrent-carrying metal parts of electric equipment shall be kept at least 6 feet away from lightning rod conductors, or they shall be bonded to the lightning rod conductors.

See Sections 250-86 and 800-31(b)(5). For further information see the Lightning Protection Code (NFPA No. 78 — 1968. ANSI C5.1 — 1969) which contains detailed information on grounding lightning protection systems.

F. Methods of Grounding

250-50. Equipment Grounding Connections. The grounding connection for metal noncurrent-carrying equipment shall be made on the supply side of the service disconnecting means or as outlined in Section 250-5(d) if for a separately derived system.

(a) For Grounded System. The connection shall be made by bonding the equipment grounding conductor to the grounded circuit conductor and the grounding electrode conductor.

(b) For Ungrounded System. The connection shall be made by bonding the equipment grounding conductor to the grounding electrode conductor.

Exception for (a) and (b) above: For branch-circuit extensions only in existing installations that do not have a grounding conductor in the branch circuit, the grounding conductor of a grounding-type receptacle outlet shall be permitted to be grounded to a grounded cold water pipe near the equipment.

250-51. Effective Grounding Path. The path to ground from circuits, equipment, and conductor enclosures shall:

(a) Be permanent and continuous.

(b) Have capacity to conduct safely any fault current likely to be imposed on it.

(c) Have sufficiently low impedance to limit the voltage to ground and to facilitate the operation of the circuit protective devices in the circuit.

250-53. Grounding Path to Grounding Electrode.

(a) Grounding Electrode Conductor. A grounding electrode conductor shall be used to connect the equipment grounding conductors, the service-equipment enclosures and, where the system is grounded, the grounded conductor to the grounding electrode.

(b) Main Bonding Jumper. For a grounded system, an unspliced main bonding jumper shall be used to connect the equipment grounding conductor and the service-equipment enclosure to the grounded conductor of the system within the service equipment or within the service conductor enclosure. A main bonding jumper shall be a wire, bus, screw, or similar suitable conductor.

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

Two or more electrodes that are effectively bonded together shall be considered as a single electrode in this sense.

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

250-56. Short Sections of Raceway. Isolated sections of metal raceway or cable armor, where required to be grounded, shall be grounded in accordance with Section 250-57.

250-57. Fixed Equipment Grounding. Metal noncurrent-carrying equipment where required to be grounded shall be grounded by one of the methods indicated in (a), (b), or (c) below.

(a) By any of the grounding means permitted by Section 250-91(b).

(b) By an equipment grounding conductor contained within the same raceway, cable, or cord or otherwise run with the circuit conductors. An insulating equipment grounding conductor shall be permitted, but if individually covered shall have a continuous outer finish that is either green, or green with one or more yellow stripes.

Exception No. 1: An insulated grounding conductor larger than No. 6 shall, at the time of installation be permitted to be suitably identified as a grounding conductor at each end and at every point where the conductor is accessible. Identification shall be accomplished by one of the following:

a. Stripping the insulation from the entire exposed length,

b. Coloring the exposed insulation green, or

c. Marking the exposed insulation with green colored tape or green colored adhesive labels.

Exception No. 2: For direct-current circuits only, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors.

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

See Section 400-7 for use of cords for fixed equipment.

250-58. Equipment Considered Effectively Grounded. The following noncurrent-carrying equipment, under the conditions specified in (a) and (b) below, shall be considered effectively grounded:

(a) **Equipment Secured to Grounded Structural Metal.** Electric equipment secured to, and in metallic contact with, the grounded structural metal frame of a building.

(b) **Metal Car Frames.** Metal car frames supported by metal hoisting cables attached to or running over metal sheaves or drums of grounded elevator machines.

250-59. Cord- and Plug-Connected Equipment. Noncurrent-carrying metal parts of cord- and plug-connected equipment, where required to be grounded, shall be grounded by one of the methods indicated in (a), (b), or (c) below.

(a) By means of the metal enclosure of the conductors supplying such equipment if grounding-type attachment plug with one fixed grounding contact is used for grounding the metal enclosure, and if the metal enclosure of the conductors is secured to the attachment plug and to equipment by connectors approved for the purpose.

Exception: A self-restoring grounding contact shall be permitted on grounding-type attachment plugs used on the power supply cord of portable hand-held, hand-guided, or hand-supported tools or appliances.

(b) By means of a grounding conductor run with the power supply conductors in a cable assembly or flexible cord properly terminated in grounding-type attachment plug with one fixed grounding contact. An uninsulated grounding conductor shall be permitted but, if individually covered, the covering shall have a continuous outer finish that is either green or green with one or more yellow stripes.

Exception: A self-restoring grounding contact shall be permitted on grounding-type attachment plugs used on the power supply cord of portable hand-held, hand-guided, or hand-supported tools or appliances.

(c) By means of a separate flexible wire or strap, insulated or bare, protected as well as practicable against physical damage, where part of an approved portable equipment, or by special permission.

250-60. Frames of Ranges and Clothes Dryers. Frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, and clothes dryers shall be grounded in the manner specified by Section 250-57 or 250-59; or except for mobile homes or travel trailers shall be permitted to be grounded to the grounded circuit conductor if all of the conditions indicated in (a) through (d) below are met.

(a) The supply circuit is 120/240-volt, single-phase, 3-wire; or 120/208-volt derived from a 3-phase, 4-wire, wye-connected system.

(b) The grounded conductor is not smaller than No. 10.

(c) The grounded conductor is insulated; or the grounded conductor is uninsulated and part of a service entrance cable and the branch circuit originates at the service equipment.

(d) Grounding contacts of receptacles furnished as part of the equipment are bonded to the equipment.

250-61. Use of Grounded Circuit Conductor for Grounding Equipment.

(a) Supply-Side Equipment. A grounded circuit conductor shall be permitted to ground noncurrent-carrying equipment on the supply side of the service disconnecting means, such as meter enclosures, service raceways, etc., and on the supply side of the main disconnecting means of separate buildings and of separately derived systems as provided in Sections 250-24 and 250-26 respectively.

(b) Load-Side Equipment. A grounded circuit conductor shall not be used for grounding noncurrent-carrying equipment on the load side of the service disconnecting means or on the load side of a separately derived system disconnecting means or the overcurrent devices for a separately derived system not having a main disconnecting means.

Exception No. 1: The frames of ranges, wall-mounted ovens, counter-mounted cooking units, and clothes dryers under the conditions specified by Section 250-60.

Exception No. 2: As permitted in Section 250-24 for separate buildings.

Exception No. 3: It shall be permissible to ground meter enclosures by connection to the grounded circuit conductor on the load-side of the service disconnect if:

a. No service ground-fault protection is installed; and

b. All meter enclosures are located near the service disconnecting means.

Exception No. 4: By special permission as provided in Section 250-57 (c).

250-62. Multiple Circuit Connections. Where an installation of fixed or portable equipment is supplied by separate connection to more than one circuit or grounded interior wiring system, a means for grounding shall be provided for each such connection as specified in Sections 250-57 and 250-59.

G. Bonding

250-70. General. Bonding shall be provided where necessary to assure electrical continuity and the capacity to conduct safely any fault current likely to be imposed.

250-71. Bonding Service Equipment. The metal noncurrent-carrying equipment indicated in (a), (b), and (c) below shall be effectively bonded together.

(a) Except as permitted in Section 250-55, the service raceways or service cable armor or sheath.

(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 that forms part of the grounding conductor to the service raceway.

250-72. Method of Bonding Service Equipment. Electrical continuity at service equipment shall be assured by one of the methods specified in (a) through (e) below.

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

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

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

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

(e) Other devices, such as bonding-type locknuts and bushings, approved for the purpose.

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

250-74. Connecting Receptacle Grounding Terminal to Box. An equipment bonding jumper shall be used to connect the grounding terminal of a grounding-type receptacle to a grounded box.

Exception No. 1: Where the box is surface-mounted, direct metal-to-metal contact between the device yoke and the box shall be permitted to ground the receptacle to the box.

Exception No. 2: Contact devices or yokes designed and listed for the purpose shall be permitted in conjunction with the supporting screws to establish the grounding circuit between the device yoke and flush-type boxes.

Exception No. 3: Floor boxes designed for and listed as providing satisfactory ground continuity between the box and the device.

Exception No. 4: Where required for the reduction of electrical noise (electromagnetic interference) on the grounding circuit, a receptacle in which the grounding terminal is purposely insulated from the receptacle mounting means shall be permitted. The receptacle grounding terminal shall be grounded by an insulated equipment grounding conductor run with the circuit conductors. This grounding conductor shall be permitted to pass through one or more panelboards without connection to the panelboard grounding terminal as permitted in Section 384-27 Exception, so as to terminate directly at the applicable derived system or service grounding terminal.

250-75. Bonding Other Enclosures. Metal raceways, cable armor, cable sheath, enclosures, frames, fittings, and other metal noncurrent-carrying parts that are to serve as grounding conductors shall be effectively bonded where necessary to assure electrical continuity and the capacity to conduct safely any fault current likely to be imposed on them. Any nonconductive paint, enamel, or similar coating shall be removed at threads, contact points, and contact surfaces or be connected by means of fittings so designed as to make such removal unnecessary.

250-76. Bonding for Over 250 Volts. For circuits of over 250 volts to ground, the electrical continuity of metal raceways and cables with

metal sheaths that contain any conductor other than service conductors shall be assured by one or more of the methods specified for services in Section 250-72(b) through (e); or by (a) or (b) below.

(a) Threadless fittings made up tight, with conduit or metal-clad cable.

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

250-77. Bonding Loosely Jointed Metal Raceways. Expansion joints and telescoping sections of raceways shall be made electrically continuous by equipment bonding jumpers or other means approved for the purpose.

250-78. Bonding in Hazardous Locations. Regardless of the voltage of the electrical system, the electrical continuity of metal noncurrent-carrying equipment in any hazardous location as defined in Article 500 of this Code shall be assured by any of the methods specified for services in Section 250-72(b) through (e) that are approved for the wiring method used.

250-79. Main and Equipment Bonding Jumpers.

(a) **Material.** Main and equipment bonding jumpers shall be of copper or other corrosion-resistant material.

(b) **Attachment.** Main and equipment bonding jumpers shall be attached in the manner specified by the applicable provisions of Section 250-113 for circuits and equipment and by Section 250-115 for grounding electrodes.

(c) **Size — Equipment Bonding Jumper on Supply Side of Service and Main Bonding Jumper.** The bonding jumper shall not be smaller than the sizes given in Table 250-94 for grounding electrode conductors. Where the service-entrance phase conductors are larger than the sizes given in Table 250-94, the bonding jumper shall have an area not less than 12½ percent of the area of the largest phase conductor. Where the service-entrance conductors are paralleled in two or more raceways, the size of the bonding jumper for each raceway shall be based on the size of service conductors in each raceway.

(d) **Size — Equipment Bonding Jumper on Load Side of Service.** The equipment bonding jumper on the load side of the service overcurrent devices shall not be smaller than the sizes listed by Table 250-95 for equipment grounding conductors.

250-80. Bonding of Piping Systems. All interior metal water and gas piping that may become energized shall be bonded together and made electrically continuous. An equipment bonding jumper sized in accordance with Table 250-95 shall be connected between the bonded piping system(s) and the grounding electrode conductor at the service disconnecting means.

Bonding to sewer piping and metal air ducts within the premises will provide additional safety.

H. Grounding Electrodes

250-81. Water Pipe Electrode. Where available on the premises, a metal underground water pipe shall always be used as the grounding

electrode, regardless of its length and whether supplied by a community or a local underground water piping system or by a well on the premises. Where the buried portion of the water pipe (including any metal well casing effectively bonded to the pipe) is less than 10 feet long or where the water pipe is or is likely to be isolated by insulated sections or joints so that the effectively grounded portion is less than 10 feet long, it shall be supplemented by the use of an additional electrode of a type specified by Section 250-82 or 250-83. The interior metal cold water piping system shall always be bonded to the service-equipment enclosure, the grounded conductor at the service, the grounding electrode conductor where of sufficient size, or to the one or more grounding electrodes used.

Expanding use of nonmetallic piping for water systems and insulating couplings on metal water systems makes it more important that water piping within a building be adequately grounded without depending on connections to an outside piping system.

250-82. Other Available Electrodes. Where a water system as described in Section 250-81 is not available, the grounding connection shall be made to any of the electrodes specified in (a) through (d) below, where available.

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

(b) Concrete-encased steel reinforcing bar or rod systems of underground footings or foundations where the total rod length, diameter, and depth below earth surface are not less than 50 feet, $\frac{3}{8}$ inch, and $2\frac{1}{2}$ feet respectively. The required length shall be made up of one or more rods.

(c) An electrically continuous metal underground gas piping system that is uninterrupted with insulating sections or joints and without an outer nonconductive coating, and then only if acceptable to and expressly permitted by both the serving gas supplier and the authority having jurisdiction.

(d) Other local metal underground systems or structures, such as piping systems and underground tanks.

250-83. Made Electrodes. Where none of the electrodes specified in Sections 250-81 and 250-82 is available, one or more of the electrodes specified in (a), (b), or (c) below shall be used. Where practicable, electrodes shall be embedded below permanent moisture level. Where more than one electrode is used (including those used for signaling or communication circuits, radio or television installations, or lightning rods), each electrode shall not be less than 6 feet from any other electrode.

Two or more electrodes that are effectively bonded together are to be treated as a single electrode in this sense.

(a) **Concrete-Encased Electrodes.** Not less than 20 feet of (1) bare copper conductor not smaller than No. 4, or (2) steel reinforcing bar or rod encased by at least 2 inches of concrete and located within and near the bottom of a concrete foundation footing that is in direct contact with the earth.

(b) **Rod and Pipe Electrodes.** Rod and pipe electrodes shall not be

less than 8 feet in length and shall consist of the following materials, and shall be installed in the following manner:

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

(2) Electrodes of rods of steel or iron shall be at least $\frac{5}{8}$ inch in diameter. Nonferrous rods or their equivalent shall be listed and shall be not less than $\frac{1}{2}$ inch in diameter.

(3) Where rock bottom is not encountered, the electrode shall be driven to a depth of 8 feet. Where rock bottom is encountered at a depth of less than 4 feet, electrodes not less than 8 feet long shall be buried in a trench. All electrodes shall be free from nonconductive coatings, such as paint or enamel.

(c) **Plate Electrodes.** Each plate electrode shall expose not less than 2 square feet of surface to exterior soil. Electrodes of iron or steel plates shall be at least $\frac{1}{4}$ inch in thickness. Electrodes of nonferrous metal shall be at least 0.06 inch in thickness.

250-84. Resistance of Made Electrodes. A single electrode consisting of a rod, pipe, or plate which does not have a resistance to ground of 25 ohms or less shall be augmented by one additional electrode of any of the types specified in Section 250-83.

250-86. Use of Lightning Rods. Lightning rod conductors and driven pipes, rods, or other made electrodes used for grounding lightning rods shall not be used in lieu of the made grounding electrodes required by Section 250-83 for grounding wiring systems and equipment. This provision shall not prohibit the bonding together of grounding electrodes of different systems.

See Sections 250-46, 800-31(b) (7), and 820-22(h).

Bonding together of all separate electrodes will limit potential differences between them and between their associated wiring systems.

J. Grounding Conductors

250-91. Material. The material for grounding conductors shall be as specified in (a) and (b) below.

(a) **Grounding Electrode Conductor.** The grounding electrode conductor shall be of copper, aluminum, or other corrosion-resistant material. The material selected shall be resistant to any corrosive condition existing at the installation or shall be suitably protected against corrosion. Where not of copper, its electrical resistance per linear foot shall not exceed that for copper of the size required by Table 250-94. The conductor shall be solid or stranded, insulated, covered, or bare and shall be installed in one continuous length without a splice or joint.

Exception No. 1: Splices in busbars shall be permitted.

Exception No. 2: Where a service consists of more than a single enclosure as permitted in Section 230-45, it shall be permissible to connect taps to the grounding electrode conductor. Each such tap conductor shall extend to the inside of each such enclosure.

(b) Types of Equipment Grounding Conductors. The equipment grounding conductor run with or enclosing the circuit conductors shall be one or more or a combination of the following: (1) a copper or other corrosion-resistant conductor. This conductor shall be solid or stranded; insulated, covered, or bare; and in the form of a wire or a busbar of any shape; (2) rigid metal conduit; (3) intermediate metal conduit; (4) electrical metallic tubing; (5) flexible metal conduit approved for the purpose and installed with fittings approved for the purpose; (6) armor of Type AC metal-clad cable; (7) the sheath of mineral-insulated metal-sheathed cable; (8) the sheath of Type ALS cable; (9) cable trays as permitted in Sections 318-2(c) and 318-6; (10) the sheath of Type CS copper-sheathed cable; (11) other raceways specifically approved for grounding purposes.

Exception No. 1: Flexible metal conduit shall be permitted for grounding if all the following conditions are met:

- a. The length does not exceed 6 feet.*
- b. The circuit conductors contained therein are protected by over-current devices rated at 20 amperes or less.*
- c. The conduit is terminated in fittings approved for the purpose.*

Exception No. 2: Liquidtight flexible metal conduit shall be permitted for grounding in the 1¼-inch and smaller trade sizes if the length is 6 feet or less and the conduit is terminated in fittings approved for the purpose.

Exception No. 3: For direct-current circuits only, the equipment grounding conductor shall be permitted to be run separately from the circuit conductors.

(c) Supplementary Grounding. Supplementary grounding electrodes shall be permitted to augment the equipment grounding conductors specified in Section 250-91(b), but the earth shall not be used as the sole equipment grounding conductor.

250-92. Installation. Grounding conductors shall be installed as specified in (a) and (b) below.

(a) Grounding Electrode Conductor. A grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried. A No. 4 or larger conductor shall be protected if exposed to severe physical damage. A No. 6 grounding conductor that is free from exposure to physical damage shall be permitted to be run along the surface of the building construction without metal covering or protection where it is rigidly stapled to the construction; otherwise, it shall be in conduit, electrical metallic tubing, or cable armor. Grounding conductors smaller than No. 6 shall be in conduit, electrical metallic tubing, or cable armor.

Metal enclosures for grounding conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode, and shall be securely fastened to the ground clamp or fitting. Metal enclosures that are not physically continuous from cabinet or equipment to the grounding electrode shall be made electrically continuous by bonding each end to the grounding conductor.

Where rigid metal 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.

Aluminum or copper-clad aluminum grounding conductors shall not be used where in direct contact with masonry or the earth or where subject to corrosive conditions. Where used outside, aluminum or copper-clad aluminum grounding conductors shall not be installed within 18 inches of the earth.

(b) Equipment Grounding Conductor. An equipment grounding conductor shall be installed as follows:

(1) Where it consists of a raceway, cable armor, or cable sheath or where it is a wire within a raceway or cable, it shall be installed in accordance with the applicable provisions in this Code using fittings for joints and terminations approved for use with the type raceway or cable used. All connections, joints, and fittings shall be made tight using suitable tools.

(2) Where it is a separate grounding conductor as provided in Section 210-7 or by special permission as provided in Section 250-57(c), it shall be installed in accordance with (a) above in regard to restrictions for aluminum and also in regard to protection from physical damage.

Exception: Sizes smaller than No. 6 shall not be required to be enclosed in a raceway or armor where run in the hollow spaces of a wall or partition or where otherwise installed so as not to be subject to physical damage.

250-93. Size of Direct-Current System Grounding Conductor. The size of the grounding conductor for a DC system shall be as specified in (a) through (c) below.

(a) Where the DC system consists of a 3-wire balancer set or a balancer winding with overcurrent protection as provided in Section 445-4(d), the grounding conductor shall not be smaller than the neutral conductor.

(b) Where the DC system is other than as in (a) above, the grounding conductor shall not be smaller than the largest conductor supplied by the system.

(c) In no case shall the grounding conductor be smaller than No. 8.

250-94. Size of Alternating-Current Grounding Electrode Conductor. The size of the grounding electrode conductor of a grounded or ungrounded AC system shall not be less than given in Table 250-94.

Exception No. 1: Grounded Systems. Where connected to made electrodes (as in Section 250-83), that portion of the grounding electrode conductor which is the sole connection between the grounding electrode and the grounded system conductor shall not be required to be larger than No. 6 copper wire or its equivalent in ampacity.

Exception No. 2: Ungrounded Systems. Where connected to made electrodes (as in Section 250-83) that portion of the grounding electrode conductor which is the sole connection between the grounding

electrode and the service equipment shall not be required to be larger than No. 6 copper wire or its equivalent in ampacity.

Table 250-94
Grounding Electrode Conductor for AC Systems

Size of Largest Service-Entrance Conductor or Equivalent for Parallel Conductors		Size of Grounding Electrode Conductor	
Copper	Aluminum or Copper-Clad Aluminum	Copper	*Aluminum or Copper-Clad Aluminum
2 or smaller	0 or smaller	8	6
1 or 0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250 MCM	4	2
Over 3/0 thru 350 MCM	Over 250 MCM thru 500 MCM	2	0
Over 350 MCM thru 600 MCM	Over 500 MCM thru 900 MCM	0	3/0
Over 600 MCM thru 1100 MCM	Over 900 MCM thru 1750 MCM	2/0	4/0
Over 1100 MCM	Over 1750 MCM	3/0	250 MCM

Where there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

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

See Section 250-23(b).

250-95. Size of Equipment Grounding Conductors. The size of copper, aluminum, or copper-clad aluminum equipment grounding conductors shall not be less than given in Table 250-95.

Where conductors are run in parallel in multiple raceways, as permitted in Section 310-4, the equipment grounding conductor, where used, shall be run in parallel. Each parallel equipment grounding conductor shall be sized on the basis of the ampere rating of the overcurrent device protecting the circuit conductors in the raceway in accordance with Table 250-95.

When conductors are adjusted in size to compensate for voltage drop, grounding conductors, where required, shall be adjusted proportionately in size.

Exception No. 1: An equipment grounding conductor not smaller than No. 18 copper and not smaller than the circuit conductors if an integral part of a listed flexible cord assembly shall be permitted for grounding cord-connected equipment where the equipment is protected by overcurrent devices not exceeding 20-ampere rating.

Exception No. 2: The equipment grounding conductor shall not be required to be larger than the circuit conductors supplying the equipment.

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

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size	
	Copper Wire No.	Aluminum or Copper-Clad Aluminum Wire No.*
15	14	12
20	12	10
30	10	8
40	10	8
60	10	8
100	8	6
200	6	4
400	3	1
600	1	2/0
800	0	3/0
1000	2/0	4/0
1200	3/0	250 MCM
1600	4/0	350 "
2000	250 MCM	400 "
2500	350 "	500 "
3000	400 "	600 "
4000	500 "	800 "
5000	700 "	1000 "
6000	800 "	1200 "

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

Exception No. 3: Where a raceway or a cable armor or sheath is used as the equipment grounding conductor, as provided in Sections 250-57(a) and 250-91(b).

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

250-98. Grounding Conductor in Common Raceway. A grounding conductor shall be permitted in the same raceway or enclosure with other conductors of the system to which it is connected.

250-99. Grounding Conductor Continuity.

(a) Separable Connections. Separable connections such as those provided in draw-out equipment or attachment plugs and mating connectors and receptacles shall provide for first-make, last-break of the equipment grounding conductor.

Exception: Interlocked equipment, plugs, receptacles and connectors which preclude energization without grounding continuity.

(b) Switches. No automatic cutout or switch shall be placed in the grounding conductor of a premises wiring system.

Exception: Where the opening of the cutout or switch disconnects all sources of energy.

K. Grounding Conductor Connections

250-111. To Raceway or Cable Armor. The point of connection of the grounding conductor to interior metal raceways, cable armor, and the like shall be as near as practicable to the source of supply and shall be so chosen that no raceway or cable armor is grounded through a run of smaller size than is called for in Section 250-95.

250-112. To Grounding Electrode. The grounding connection of a grounding conductor to a grounding electrode shall be made at a point and in a manner that will assure a permanent and effective ground. Where necessary to assure this for a metal piping system used as a grounding electrode, effective bonding shall be provided around insulated joints and sections and around any equipment that is likely to be disconnected for repairs or replacement.

250-113. To Conductors and Equipment. Required grounding conductors and bonding jumpers shall be connected by pressure connectors, clamps, or other approved means. Connection devices or fittings that depend on solder shall not be used.

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

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

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

250-115. Connection to Electrodes. The grounding conductor shall be connected to the grounding fitting by suitable lugs, pressure connectors, clamps, or other approved means. Connections depending on solder shall not be used. Ground clamps shall be suitable for the materials of the grounding electrode and the grounding electrode conductor. Not more than one conductor shall be connected to the grounding electrode by a single clamp or fitting unless the clamp or fitting is approved for the use. One of the methods indicated in (a), (b), (c), or (d) below shall be used.

(a) An approved bolted clamp of cast bronze or brass or plain or malleable iron.

(b) A pipe fitting, pipe plug, or other approved device screwed into a pipe or pipe fitting.

(c) A sheet-metal-strap type ground clamp having a rigid metal base that seats on the electrode and having a strap of such material and dimensions that it is not likely to stretch during or after installation.

(d) An equally substantial approved means.

250-117. Protection of Attachment. Ground clamps or other fittings shall be approved for general use without protection or shall be protected from ordinary physical damage as indicated in (a) or (b) below.

(a) Installations where they are not likely to be damaged.

(b) Enclosing in metal, wood, or equivalent protective covering.

250-118. Clean Surfaces. Nonconductive coatings (such as paint, lacquer, and enamel) on equipment to be grounded shall be removed from threads and other contact surfaces to assure good electrical continuity.

L. Instrument Transformers, Relays, etc.

250-121. Instrument Transformer Circuits. Secondary circuits of current and potential instrument transformers shall be grounded where the primary windings are connected to circuits of 300 volts or more to ground, and where on switchboards, shall be grounded irrespective of voltage.

Exception: Circuits where the primary windings are connected to circuits of 750 volts or less with no live parts or wiring exposed or accessible to other than qualified persons.

250-122. Instrument Transformer Cases. Cases or frames of instrument transformers shall be grounded where accessible to other than qualified persons.

Exception: 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.

250-123. Cases of Instruments, Meters, and Relays — Operating at 750 Volts or Less. Instruments, meters, and relays operating with windings or working parts at 750 volts or less shall be grounded as specified in (a), (b), or (c) below.

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

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

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

nominal?

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

Exception: Cases of electrostatic ground detectors where the internal ground segments of the instrument are connected to the instrument case and grounded and the ground detector is isolated by elevation.

250-125. Instrument Grounding Conductor. The grounding conductor for secondary circuits of instrument transformers and for instrument cases shall not be smaller than No. 12 copper or equivalent. Cases of instrument transformers, instruments, meters, and relays which are mounted directly on grounded metal surfaces of enclosures or grounded metal switchboard panels shall be considered to be grounded and no additional grounding conductor will be required.

M. Connecting Lightning Arresters

250-131. Services of Less Than 1000 Volts. Where a lightning arrester is installed on a service of less than 1000 volts, the connecting conductors shall be as short and straight as practicable and of copper not smaller than No. 14 or of equivalent corrosion-resistant material. Bends, especially sharp bends, shall be avoided where practicable. The arrester grounding conductor shall be connected to one of the following:

- (a) The grounded service conductor.
- (b) The grounding electrode conductor.
- (c) The grounding electrode for the service.

250-132. On Circuits of 1 KV and Over. The grounding conductor of a lightning arrester protecting a transformer that supplies a secondary distribution system shall be permitted to be interconnected as specified in (a), (b), or (c) below.

(a) **Metallic Interconnection.** A metallic interconnection shall be permitted to 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 metal underground water piping system. However, in urban water-pipe areas where there are at least four water-pipe connections on the neutral and not less than four such connections in each mile of neutral, the metallic interconnection shall be permitted to 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 multigrounded 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 250-82 and 250-83, such interconnection, where made, shall be through a spark gap having a 60-Hertz breakdown voltage of at least twice the primary circuit voltage but not necessarily more than 10 kV, and there shall be at

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

(c) **By Special Permission.** An interconnection of the arrester ground and the secondary neutral, other than as provided in (a) and (b) above, may be made only by special permission.

N. Grounding of Systems and Circuits of 1 KV and Over (High Voltage).

250-150. General. Where high-voltage systems are grounded, they shall comply with all applicable provisions of the preceding Sections of this Article and with the following Sections which supplement and modify the preceding Sections.

250-151. Derived Neutral Systems. A system neutral derived from a grounding transformer shall be permitted to be used for grounding a high-voltage system.

250-152. Solidly Grounded Neutral Systems.

(a) **Neutral Conductor.** The neutral of a solidly grounded neutral system shall comply with (1) and (2) below:

(1) The minimum insulation level for neutral conductors of solidly grounded systems shall be 600 V.

Exception No. 1: Bare copper conductors shall be permitted to be used for the neutral of service entrances and the neutral of direct buried portions of feeders.

Exception No. 2: Bare conductors shall be permitted for the neutral of overhead portions installed outdoors.

(2) The neutral grounding conductor shall be permitted to be a bare conductor if isolated from phase conductors and protected from physical damage.

(b) **Multiple Grounding.** The neutral of a solidly grounded neutral system shall be permitted to be grounded at more than one point for:

(1) Services.

(2) Direct buried portions of feeders employing a bare copper neutral.

(3) Overhead portion installed outdoors.

250-153. Impedance Grounded Neutral Systems. Impedance grounded neutral systems shall comply with the provisions of (a) through (d) below:

(a) The grounding impedance shall be inserted in the grounding conductor between the grounding electrode of the supply system and the neutral point of the supply transformer or generator.

(b) Where the neutral conductor of an impedance grounded neutral system is used, it shall be identified, as well as fully insulated with the same insulation as the phase conductors.

(c) The system neutral shall not be connected to ground, except through the neutral grounding impedance.

(d) Equipment grounding conductors shall be permitted to be bare and shall be connected to the ground bus and grounding electrode conductor at the service-entrance equipment and extended to the system ground.

250-154. Grounding of Systems Supplying Portable Equipment. Systems supplying portable high-voltage equipment, other than substations installed on a temporary basis, shall comply with (a) through (f) below:

(a) Portable high-voltage equipment shall be supplied from a system having its neutral grounded through an impedance. Where a delta-connected high-voltage system is used to supply portable equipment, a system neutral shall be derived.

(b) Exposed noncurrent-carrying metal parts of portable equipment shall be connected by an equipment grounding conductor to the point at which the system neutral impedance is grounded.

(c) The voltage developed between the portable equipment frame and ground by the flow of maximum ground fault current shall not exceed 100 volts.

(d) Ground-fault detection and relaying shall be provided to automatically de-energize any high-voltage system component which has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to de-energize automatically the high-voltage feeder to the portable equipment upon loss of continuity of the equipment grounding conductor.

(e) The grounding electrode to which the portable equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 20 feet from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe, fence, etc.

(f) High-voltage trailing cables and couplers for interconnection of portable equipment shall be of a type approved for the purpose.

See Article 400.

250-155. Grounding of Equipment. All noncurrent-carrying metal parts of fixed and portable equipment and associated fences, housings, enclosures, and supporting structures shall be grounded.

Exception No. 1: Where isolated from ground and located so as to prevent any person who can make contact with ground from contacting such metal parts when the equipment is energized.

Exception No. 2: Pole mounted distribution apparatus as provided in Section 250-42, Exception No. 3.

Grounding conductors not an integral part of a cable assembly shall not be smaller than No. 6.

ARTICLE 280 — LIGHTNING ARRESTERS

A. General

280-1. Scope. This Article covers general requirements, location requirements, and installation methods for lightning arresters.

B. Industrial Stations

280-10. Where Required. Lightning arresters shall be provided in industrial stations in locations where thunderstorms are frequent and adequate protection against lightning is not otherwise provided.

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

280-11. Number Required. A lightning arrester shall be connected to each ungrounded overhead conductor entering or leaving the station.

Exception: Where there is more than one circuit, a single set of arresters shall be permitted to be installed on the station bus where means are provided to protect circuits that may remain disconnected from the bus.

280-12. Where Connected. The arrester shall be connected on the line side of all connected station apparatus.

C. Other Occupancies

280-20. Utilization Equipment. Lightning arresters installed for the protection of utilization equipment shall be installed either inside or outside the building or enclosure containing the equipment to be protected. Arresters shall be isolated by elevation or made otherwise inaccessible to unqualified persons, or they shall be enclosed. Where the operating voltage of the circuit exceeds 750 volts between conductors, they shall be inaccessible to unqualified persons.

Secondary lightning protection devices may reduce damage to wiring and equipment caused by lightning disturbances. (See Section 502-3.)

D. Installation

280-30. Location. Arresters installed indoors shall be located well away from other equipment, passageways, and combustible parts of buildings.

280-32. Arrester Conductors — Size and Material. The conductor between the arrester and the line wire or bus and between the arrester and the grounding connection shall be: (1) copper wire or cable or the equivalent; (2) not smaller than No. 6, except as provided for services in Section 250-131 for services of 750 volts or less; and (3) as short and straight as practicable, avoiding unnecessary bends and especially sharp bends and turns.

280-33. Insulation. Lightning-protection accessories, such as gap electrodes and choke coils where used, shall have an insulation from ground or from other conductors at least equal to the insulation required at other points of the circuit.

280-34. Switch for Isolating Arrester. Where isolating switches or disconnecting devices are used, they shall withstand, in full open position, a voltage test between live parts 10 percent in excess of the maximum voltage test they will withstand to ground.

280-35. Grounding. Lightning arresters shall be grounded in the manner specified in Article 250. Grounding conductors shall not be run in metal enclosures unless bonded to both ends of such enclosures.

Chapter 3. Wiring Methods and Materials

ARTICLE 300 — WIRING METHODS

A. General Requirements

300-1. Scope.

(a) The provisions of this Article shall apply to all wiring installations.

Exception No. 1: Class 1, Class 2, and Class 3 circuits as provided for in Article 725.

Exception No. 2: Fire Protective Signaling circuits as provided for in Article 760.

Exception No. 3: Communication systems as provided in Article 800.

(b) The provisions of this Article are not intended to apply to the conductors which form an integral part of equipment, such as motors, controllers, motor control centers, or factory-assembled control equipment.

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

300-3. Conductors of Different Systems.

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

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

(c) Secondary wiring to electric-discharge lamps of 1000 volts or less, if insulated for the secondary voltage involved, shall be permitted to occupy the same fixture enclosure as the branch-circuit conductors.

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

(e) Excitation, control, relay, and ammeter conductors used in connection with any individual motor or starter shall be permitted to occupy the same enclosure as the motor circuit conductors.

(f) Conductors of signaling or radio systems shall not occupy the same enclosure with conductors of light or power systems.

Exception No. 1: As permitted for elevators in Section 620-36.

Exception No. 2: For sound recording in Section 640-6.

Exception No. 3: As permitted for Class 1, Class 2, and Class 3 circuits in Sections 725-15 and 725-38.

Exception No. 4: As permitted for communication system in Sections 800-3 and 800-21.

Exception No. 5: As permitted for Fire Protective Signaling circuits in Sections 760-15 and 760-28.

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

(a) Cables Through Wood Framing Members.

(1) Bored Holes. In both exposed and concealed locations, where a cable or raceway type wiring method is installed through bored holes in joists, rafters, or similar structural wood members, holes shall be bored at the approximate center of the face of the member. Holes in studs for cable type wiring methods shall be bored at the approximate center of the face of the member but not less than one and one-half inches from the nearest edge or shall be protected from nails and screws by either a steel plate or bushing at least 1/16 inch thick and of appropriate length and width installed to cover the area through which nails or screws might penetrate the installed cable.

(2) Notches in Wood. Where there is no objection because of weakening the building structure, in both exposed and concealed locations, cables shall be permitted to be laid in notches in wood studs, joists, rafters or other wood members where the cable at those points is protected against nails or screws by a steel plate at least 1/16 inch thick installed before the building finish is applied.

(b) Cables Through Metal Framing Members. In both exposed and concealed locations where nonmetallic-sheathed cables pass through either factory or field punched, cut or drilled slots or holes in metal members, the cable shall be protected by bushings or grommets approved for the purpose securely fastened in the opening. Where nails or screws are likely to penetrate the cable, a steel sleeve not less than 1/16 inch in wall thickness shall be used to protect the nonmetallic cable.

Exception: When the slots or holes are so formed that no metal edge can cut or tear cable insulation, bushings or grommets shall not be required.

300-5. Underground Installations.

(a) Minimum Cover Requirements. Direct buried cable or conduit or other raceways approved for the purpose or duct shall be installed to meet the minimum cover requirements of Table 300-5.

Exception No. 1: The minimum cover requirements shall be permitted to be reduced by six inches for installations where a two-inch thick concrete pad or equivalent in physical protection is placed in the trench over the underground installation.

Exception No. 2: Areas subject to heavy vehicular traffic, such as thoroughfares, gasoline service stations, or commercial parking areas, shall have a minimum cover of 24 inches.

Table 300-5**Minimum Cover Requirements, 0 to 600 Volts**

(Cover is defined as the distance between the top surface of direct buried cable, conduit, or other raceways approved for the purpose or duct and the finished grade.)

Wiring Method	Minimum Burial (inches)
Direct Buried Cables	24
Rigid Metal Conduit	6
Rigid Non-Metallic Conduit Approved for Direct Burial without Concrete Encasement	18
Other Approved Raceways*	18

* NOTE: Raceways approved for burial only when concrete encased shall require a concrete envelope not less than two inches thick.

Exception No. 3: Residential branch circuits rated 300 volts or less and provided with overcurrent protection of not more than 30 amperes shall be permitted with a cover requirement of 12 inches.

Exception No. 4: Lesser depths are permitted where cables and conductors rise for terminations or splices or where access is otherwise required.

Exception No. 5: In airport runways, including adjacent defined areas where trespass is prohibited, cable shall be permitted to be buried not less than 18 inches deep and without raceways, concrete encasement or equivalent.

Exception No. 6: Ducts and raceways installed in solid rock shall be permitted to be buried at a lesser depth when covered by two inches or more of concrete over the installation and extending down to the rock surface.

(b) Grounding. Metallic shielding, sheath, or metallic conduit shall be effectively grounded at terminations and meet the requirements of Section 250-51.

(c) Underground Cables Under Buildings. Underground cable installed under a building shall be in a raceway that is extended beyond the outside walls of the building.

(d) Protection From Damage. Conductors emerging from the ground shall be enclosed in enclosures or raceways approved for the purpose. Raceways installed on poles shall be of rigid metal conduit, PVC Schedule 80, or equivalent. The enclosures or raceways shall extend from below the ground line up to a point eight feet above finished grade. Conductors entering a building shall be protected by an approved enclosure or raceway from below the ground line to the point of entrance.

(e) Splices and Taps. Underground cables in trenches shall be permitted to be spliced or tapped without the use of splice boxes. The

splices or taps shall be made by methods and with material approved for the purpose.

(f) Backfill. Backfill containing large rock, paving materials, cinders, large or sharply angular substance, or corrosive material, shall not be placed in an excavation where materials may damage ducts, cables, or other substructures or prevent adequate compaction of fill or contribute to corrosion of ducts, cables or other substructures.

(g) Raceway Seals. Conduits or raceways through which moisture may contact energized live parts shall be sealed or plugged at either or both ends.

(h) Bushing. A bushing shall be used at the end of a conduit which terminates underground where cables leave the conduit as a direct burial wiring method. A seal incorporating the physical protection characteristics of a bushing shall be permitted to be used in lieu of a bushing.

(i) Single Conductors. All conductors of the same circuit including the grounding conductor where required shall be installed in the same raceway or shall be installed in close proximity in the same trench.

300-6. Protection Against Corrosion. Metal raceways, cable armor, boxes, cable sheathing, cabinets, elbows, couplings, fittings, supports, and support hardware shall be of materials suitable for the environment in which they are to be installed.

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

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

(c) In portions of dairies, laundries, canneries, and other indoor wet locations, and in locations where walls are frequently washed or where there are surfaces of absorbent materials, such as damp paper or wood, the entire wiring system, including all boxes, fittings, conduits, and cable used therewith, shall be mounted so that there is at least 1/4-inch air space between it and the wall or supporting surface.

In general, areas where acids and alkali chemicals are handled and stored may present such corrosive conditions, particularly when wet or damp. Severe corrosive conditions may also be present in portions of meat-packing plants, tanneries, glue houses, and some stables; installations immediately adjacent to a seashore and swimming pool areas; areas where chemical de-icers are used; and storage cellars or rooms for hides, casings, fertilizer, salt, and bulk chemicals.

300-7. Raceways Exposed to Different Temperatures.

(a) Sealing. Where portions of an interior raceway system are ex-

posed to widely different temperatures, as in refrigerating or cold-storage plants, circulation of air from a warmer to a colder section through the raceway shall be prevented.

(b) **Expansion Joints.** Raceways shall be provided with expansion joints where necessary to compensate for thermal expansion and contraction.

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

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

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

See Article 318 for cable trays.

300-12. Mechanical Continuity — Raceways and Cables. Metal or non-metallic raceways, cable armors, and cable sheaths shall be continuous between cabinets, boxes, fittings, or other enclosures or outlets.

300-13. Mechanical and Electrical Continuity — Conductors.

(a) Conductors shall be continuous between outlets, devices, etc., and there shall be no splice or tap within a raceway itself.

Exception No. 1: As provided in Section 374-8 for auxiliary gutters.

Exception No. 2: As provided in Section 362-6 for wireways.

Exception No. 3: As provided in Section 300-15(a), Exception No. 1 for boxes or fittings.

Exception No. 4: As provided in Section 352-7 for metal surface raceways.

(b) In multiwire circuits the continuity of an identified grounded conductor shall not be dependent upon device connections, such as lamp-holders, receptacles, etc., where the removal of such devices would interrupt the continuity.

300-14. Length of Free Conductors at Outlets and Switch Points. At least 6 inches of free conductor shall be left at each outlet and switch point for splices or the connection of fixtures or devices.

Exception: Conductors that are not spliced or terminated at the outlet or switch point.

300-15. Boxes or Fittings — Where Required.

(a) **Box or Fitting.** A box or fitting shall be installed at each conductor splice connection point, outlet, switch point, junction point, or pull point for the connection of conduit, electrical metallic tubing, surface raceway, or other raceways.

Exception No. 1: A box or fitting shall not be required for a conductor splice connection in surface raceways, wireways, header ducts, multi-

outlet assemblies, and auxiliary gutters, cable trays and conduit bodies having removable covers which are accessible after installation.

Exception No. 2: As permitted in Section 410-31 where a fixture approved for the purpose is used as a raceway.

(b) Box Only. A box shall be installed at each conductor splice connection point, outlet, switch point, junction point, or pull point for the connection of metal-clad cable, mineral-insulated metal-sheathed cable, aluminum-sheathed cable, copper-sheathed cable, nonmetallic-sheathed cable, or other cables, at the connection point between any such cable system and a raceway system and at each outlet and switch point for concealed knob-and-tube wiring.

Exception No. 1: As permitted by Section 336-11 for insulated outlet devices supplied by nonmetallic-sheathed cable.

Exception No. 2: As permitted by Section 410-62 for rosettes.

Exception No. 3: Where accessible fittings approved for the purpose are used for straight-through splices in mineral-insulated metal-sheathed cable.

Exception No. 4: Where cables enter or exit from conduit or tubing which is used to provide cable support or protection against physical damage.

Exception No. 5: A device approved for the purpose having brackets that securely fasten the device in walls or ceilings of frame construction for use with nonmetallic-sheathed cable, shall be permitted without a separate box.

See Sections 336-5 Exception No. 2, 336-11, 545-10, 550-8(j), and 551-15(a) Exception.

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

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

(b) A bushing shall be permitted in lieu of a box or terminal fitting at the end of a conduit or electrical metallic tubing where the raceway terminates behind an open (unenclosed) switchboard or at an unenclosed control and similar equipment. The bushing shall be of the insulating type for other than lead-sheathed conductors.

300-17. Number and Size of Conductors in Raceway. The number and size of conductors in any raceway shall not be more than will permit dissipation of the heat and ready installation or withdrawal of the conductors without damage to the conductors or to their insulation.

See the following Sections of this Code: conduit, Sections 345-7 and 346-6; electrical metallic tubing, 348-6; flexible metal conduit, 350-3; liquid-tight flexible metal conduit, 351-4; surface raceways, 352-4 and 352-25; underfloor raceways, 354-5; cellular metal floor raceways, 356-5; cellular concrete floor raceways, 358-9; wireways, 362-5; auxiliary gutters, 374-5; fixture wire, 402-7; theaters, 520-5; signs, 600-21(d); elevators, 620-33; sound recording, 640-3 and 640-4; Class 1, Class 2, and Class 3 circuits, Article 725; and fire protective signaling circuits, Article 760.

300-18. Inserting Conductors in Raceways.

(a) Raceways shall first be installed as a complete raceway system without conductors.

Exception: Exposed raceways having a removable cover or capping.

(b) Where possible, conductors shall not be inserted until the interior of the building has been physically protected from the weather, and all mechanical work on the building which is likely to injure the conductors has been completed.

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

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

300-19. Supporting Conductors in Vertical Raceways.

(a) **Spacing Intervals — Maximum.** Conductors in vertical raceways shall be supported. One cable support shall be provided at the top of the vertical raceway or as close to the top as practical, plus a support for each additional interval of spacing as specified in Table 300-19(a).

Exception No. 1: If the total vertical riser is less than 25 percent of the spacing specified in Table 300-19(a), no cable support shall be required.

Exception No. 2: Steel wire armor cable shall be supported at the top of the riser with a cable support that clamps the steel wire armor. A safety device shall be permitted at the lower end of the riser to hold the cable in the event there is slippage of the cable in the wire armored cable support. Additional wedge type supports shall be permitted to relieve the strain on the equipment terminals caused by expansion of the cable under load.

Table 300-19(a). Spacings for Conductor Supports

		Conductors	
		Aluminum or Copper-Clad Aluminum	Copper
No. 18	to No. 8	Not greater than	100 feet
No. 6	to No. 0	" " "	200 feet
No. 00	to No. 0000	" " "	180 feet
211,601 CM	to 350,000 CM	" " "	135 feet
350,001 CM	to 500,000 CM	" " "	120 feet
500,001 CM	to 750,000 CM	" " "	95 feet
	Above 750,000 CM	" " "	85 feet

(b) **Support Methods.** One of the following methods of support shall be used:

(1) By clamping devices constructed of or employing insulating wedges inserted in the ends of the conduits. Where clamping of insulation does not adequately support the cable, the conductor also shall be clamped.

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

(3) In junction boxes, by deflecting the cables not less than 90 degrees and carrying them horizontally to a distance not less than twice the diameter of the cable, the cables being carried on two or more insulating supports, and additionally secured thereto by tie wires if desired. When this method is used, cables shall be supported at intervals not greater than 20 percent of those mentioned in the preceding tabulation.

(4) By a method of equal effectiveness.

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

Exception: As permitted in Section 250-50, Exception for equipment grounding connections.

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

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

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

Exception: In the case of circuits supplying vacuum or electric-discharge lighting systems or signs, or X-ray apparatus, the currents carried by the conductors are so small that the inductive heating effect can be ignored where these conductors are placed in metal enclosures or pass through metal.

Because aluminum is not a magnetic metal, there will be no heating due to hysteresis; however, induced currents will be present. They will not be of sufficient magnitude to require grouping of conductors or special treatment in passing conductors through aluminum wall sections.

300-21. Prevention of Fire Spread. Electrical installations shall be so made that the possible spread of fire or products of combustion through fire-rated, fire-resistant or fire-stopped walls, partitions, ceilings and floors; hollow spaces; vertical shafts; and ventilating or air-handling ducts will not be substantially increased.

300-22. Wiring in Ducts, Plenums, and Other Air Handling Spaces. The provisions of this Section apply to the installation and uses of electric wiring and equipment in ducts, plenums, and other air handling spaces.

See Article 424 Part F for Electric Duct Heaters.

(a) **Ducts for Dust, Loose Stock, or Vapor Removal.** No wiring systems of any type shall be installed in ducts used to transport dust, loose stock or flammable vapors. No wiring system of any type shall be installed in any duct, or shaft containing only such ducts, used for vapor removal or for ventilation of commercial-type cooking equipment.

(b) Ducts or Plenums Used for Environmental Air. Wiring systems of mineral-insulated metal-sheathed cable, aluminum-sheathed cable, copper-sheathed cable, electrical metallic tubing, intermediate metal conduit, or rigid metal conduit shall be permitted to be installed in ducts or plenum chambers used to transport environmental air. Flexible metal conduit and liquid tight flexible metal conduit shall be permitted, in lengths not to exceed 4 feet, to connect physically adjustable equipment and devices permitted to be in these ducts and plenum chambers. The connectors used with flexible metal conduit shall effectively close any openings in the connection. Equipment and devices shall be permitted within such ducts or plenum chambers only if necessary for their direct action upon, or sensing of, the contained air. Where equipment or devices are installed and illumination is necessary to facilitate maintenance and repair, enclosed gasketed-type fixtures shall be permitted.

(c) Hollow Spaces Used As Ducts or Plenums for Environmental Air. Hollow spaces used as ducts or plenum chambers for environmental air, other than those described in paragraph (b) above, may contain mineral-insulated metal-sheathed cable, aluminum-sheathed cable, copper-sheathed cable, electrical metallic tubing, intermediate metal conduit, rigid metal conduit, metal surface raceway with metal covers where accessible, flexible metal conduit, liquidtight flexible metal conduit in lengths not exceeding six feet, or metal-clad cables, and other electric equipment that is permitted within the concealed spaces of such structures if the wiring materials, including fixtures, are suitable for the expected ambient temperature to which they will be subjected.

Exception No. 1: The above provisions shall not apply to integral fan systems specifically approved for the purpose.

Exception No. 2: This Section does not include habitable rooms or areas of buildings, the prime purpose of which is not air handling.

(d) Data Processing Systems. Electric wiring in air handling areas beneath raised floors for data processing systems shall comply with Article 645.

B. Requirements For Over 600 Volts, Nominal

300-31. Covers Required. Suitable covers shall be installed on all boxes, fittings, and similar enclosures to prevent accidental contact with energized parts or physical damage to parts or insulation.

300-32. Conductors of Different Systems. Conductors of high-voltage and low-voltage systems shall not occupy the same wiring enclosure or pull and junction boxes.

Exception No. 1: In motors, switchgear and control assemblies and similar equipment.

Exception No. 2: In manholes, if low-voltage conductors are separated from high-voltage conductors.

300-33. Inserting Conductors in Raceways. Raceways, except those used for exposed work and having a removable cover, shall first be installed as a complete raceway system without the conductors. Pull wires, if used, shall not be installed until the raceway system is in place.

Approved pulling compound may be used as a lubricant in inserting conductors in raceways. Cleaning agents or lubricants having a deleterious effect on conductor coverings shall not be used.

300-34. Conductor Bending Radius. The conductor shall not be bent to a radius less than 8 times the overall diameter for nonshielded conductors or 12 times the diameter for shielded or lead-covered conductors during or after installation.

300-35. Protection Against Induction Heating. Metallic ducts and associated conductors shall be so arranged as to avoid heating of the raceway by induction.

300-36. Grounding. Wiring and equipment installations shall be grounded in accordance with the applicable provisions of Article 250.

ARTICLE 305 — TEMPORARY WIRING

A. 600 Volts, Nominal or Less

305-1. Scope. The provisions of this Article apply to temporary electrical power and lighting wiring methods which may be of a class less than would be required for a permanent installation. Except as specifically modified in this Article, all other requirements of this Code for permanent wiring shall apply to temporary wiring installations.

(a) Temporary electrical power and lighting installations shall be permitted during the period of construction, remodeling, or demolition of buildings, structures, equipment, or similar activities.

(b) Temporary electrical power and lighting installations shall be permitted for a period not to exceed 90 days for Christmas decorative lighting, carnivals, and similar purposes, and for experimental or development work.

305-2. General.

(a) **Services.** Services shall be installed in conformance with Article 230.

(b) **Feeders.** Feeders shall be protected as provided in Article 240. They shall originate in an approved distribution center. The conductors shall be permitted within multi-conductor cord or cable assemblies or where not subject to mechanical injury, they shall be permitted to be run as open conductors on insulators not more than 10 feet apart.

(c) **Branch Circuits.** All branch circuits shall originate in an approved power outlet or panelboard. Conductors shall be permitted within multi-conductor cord or cable assemblies or as open conductors. All conductors shall be protected by overcurrent devices at their rated ampacity. When run as open conductors they shall be fastened at ceiling height every 10 feet. No conductor shall be laid on the floor. Each branch circuit that supplies receptacles or fixed equipment shall contain a separate equipment grounding conductor when run as open conductors.

(d) **Receptacles.** All receptacles shall be of the grounding-type. Unless installed in a complete metallic raceway all branch circuits shall

contain a separate equipment grounding conductor and all receptacles shall be electrically connected to the grounding conductor.

See Section 210-8 for receptacles installed on construction sites.

(e) **Earth Returns.** No bare conductors nor earth returns shall be used for the wiring of any temporary circuit.

(f) **Disconnecting Means.** Suitable disconnecting switches or plug connectors shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.

(g) **Lamp Protection.** All lamps for general illumination shall be protected from accidental contact or breakage. Protection shall be provided by elevation of at least 7 feet from normal working surface or by a suitable fixture or lampholder with a guard.

305-3. Grounding. All grounding shall conform with Article 250.

B. Over 600 Volts

305-10. Use. Temporary wiring over 600 volts shall be permitted during periods of construction, tests, experiments, or emergency. A less permanent class of wiring and equipment shall be permitted than would be required for permanent installations.

305-11. Guarding. Suitable fencing, barriers, or other effective means shall be provided to prevent access of other than authorized and qualified personnel to temporary wiring.

305-12. Temporary wiring over 600 volts shall be removed immediately upon completion of construction or purpose for which the wiring was installed.

305-13. Grounding of Equipment. Equipment shall be grounded in accordance with Section 250-42.

ARTICLE 310 — CONDUCTORS FOR GENERAL WIRING

A. General

310-1. Scope. This Article covers general requirements for conductors and their type designations, insulations, markings, mechanical strengths, ampacity ratings, and uses. These requirements do not apply to conductors that form an integral part of equipment, such as motors, motor controllers, and similar equipment, or to conductors specifically provided for elsewhere in this Code.

For flexible cords and cables, see Article 400. For fixture wires, see Article 402.

310-2. Conductors to Be Insulated. Conductors shall be insulated.

Exception: Where covered or bare conductors are specifically permitted elsewhere in this Code.

310-3. Stranded Conductors. Where installed in raceways, conductors of size No. 8 and larger shall be stranded.

Exception No. 1: When used as busbars or in mineral-insulated metal-sheathed cable.

Exception No. 2: Bonding conductors as required in Section 680-22(a).

310-4. Conductors in Parallel. Aluminum, copper-clad aluminum, or copper conductors of size 1/0 and larger, comprising each phase or neutral, shall be permitted to be connected in parallel (electrically joined at both ends to form a single conductor) only if all of the following conditions are met: All of the parallel conductors shall be of the same length, of the same conductor material, circular-mil area, same insulation type and terminated in the same manner. Where run in separate raceways or cables, the raceways or cables shall have the same physical characteristics.

When metallic equipment grounding conductors are used with conductors in parallel, they shall comply with the requirements of this Section except that they shall be sized as per Section 250-95.

When conductors are used in parallel, space in enclosures shall be given consideration (See Articles 370 and 373). Conductors installed in parallel shall be subject to ampacity reduction factors as required in Note 8 to Tables 310-16 through 310-19.

310-5. Minimum Size of Conductors. Whether solid or stranded, conductors shall not be smaller than No. 14 copper or No. 12 aluminum or copper-clad aluminum.

Exception No. 1: For flexible cords as permitted by Section 400-12.

Exception No. 2: For fixture wire as permitted by Section 410-23.

Exception No. 3: For fractional hp motors as permitted by Section 430-22.

Exception No. 4: For cranes and hoists as permitted by Section 610-14.

Exception No. 5: For elevator control and signaling circuits as permitted by Section 620-12.

Exception No. 6: For Class 1, Class 2 and Class 3 circuits as permitted by Sections 725-16, 725-33, and 725-40.

Exception No. 7: For fire protective signaling circuits as permitted by Sections 760-16 and 760-30.

310-6. Underground Conductors. Cables of one or more conductors for direct burial in the earth or in underground raceways shall be of a type approved for the purpose and use.

Where necessary to prevent physical damage to the conductors from rocks, slate, or similar materials, or from vehicular or similar traffic, direct buried conductors shall be provided with supplementary protection, such as sand, sand and suitable running boards, suitable sleeves, or other approved means.

See Section 339-3 for Type UF cable.

310-7. Wet Locations.

(a) Insulated Conductors. Insulated conductors used in wet locations shall be (1) lead-covered; (2) Types RHW, RUW, TW, THW, THWN, XHHW; or (3) of a type approved for the purpose.

(b) **Cables.** Cables of one or more conductors used in wet locations shall be of a type approved for the purpose and use.

Such conductors shall not be used for direct burial in the earth unless of a type approved for the purpose.

310-8. Corrosive Conditions. Conductors exposed to oils, greases, vapors, gases, fumes, liquids, or other substances having a deleterious effect upon the conductor or insulation shall be of a type approved for the purpose.

310-9. Temperature Limitation. No conductor shall be used under such conditions that its operating temperature will exceed that specified for the type of insulation involved.

310-10. Conductor Identification.

(a) **Grounded Conductors.** Insulated conductors of No. 6 or smaller, intended for use as grounded conductors of circuits, shall have an outer identification of a white or natural gray color. Multiconductor flat cable No. 4 or larger shall be permitted to employ an external ridge on the grounded conductor.

Exception No. 1: Multiconductor varnished-cloth-insulated cables.

Exception No. 2: Fixture wires as outlined in Article 402.

Exception No. 3: Mineral-insulated metal-sheathed cable.

Exception No. 4: A conductor identified as required by Section 210-5(a) for branch circuits.

For aerial cable the identification shall be as above, or by means of a ridge so located on the exterior of the cable as to identify it.

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

For identification requirements for conductors larger than No. 6, see Section 200-6.

(b) **Grounding Conductors.** An insulating equipment grounding conductor shall be permitted, but if individually covered shall have a continuous outer finish that is either green, or green with one or more yellow stripes.

Exception: An insulated grounding conductor larger than No. 6 shall, at the time of installation, be permitted to be suitably identified as a grounding conductor at each end and at every point where the conductor is accessible. Identification shall be accomplished by one of the following means:

- 1. Stripping the insulation from the entire exposed length.*
- 2. Coloring the exposed insulation green, or*
- 3. Marking the exposed insulation with green colored tape or green colored adhesive labels.*

(c) **Ungrounded Conductor.** Conductors which are intended for use as ungrounded conductors, whether used as single conductors or in multi-conductor cables, shall be finished to be clearly distinguishable from grounded and grounding conductors. Ungrounded conductors shall be distinguished by colors other than white, natural gray, or

green; or by a combination of color plus distinguishing marking. Distinguishing markings shall also be in a color other than white, natural gray, or green, and shall consist of a stripe or stripes or a regularly spaced series of identical marks. Distinguishing markings shall not conflict in any manner with the surface markings required by Section 310-11(b)(1).

310-11. Marking.

(a) **Required Information.** All conductors and cables shall be marked to indicate the following information using the applicable method described in (b) below.

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

(2) The proper type letter or letters for the type of wire or cable as specified elsewhere in this Article, in Table 310-13 and in Articles 336, 337, 338, 339, and 340.

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

(4) The AWG size or circular-mil area.

(b) Method of Marking.

(1) **Surface Marking.** The following conductors and cables shall be durably marked on the surface at intervals not exceeding 24 inches:

- (a) Single- and multiconductor rubber- and thermoplastic-insulated wire and cable.
- (b) Nonmetallic-sheathed cable.
- (c) Service-entrance cable.
- (d) Underground feeder and branch-circuit cable.
- (e) Tray cable.
- (f) Irrigation cable.

(2) **Marker Tape.** Metal-covered multiconductor cables shall employ a marker tape located within the cable and running for its complete length.

Exception No. 1: Mineral-insulated metal-sheathed cable.

Exception No. 2: Type AC metal-clad cables.

Included in the group of metal-covered cables are: aluminum-sheathed cable, Type ALS (Article 331); copper-sheathed cable, Type CS (Article 332); Type MC metal-clad cable (Article 334) and lead-sheathed cable.

(3) **Tag Marking.** The following conductors and cables shall be marked by means of a printed tag attached to the coil, reel, or carton:

- (a) Mineral-insulated, metal-sheathed cable.
- (b) Switchboard wires.
- (c) Metal-covered single-conductor cables.
- (d) Conductors having outer surface of asbestos.
- (e) Type AC metal-clad cable.

(4) **Optional Marking of Wire Size.** For the following multiconductor cables, the information required in (a) (4) above shall be permitted to be marked on the surface of the individual insulated conductors:

- (a) Type MC metal-clad cable.
- (b) Tray cable.
- (c) Irrigation cable.
- (d) Type ALS aluminum-sheathed cable.
- (e) Type CS copper-sheathed cable.

(c) Suffixes to Designate Number of Conductors. A type letter or letters used alone shall indicate a single insulated conductor. The following letter suffixes shall indicate the following:

D—for two insulated conductors laid parallel within an outer nonmetallic covering.

M—for an assembly of two or more insulated conductors twisted spirally within an outer nonmetallic covering.

B. Conductors 600 Volts, Nominal or Less

310-12. Conductor Application. Insulated conductors listed in Table 310-13 shall be permitted for use with any of the wiring methods recognized by Chapter 3 as specified in the Table.

Thermoplastic insulation may stiffen at temperatures colder than minus 10°C (plus 14°F), requiring care be exercised during installation at such temperatures. Thermoplastic insulation may also be deformed at normal temperatures where subjected to pressure, requiring care be exercised during installation and at points of support.

310-13. Conductor Construction. Insulated conductors for use at 600 volts or less shall comply with Table 310-13.

Rubber insulations include those made from natural and synthetic rubber, and other vulcanizable materials.

Table 310-13. Conductor Application and Insulations

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions	Insulation	AWG or MCM	Thickness of Insulation Mils	Outer Covering
Heat-Resistant Rubber	RH	75°C 167°F	Dry locations.	Heat-Resistant Rubber	**14-12	30	*Moisture-resistant, flame-retardant, non-metallic covering
					10	45	
					8-2	60	
					1-4/0	80	
					213-500	95	
Heat-Resistant Rubber	RHH	90°C 194°F	Dry locations.		501-1000	110	
					1001-2000	125	
Moisture and Heat-Resistant Rubber	RHW	75°C 167°F	Dry and wet locations. For over 2000 volts insulation shall be ozone-resistant.	Moisture and Heat Resistant Rubber	14-10	45	*Moisture-resistant, flame-retardant, non-metallic covering
					8-2	60	
					1-4/0	80	
					213-500	95	
					501-1000	110	
					1001-2000	125	
Heat-Resistant Latex Rubber	RUH	75°C 167°F	Dry locations.	90% Unmilled, Grainless Rubber	14-10	18	Moisture-resistant, flame-retardant, non-metallic covering
					8-2	25	

* Outer covering shall not be required over rubber insulations which have been specifically approved for the purpose.

** For 14-12 sizes RHH shall be 45 mils thickness insulation.

For insulated aluminum and copper-clad aluminum conductors, the minimum size shall be No. 12. See Tables 310-18 and 310-19.

Table 310-13 (Continued)

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions	Insulation	AWG or MCM	Thickness of Insulation	Mils	Outer Covering
Moisture-Resistant Latex Rubber	RUW	60°C 140°F	Dry and wet locations.	90% Unmilled, Grainless Rubber	14-10 8-2	18 25		Moisture-resistant, flame-retardant, non-metallic covering
Thermoplastic	T	60°C 140°F	Dry locations.	Flame-Retardant, Thermo-plastic Compound	14-10 8 6-2 1-4/0 213-500 501-1000 1001-2000	30 45 60 80 95 110 125		None
Moisture-Resistant Thermoplastic	TW	60°C 140°F	Dry and wet locations.	Flame-Retardant, Moisture-Resistant Thermo-plastic	14-10 8 6-2 1-4/0 213-500 501-1000 1001-2000	30 45 60 80 95 110 125		None
Heat-Resistant Thermoplastic	THHN	90°C 194°F	Dry locations.	Flame-Retardant Heat-Resistant Thermo-plastic	14-12 10 8-6 4-2 1-4/0 250-500 501-1000	15 20 30 40 50 60 70		Nylon Jacket

Table 310-13 (Continued)

Moisture- and Heat-Resistant Thermoplastic	THW	75°C 167°F 90°C 194°F	Dry and wet locations. Special applications <i>within</i> electric discharge lighting equipment. Limited to 1000 open-circuit volts or less. (Size 14-8 only as permitted in Section 410-26.)	Flame-Retardant, Moisture- and Heat-Resistant Thermoplastic	14-10 45 8-2 60 1-4/0 80 213-500 95 501-1000 110 1001-2000 125	None
Moisture- and Heat-Resistant Thermoplastic	THWN	75°C 167°F	Dry and wet locations.	Flame-Retardant, Moisture- and Heat-Resistant Thermoplastic	14-12 15 10 20 8-6 30 4-2 40 1-4/0 50 250-500 60 501-1000 70	Nylon Jacket
Moisture- and Heat-Resistant Cross-Linked Synthetic Polymer	XHHW	90°C 194°F 75°C 167°F	Dry locations. Wet locations.	Flame-Retardant Cross-Linked Synthetic Polymer	14-10 30 8-2 45 1-4/0 55 213-500 65 501-1000 80 1001-2000 95	None
Moisture-, Heat- and Oil-Resistant Thermoplastic	MTW	60°C 140°F 90°C 194°F	Machine Tool Wiring in wet locations as permitted in NFPA Standard No. 79 (See Article 670). Machine Tool Wiring in dry locations as permitted in NFPA Standard No. 79 (See Article 670).	Flame-Retardant, Moisture-, Heat- and Oil-Resistant Thermoplastic	(A) (B) 22-12 30 15 10 30 20 8 45 30 6 60 30 4-2 60 40 1-4/0 80 50 213-500 95 60 501-1000 110 70	(A) None (B) Nylon jacket

For insulated aluminum and copper-clad aluminum conductors, the minimum size shall be No. 12. See Tables 310-18 and 310-19.

Table 310-13 (Continued)

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions	Insulation	AWG or MCM	Thickness of Insulation	Mils	Outer Covering
Extruded Polytetrafluoroethylene	TFE	250°C 482°F	Dry locations only. Only for leads within apparatus or within raceways connected to apparatus, or as open wiring. (Nickel or nickel-coated copper only.)	Extruded Polytetrafluoroethylene	14-10 8-2 1-4/0 .....	..... ..... .....	20 30 45	None
Thermoplastic and Asbestos	TA	90°C 194°F	Switchboard wiring only.	Thermoplastic and Asbestos	14-8 6-2 1-4/0	Th'pl'.	Asb. 20 25 30	Flame-retardant, nonmetallic covering
Thermoplastic and Fibrous Outer Braid	TBS	90°C 194°F	Switchboard wiring only.	Thermoplastic	14-10 8 6-2 1-4/0 .....	..... ..... ..... .....	30 45 60 80	Flame-retardant, nonmetallic covering
Synthetic Heat-Resistant	SIS	90°C 194°F	Switchboard wiring only.	Heat-Resistant Rubber	14-10 8 6-2 1-4/0 .....	..... ..... ..... .....	30 45 60 80	None
Mineral Insulation (Metal Sheathed)	MI	85°C 185°F 250°C 482°F	Dry and wet locations. For special application.	Magnesium Oxide	16-10 9-4 3-250 .....	..... ..... .....	36 50 55	Copper

Table 310-13 (Continued)

Underground Feeder & Branch-Circuit Cable-Single Conductor. (For Type UF cable employing more than one conductor see Article 339)	UF	60°C 140°F	See Art, 339	Moisture-Resistant	14-10 *60 8-2 *80 1-4/0 *95	Integral with insulation
		75°C** 167°F		Moisture- and Heat-Resistant		
Underground Service Entrance Cable-Single Conductor. (For Type USE cable employing more than one conductor see Article 338)	USE	75°C 167°F	See Art, 338	Heat- and Moisture-Resistant	12-10 45 8-2 60 1-4/0 80 213-500 95 501-1000 110 1001-2000 125	Moisture-resistant non-metallic covering See 338-1 (2)
Silicone-Asbestos	SA	90°C 194°F 125°C 257°F	Dry locations: For special application.	Silicone Rubber	14-10 45 8-2 60 1-4/0 80 213-500 95 501-1000 110 1001-2000 125	Asbestos or glass

* Includes integral jacket.

** For ampacity limitation, see 339-1(a).

The nonmetallic covering over individual rubber-covered conductors of aluminum-sheathed cable and of lead-sheathed or multiconductor cable shall not be required to be flame retardant. For metal-clad cable, see Section 334-4. For nonmetallic-sheathed cable, see Section 336-2. For Type UF cable, see Section 339-1. For aluminum-sheathed cable, see Section 331-23.

For insulated aluminum and copper-clad aluminum conductors, the minimum size shall be No. 12. See Tables 310-18 and 310-19.

Table 310-13 (Continued)

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions	Insulation	AWG or MCM	Thickness of Insulation	Mils	Outer Covering	
Fluorinated Ethylene Propylene	FEP or FEPB	90°C 194°F 200°C 392°F	Dry locations. Dry locations—special applications.	Fluorinated Ethylene Propylene	14-10	20	None		
				8-2	30				
				Fluorinated Ethylene Propylene	14-8	14	Glass braid		
					6-2	14	Asbestos braid		
Varnished Cambric	V	85°C 185°F	Dry locations only. Smaller than No. 6 by special permission.	Varnished Cambric	14-8	45	Nonmetallic covering or lead-sheath		
6-2	60								
1-4/0	80								
213-500	95								
500-1000	110								
1001-2000	125								
Asbestos and Varnished Cambric	AVA	110°C 230°F	Dry locations only.	Impregnated Asbestos and Varnished Cambric	1st Asb. VC			AVA-asbestos braid or glass	
					AVA 2nd 2nd Asb. Asb.				
					14-8 (solid only) ..	—	30	20	25
					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
Asbestos and Varnished Cambric	AVL	110°C 230°F	Dry and wet locations.					AVL-lead sheath	

Table 310-13 (Continued)

Asbestos and Varnished Cambric	AVB	90°C 194°F	Dry locations only.	Impregnated Asbestos and Varnished Cambric	18-8 VC 30 Asb. 20 6-2 40 30 1-4/0 40 40	Flame-retardant, cotton braid (switchboard wiring)
					14-8 Asb. 10 VC 30 2nd Asb. 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	200°C 392°F	Dry locations only. Only for leads within apparatus or within raceways connected to apparatus. Limited to 300 volts.	Asbestos	14 30 12-8 40	Without asbestos braid
Asbestos	AA	200°C 392°F	Dry locations only. Only for leads within apparatus or within raceways connected to apparatus or as open wiring. Limited to 300 volts.	Asbestos	14 30 12-8 30 6-2 40 1-4/0 60	With asbestos braid or glass
Asbestos	AI	125°C 257°F	Dry locations only. Only for leads within apparatus or within raceways connected to apparatus. Limited to 300 volts.	Impregnated Asbestos	14 30 12-8 40	Without asbestos braid

For insulated aluminum and copper-clad aluminum conductors, the minimum size shall be No. 12. See Tables 310-18 and 310-19.

Table 310-13 (Continued)

Trade Name	Type Letter	Max. Operating Temp.	Application Provisions	Insulation	AWG or MCM	Thickness of Insulation	Mils	Outer Covering
Asbestos	AIA	125°C 257°F	Dry locations only. Only for leads within apparatus or within raceways connected to apparatus or as open wiring.	Impregnated Asbestos		Sol. 14 30 12-8 30 6-2 40 1-4/0 60 213-500 90 501-1000 105	Str. 30 40 60 75 90 105	With asbestos braid or glass
Paper		85°C 185°F	For underground service conductors, or by special permission.	Paper				Lead sheath

For insulated aluminum and copper-clad aluminum conductors, the minimum size shall be No. 12. See Tables 310-18 and 310-19.

310-15. Ampacity. The maximum continuous ampacities for copper, aluminum, and copper-clad aluminum conductors shall be as specified in Tables 310-16 through 310-19 and accompanying Notes 1 through 14.

Table 310-16. Allowable Ampacities of Insulated Copper Conductors

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

Size	Temperature Rating of Conductor. See Table 310-13							
AWG MCM	60°C (140°F)	75°C (167°F)	85°C (185°F)	90°C (194°F)	110°C (230°F)	125°C (257°F)	200°C (392°F)	250°C (482°F)
	TYPES RUW (14-2), T, TW, UF	TYPES RH, RHW, RUH (14-2), THW, THWN, XHHW, USE	TYPES V, MI	TYPES TA, TBS, SA, AVB, SIS, FEP, FEPB, RHH, THHN, XHHW**	TYPES AVA, AVL	TYPES AI (14-8), AIA	TYPES A (14-8), AA, FEP*, FEPB*	TYPE TFE (Nickel or nickel- coated copper only)
18	.....	.....	.....	21	.....	.....	.....	.....
16	.....	.....	22	22	.....	.....	.....	.....
14	15	15	25	25†	30	30	30	40
12	20	20	30	30†	35	40	40	55
10	30	30	40	40†	45	50	55	75
8	40	45	50	50	60	65	70	95
6	55	65	70	70	80	85	95	120
4	70	85	90	90	105	115	120	145
3	80	100	105	105	120	130	145	170
2	95	115	120	120	135	145	165	195
1	110	130	140	140	160	170	190	220
1/0	125	150	155	155	190	200	225	250
2/0	145	175	185	185	215	230	250	280
3/0	165	200	210	210	245	265	285	315
4/0	195	230	235	235	275	310	340	370
250	215	255	270	270	315	335	.....	.....
300	240	285	300	300	345	380	.....	.....
350	260	310	325	325	390	420	.....	.....
400	280	335	360	360	420	450	.....	.....
500	320	380	405	405	470	500	.....	.....
600	355	420	455	455	525	545	.....	.....
700	385	460	490	490	560	600	.....	.....
750	400	475	500	500	580	620	.....	.....
800	410	490	515	515	600	640	.....	.....
900	435	520	555	555	.....	.....	.....	.....
1000	455	545	585	585	680	730	.....	.....
1250	495	590	645	645	.....	.....	.....	.....
1500	520	625	700	700	785	.....	.....	.....
1750	545	650	735	735	.....	.....	.....	.....
2000	560	665	775	775	840	.....	.....	.....

* Special use only. See Table 310-13.

** For dry locations only. See Table 310-13.

These ampacities relate only to conductors described in Table 310-13.

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

For ambient temperatures over 30°C, see Correction Factors, Note 13.

Table 310-17. Allowable Ampacities of Insulated Copper Conductors

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

Size	Temperature Rating of Conductor. See Table 310-13								
AWG MCM	60°C (140°F)	75°C (167°F)	85°C (185°F)	90°C (194°F)	110°C (230°F)	125°C (257°F)	200°C (392°F)	250°C (482°F)	
	TYPES RUW (14-2), T, TW	TYPES RH, RHW, RUH (14-2), THW, THWN, XHHW	TYPES V, MI	TYPES TA, TBS, SA, AVB, SIS, FEP, FEPB, RHH, XHHW**	TYPES AVA, AVL	TYPES AI (14-8), AIA	TYPES A (14-8), AA, FEP* FEPB*	TYPE TFE (Nickel or nickel-coated copper only)	Bare and Covered Conduc- tors
18	.....	.....	.....	25	.....	.....	.....	.....	.....
16	.....	.....	27	27	.....	.....	.....	.....	.....
14	20	20	30	30†	40	40	45	60	30
12	25	25	40	40†	50	50	55	80	40
10	40	40	55	55†	65	70	75	110	55
8	55	65	70	70	85	90	100	145	70
6	80	95	100	100	120	125	135	210	100
4	105	125	135	135	160	170	180	285	130
3	120	145	155	155	180	195	210	335	150
2	140	170	180	180	210	225	240	390	175
1	165	195	210	210	245	265	280	450	205
1/0	195	230	245	245	285	305	325	545	235
2/0	225	265	285	285	330	355	370	605	275
3/0	260	310	330	330	385	410	430	725	320
4/0	300	360	385	385	445	475	510	850	370
250	340	405	425	425	495	530	.....	.....	410
300	375	445	480	480	555	590	.....	.....	460
350	420	505	530	530	610	655	.....	.....	510
400	455	545	575	575	665	710	.....	.....	555
500	515	620	660	660	765	815	.....	.....	630
600	575	690	740	740	855	910	.....	.....	710
700	630	755	815	815	940	1005	.....	.....	780
750	655	785	845	845	980	1045	.....	.....	810
800	680	815	880	880	1020	1085	.....	.....	845
900	730	870	940	940	.....	.....	.....	.....	905
1000	780	935	1000	1000	1165	1240	.....	.....	965
1250	890	1065	1130	1130	.....	.....	.....	.....	.....
1500	980	1175	1260	1260	1450	.....	.....	.....	1215
1750	1070	1280	1370	1370	.....	.....	.....	.....	.....
2000	1155	1385	1470	1470	1715	.....	.....	.....	1405

* Special use only. See Table 310-13.

** For dry locations only. See Table 310-13.

These ampacities relate only to conductors described in Table 310-13.

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

For ambient temperatures over 30°C, see Correction Factors, Note 13.

Table 310-18. Allowable Ampacities of Insulated Aluminum and Copper-Clad Aluminum Conductors

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

Size	Temperature Rating of Conductor. See Table 310-13						
AWG MCM	60°C (140°F)	75°C (167°F)	85°C (185°F)	90°C (194°F)	110°C (230°F)	125°C (257°F)	200°C (392°F)
	TYPES RUW (12-2), T, TW, UF	TYPES RH, RHW, RUH (12-2), THW THWN XHHW, USE	TYPES V, MI	TYPES TA, TBS, SA, AVB, SIS, RHH THHN XHHW*	TYPES AVA, AVL	TYPES AI (12-8), AIA	TYPES A (12-8), AA
12	15	15	25	25 †	25	30	30
10	25	25	30	30 †	35	40	45
8	30	40	40	40	45	50	55
6	40	50	55	55	60	65	75
4	55	65	70	70	80	90	95
3	65	75	80	80	95	100	115
2	75	90	95	95	105	115	130
1	85	100	110	110	125	135	150
1/0	100	120	125	125	150	160	180
2/0	115	135	145	145	170	180	200
3/0	130	155	165	165	195	210	225
4/0	155	180	185	185	215	245	270
250	170	205	215	215	250	270	....
300	190	230	240	240	275	305	....
350	210	250	260	260	310	335	....
400	225	270	290	290	335	360	....
500	260	310	330	330	380	405	....
600	285	340	370	370	425	440	....
700	310	375	395	395	455	485	....
750	320	385	405	405	470	500	....
800	330	395	415	415	485	520	....
900	355	425	455	455	....	....	....
1000	375	445	480	480	560	600	....
1250	405	485	530	530	....	....	....
1500	435	520	580	580	650	....	....
1750	455	545	615	615	....	....	....
2000	470	560	650	650	705	....	....

These ampacities relate only to conductors described in Table 310-13.

* For dry locations only. See Table 310-13.

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

For ambient temperatures over 30°C, see Correction Factors, Note 13.

Table 310-19. Allowable Ampacities of Insulated Aluminum and Copper-Clad Aluminum Conductors

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

Size	Temperature Rating of Conductor. See Table 310-13							
AWG MCM	60°C (140°F)	75°C (167°F)	85°C (185°F)	90°C (194°F)	110°C (230°F)	125°C (257°F)	200°C (392°F)	
	TYPES RUW (12-2), T, TW	TYPES RH, RHW, RUH (12-2), THW THWN XHHW	TYPES V, MI	TYPES TA, TBS, SA, AVB, SIS, RHH, THHN, XHHW*	TYPES AVA, AVL	TYPES AI (12-8), AIA	TYPES A (12-8), AA	Bare and Covered Conduc- tors
12	20	20	30	30 †	40	40	45	30
10	30	30	45	45 †	50	55	60	45
8	45	55	55	55	65	70	80	55
6	60	75	80	80	95	100	105	80
4	80	100	105	105	125	135	140	100
3	95	115	120	120	140	150	165	115
2	110	135	140	140	165	175	185	135
1	130	155	165	165	190	205	220	160
1/0	150	180	190	190	220	240	255	185
2/0	175	210	220	220	255	275	290	215
3/0	200	240	255	255	300	320	335	250
4/0	230	280	300	300	345	370	400	290
250	265	315	330	330	385	415	....	320
300	290	350	375	375	435	460	....	360
350	330	395	415	415	475	510	....	400
400	355	425	450	450	520	555	....	435
500	405	485	515	515	595	635	....	490
600	455	545	585	585	675	720	....	560
700	500	595	645	645	745	795	....	615
750	515	620	670	670	775	825	....	640
800	535	645	695	695	805	855	....	670
900	580	700	750	750	....	....	....	725
1000	625	750	800	800	930	990	....	770
1250	710	855	905	905	....	....	....	....
1500	795	950	1020	1020	1175	....	....	985
1750	875	1050	1125	1125	....	....	....	....
2000	960	1150	1220	1220	1425	....	....	1165

These ampacities relate only to conductors described in Table 310-13.

* For dry locations only. See Table 310-13.

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

For ambient temperatures over 30°C, see Correction Factors, Note 13.

Notes To Tables 310-16 through 310-19

Ampacity. The maximum, continuous, ampacities of copper conductors are given in Tables 310-16 and 310-17. The ampacities of aluminum and copper-clad aluminum conductors are given in Tables 310-18 and 310-19.

1. Explanation of Tables. For explanation of Type Letters, and for recognized size of conductors for the various conductor insulations, see Sections 310-12 and 310-13. For installation requirements, see Sections 310-1 through 310-9, and the various Articles of this Code. For flexible cords see Tables 400-4 and 400-5.

2. Application of Tables. For open wiring on insulators and for concealed knob-and-tube wiring, the allowable ampacities of Tables 310-17 and 310-19 shall be used. For all other recognized wiring methods, the allowable ampacities of Tables 310-16 and 310-18 shall be used, unless otherwise provided in this Code.

3. Three-Wire Single-Phase Residential Services. For 3-wire, single-phase residential services, the allowable ampacity of Types RH, RHH, RHW, THW, and XHHW copper service-entrance conductors shall be for sizes No. 4-100 Amp., No. 3-110 Amp., No. 2-125 Amp., No. 1-150 Amp., No. 1/0-175 Amp., and No. 2/0-200 Amp., and the allowable ampacity of Types RH, RHH, RHW, THW, and XHHW aluminum and copper-clad aluminum service-entrance conductors shall be for sizes No. 2-100 Amp., No. 1-110 Amp., No. 1/0-125 Amp., No. 2/0-150 Amp., No. 3/0-175 Amp. and No. 4/0-200 Amp.

4. Aluminum and Copper-Clad Aluminum Conductors. For aluminum and copper-clad aluminum conductors the allowable ampacities shall be in accordance with Tables 310-18 and 310-19.

5. Bare Conductors. Where bare conductors are used with insulated conductors, their allowable ampacities shall be limited to that permitted for the insulated conductors of the same size.

6. Mineral-Insulated, Metal-Sheathed Cable. The temperature limitation on which the ampacities of mineral-insulated, metal-sheathed cable are based is determined by the

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

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

8. More Than 3 Conductors in a Raceway or Cable. Where the number of conductors in a raceway or cable exceed 3, the maximum allowable load current of each conductor shall be reduced as shown in the following table:

Number of Conductors	Percent of Values in Tables 310-16 and 310-18
4 thru 6	80
7 thru 24	70
25 thru 42	60
43 and above	50

Where single conductors or multiconductor cables are stacked or bunched without maintaining spacing and are not installed in raceways, the maximum allowable load current of each conductor shall be reduced as shown in the above table.

Exception No. 1: When conductors of different systems, as provided in Section 300-3, are installed in a common raceway the derating factors shown above shall apply to the number of power and lighting (Articles 210, 215, 220, and 230) conductors only.

Exception No. 2: The derating factors of Sections 210-22(c), 220-2(a) and 220-10(b) shall not apply when the above derating factors are also required.

Exception No. 3: For conductors installed in cable trays, the provisions of Section 318-10 shall apply.

9. Overcurrent Protection. Where the standard ratings and settings of overcurrent devices do not corre-

[illegible]

14. Type MTW Machine Tool Wire. The ampacities of Type MTW wire are specified in Table 200-B of the Electrical Standard for Metalworking Machine Tools 1973 (NFPA Publication No. 79).

C. Conductors Over 600 Volts, Nominal

310-30. General. In addition to the generally applicable provisions of Part A of this article, the following rules shall apply.

310-31. Construction of Conductors For Over 600 Volts. Insulated conductors for use over 600 volts, nominal shall comply with Table 310-31 through 310-37.

Table 310-31. Conductor Application and Insulation

Trade Name	Type Letter	Maximum Operating Temperature	Application Provision	Insulation	Outer Covering
Medium voltage solid dielectric	MV-75 MV-85 MV-90	75C 85C 90C	Dry or wet locations rated 2001 volts and higher	Thermoplastic or Thermo-setting	Jacket, Sheath or Armor

Table 310-32. Thickness Of Insulation For 601-2000 Volt Non-Shielded Types RHH and RHW, In Mils

Conductor Size AWG-MCM	A	B
14-10*	80	60
8	80	70
6-2	95	70
1-2/0	110	90
3/0-4/0	110	90
213-500	125	105
501-1000	140	120

Note: Column A insulations are limited to natural, SBR, and butyl rubbers.

Note: Column B insulations are those specifically approved for the purpose, such as cross-linked polyethylene and ethylene propylene rubber:

* Note: No. 12 shall be the minimum conductor size for aluminum and copper-clad aluminum.

Table 310-33. Thickness of Insulation and Jacket For Nonshielded Solid Dielectric Insulated Conductors Rated 2001 to 8000 Volts in Mils

Conductor Size AWG-MCM	2001-5000 Volts						5001-8000 Volts 100 Percent Insulation Level Wet or Dry Locations		
	Dry Locations Single Conductor			Wet or Dry Locations			Single Conductor		Multi- Conductor*
	Without Jacket	With Jacket		Single Conductor		Multi- Conductor*			
	Insulation	Insulation	Jacket	Insulation	Jacket	Insulation	Insulation	Jacket	Insulation
8	110	90	30	125	80	90	180	80	180
6	110	90	30	125	80	90	180	80	180
4-2	110	90	45	125	80	90	180	95	180
1-2/0	110	90	45	125	80	90	180	95	180
3/0-4/0	110	90	65	125	95	90	180	110	180
213-500	120	90	65	140	110	90	210	110	210
501-750	130	90	65	155	125	90	235	125	235
751-1000	130	90	65	155	125	90	250	140	250

* Note: Under a common overall covering such as a jacket, sheath or armor.

Table 310-34. Thickness of Insulation For Shielded Solid Dielectric Insulated Conductors Rated 2001 to 15000 Volts, In Mils

Conductor Size AWG-MCM	2001-5000 Volts	5001-8000		8001-15000	
		100* Percent insulation level	133* Percent insulation level	100* Percent insulation level	133* Percent insulation level
8	90	—	—	—	—
6-4	90	115	140	—	—
2	90	115	140	175	—
1-1000	90	115	140	175	215

*** DEFINITIONS:**

100 Percent Insulation Level. Cables in this category shall be permitted to be applied where the system is provided with relay protection such that ground faults will be cleared as rapidly as possible, but in any case within 1 minute. While these cables are applicable to the great majority of cable installations which are on grounded systems, they shall be permitted to be used also on other systems for which the application of cables is acceptable provided the above clearing requirements are met in completely de-energizing the faulted section.

133 Percent Insulation Level. This insulation level corresponds to that formerly designated for ungrounded systems. Cables in this category shall be permitted to be applied in situations where the clearing time requirements of the 100 percent level category cannot be met, and yet there is adequate assurance that the faulted section will be de-energized in a time not exceeding 1 hour. Also they shall be permitted to be used when additional insulation strength over the 100 percent level category is desirable.

Table 310-35
Thickness of Varnished-Cambric Insulation for
Single-Conductor Cable, in Mils

Conductor Size AWG or MCM	For Voltages Not Exceeding				
	1000	2000	3000	4000	5000
14	60	..	..	..	..
12	60	80	..	..	..
10	60	80	95	..	..
8-2	60	80	95	110	140
1-4/0	80	95	95	110	140
213-500	95	95	110	125	155
501-1000	110	110	110	125	155
1001-2000	125	125	125	140	155

Table 310-36**Thickness of Varnished-Cambric Insulation for Multiconductor Cable, in Mils**

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	60	0	..	..	..	..	..	..	..	..
12	60	0	80	0	..	..	..	..	..	..
10	60	0	80	0	80	30	..	..	..	..
8-2	60	0	80	0	80	30	95	45	95	60
1-4/0	80	0	95	0	95	30	95	45	95	60
213-500	95	0	95	0	95	30	95	45	110	60
501-1000	95	30	95	30	95	45	95	60	110	60
1001-2000	110	30	110	30	110	45	110	60	110	80

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 over-all belt of insulation.

Table 310-37**Thickness of Asbestos and Varnished-Cambric Insulation for Single-Conductor Cable, Types AVA, AVB, and AVL, in Mils**

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

310-38. Ampacity. The maximum continuous ampacities for copper and aluminum solid dielectric insulated conductors rated 2001 to 15000 volts shall be as given in Tables 310-39 through 310-50 and accompanying notes, while for conductors rated 601 to 2000 volts the maximum continuous ampacities shall be as given in Tables 310-16 through 310-19 and their accompanying notes.

Table 310-39**Allowable Ampacities for Insulated Single Copper
Conductor Isolated In Air****Based on Conductor Temperature of 90°C and Ambient
Air Temperature of 40°C**

Conductor Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	83	—
6	110	110
4	145	150
2	190	195
1	225	225
1/0	260	260
2/0	300	300
3/0	345	345
4/0	400	400
250	445	445
350	550	550
500	695	685
750	900	885
1000	1075	1060
1250	1230	1210
1500	1365	1345
1750	1495	1470
2000	1605	1575

Table 310-40**Allowable Ampacities of an Insulated Three Conductor Copper
Cable, Isolated in Air****Based On Conductor Temperature of 90°C and Ambient
Air Temperature of 40°C**

Conductor Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	59	—
6	79	93
4	105	120
2	140	165
1	160	185
1/0	185	215
2/0	215	245
3/0	250	285
4/0	285	325
250	320	360
350	395	435
500	485	535
750	615	670
1000	705	770

Table 310-41

**Allowable Ampacities of an Insulated Triplexed or Three Single
Conductor Copper Cables In Isolated Conduit In Air**

**Based On Conductor Temperature of 90°C and Ambient
Air Temperature of 40°C**

Conductor Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	55	—
6	75	83
4	97	110
2	130	150
1	155	170
1/0	180	195
2/0	205	225
3/0	240	260
4/0	280	295
250	315	330
350	385	395
500	475	480
750	600	585
1000	690	675

Table 310-42

**Allowable Ampacities of An Insulated Three Conductor
Copper Cable In Isolated Conduit In Air**

**Based On Conductor Temperature of 90°C and Ambient
Air Temperature of 40°C**

Conductor Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	52	—
6	69	83
4	91	105
2	125	145
1	140	165
1/0	165	195
2/0	190	220
3/0	220	250
4/0	255	290
250	280	315
350	350	385
500	425	470
750	525	570
1000	590	650

Table 310-43

**Allowable Ampacities of An Insulated Triplexed or Three Single
Conductor Copper Cables In Underground Ducts**

**Based on Conductor Temperature of 90°C, Ambient Earth Temperature
of 20°C, 100% Load Factor and Thermal Resistance (RHO) of 90**

One Circuit Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	64	—
6	85	90
4	110	115
2	145	155
1	170	175
1/0	195	200
2/0	220	230
3/0	250	260
4/0	290	295
250	320	325
350	385	390
500	470	465
750	585	565
1000	670	640
Three Circuit Size		
8	56	—
6	73	77
4	95	99
2	125	130
1	140	145
1/0	160	165
2/0	185	185
3/0	210	210
4/0	235	240
250	260	260
350	315	310
500	375	370
750	460	440
1000	525	495
Six Circuit Size		
8	48	—
6	62	64
4	80	82
2	105	105
1	115	120
1/0	135	135
2/0	150	150
3/0	170	170
4/0	195	190
250	210	210
350	250	245
500	300	290
750	365	350
1000	410	390

Table 310-44**Allowable Ampacities of An Insulated Three Conductor Copper Cable In Underground Ducts****Based On Conductor Temperature of 90°C, Ambient Earth Temperature of 20°C, 100% Load Factor and Thermal Resistance (RHO) of 90**

One Circuit Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	59	—
6	78	88
4	100	115
2	135	150
1	155	170
1/0	175	195
2/0	200	220
3/0	230	250
4/0	265	285
250	290	310
350	355	375
500	430	450
750	530	545
1000	600	615
Three Circuit Size		
8	53	—
6	69	75
4	89	97
2	115	125
1	135	140
1/0	150	160
2/0	170	185
3/0	195	205
4/0	225	230
250	245	255
350	295	305
500	355	360
750	430	430
1000	485	485
Six Circuit Size		
8	46	—
6	60	63
4	77	81
2	98	105
1	110	115
1/0	125	130
2/0	145	150
3/0	165	170
4/0	185	190
250	200	205
350	240	245
500	290	290
750	350	340
1000	390	380

Table 310-45**Allowable Ampacities For Insulated Single Aluminum Conductor
Isolated In Air****Based On Conductor Temperature of 90°C and Ambient
Air Temperature of 40°C**

Conductor Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	64	—
6	85	87
4	115	115
2	150	150
1	175	175
1/0	200	200
2/0	230	235
3/0	270	270
4/0	310	310
250	345	345
350	430	430
500	545	535
750	710	700
1000	855	840
1250	980	970
1500	1105	1085
1750	1215	1195
2000	1320	1295

Table 310-46**Allowable Ampacities of An Insulated Three Conductor
Aluminum Cable Isolated In Air****Based On Conductor Temperature of 90°C and Ambient
Air Temperature of 40°C**

Conductor Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	46	—
6	61	72
4	81	95
2	110	125
1	125	145
1/0	145	170
2/0	170	190
3/0	195	220
4/0	225	255
250	250	280
350	310	345
500	385	425
750	495	540
1000	585	635

Table 310-47

**Allowable Ampacities of Insulated Triplexed Or Three Single
Conductor Aluminum Cables In Isolated Conduit In Air**
Based On Conductor Temperature of 90°C and Ambient
Air Temperature of 40°C

Conductor Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	43	—
6	58	65
4	76	84
2	100	115
1	120	130
1/0	140	150
2/0	160	175
3/0	190	200
4/0	215	230
250	250	255
350	305	310
500	380	385
750	490	485
1000	580	565

Table 310-48

**Allowable Ampacities of an Insulated Three Conductor
Aluminum Cable in Isolated Conduit in Air**
Based On Conductor Temperature of 90°C and Ambient
Air Temperature of 40°C

Conductor Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	41	—
6	53	64
4	71	84
2	96	115
1	110	130
1/0	130	150
2/0	150	170
3/0	170	195
4/0	200	225
250	220	250
350	275	305
500	340	380
750	430	470
1000	505	550

Table 310-49**Allowable Ampacities of Insulated Triplexed or Three Single
Conductor Aluminum Cables in Underground Ducts****Based on Conductor Temperature of 90°C, Ambient Earth Temperature
of 20°C, 100% Load Factor and Thermal Resistance (RHO) of 90**

One Circuit Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	50	—
6	66	70
4	86	91
2	115	120
1	130	135
1/0	150	155
2/0	170	175
3/0	195	200
4/0	225	230
250	250	250
350	305	305
500	370	370
750	470	455
1000	545	525
Three Circuit Size		
8	44	—
6	57	60
4	74	77
2	96	100
1	110	110
1/0	125	125
2/0	145	145
3/0	160	165
4/0	185	185
250	205	200
350	245	245
500	295	290
750	370	355
1000	425	405
Six Circuit Size		
8	38	—
6	48	50
4	62	64
2	80	80
1	91	90
1/0	105	105
2/0	115	115
3/0	135	130
4/0	150	150
250	165	165
350	195	195
500	240	230
750	290	280
1000	335	320

Table 310-50**Allowable Ampacities of an Insulated Three Conductor Aluminum Cable in Underground Ducts****Based on Conductor Temperature of 90°C, Ambient Earth Temperature of 20°C, 100% Load Factor and Thermal Resistance (RHO) of 90**

One Circuit Size AWG-MCM	2001-5000 Volts Ampacity	5001-15,000 Volts Ampacity
8	46	—
6	61	69
4	80	89
2	105	115
1	120	135
1/0	140	150
2/0	160	170
3/0	180	195
4/0	205	220
250	230	245
350	280	295
500	340	355
750	425	440
1000	495	510
Three Circuit Size		
8	41	—
6	54	59
4	70	75
2	90	100
1	105	110
1/0	120	125
2/0	135	140
3/0	155	160
4/0	175	180
250	190	200
350	230	240
500	280	285
750	345	350
1000	400	400
Six Circuit Size		
8	36	—
6	46	49
4	60	63
2	77	80
1	87	90
1/0	99	105
2/0	110	115
3/0	130	130
4/0	145	150
250	160	160
350	190	190
500	230	230
750	280	275
1000	320	315

Notes To Tables 310-39 Through 310-50

Ampacities calculated in accordance with the following Notes 1 and 2 will require reference to AIEE/IPCEA "Power Cable Ampacities" Vols. I and II (IPCEA PUB. No. P-46-426) and "The References" therein for availability of all factors and constants.

1. *Ambients Not in Tables.* Ampacities at ambient temperatures other than those shown in the Tables shall be determined by means of the following formula:

$$I_2 = I_1 \sqrt{\frac{TC - TA_2 - \text{DELTA TD}}{TC - TA_1 - \text{DELTA TD}}}$$

Where,

I_1 = Ampacity from Tables at ambient TA_1

I_2 = Ampacity at desired ambient TA_2

TC = Conductor temperature in degrees C

TA_1 = Surrounding ambient from Tables in degrees C

TA_2 = Desired ambient in degrees C

DELTA TD = Dielectric loss temperature rise

2. *Applications Not Covered by Tables.* Ampacities for cable insulations, cable configurations, voltage levels, or thermal resistivities not included in the Tables shall be permitted to be calculated, under engineering supervision, by means of the following general formula:

$$I = \sqrt{\frac{TC - (TA + \text{DELTA TD})}{RDC (1 + YC) RCA}}$$

TC = Conductor temperature in degrees C

TA = Ambient temperature in degrees C

DELTA TD = Dielectric loss temperature rise

RDC = D-c resistance of conductor at temperature TC

YC = Component a-c resistance resulting from skin effect and proximity effect

RCA = Effective thermal resistance between conductor and surrounding ambient.

3. *Grounded Shields* — Ampacities shown in Tables 310-39 and 310-45 are for cable with shields grounded at one point only.

4. *Duct Bank Configuration* — Ampacities shown in Tables 310-43, 310-44, 310-49 and 310-50 shall apply only when the cables are located in the outer ducts of the duct bank. Ampacities for cables located in the inner ducts of the duct bank will have to be determined by special calculations.

310-51. Shielding.

Solid dielectric insulated conductors operated above 2000 volts in permanent installations shall have ozone resistant insulation and shall be shielded. Shielding shall be for the purpose of confining the voltage stresses to the insulation.

Exception: Non-shielded insulated conductors listed by a nationally recognized testing laboratory and approved for the purpose shall be permitted for use up to 8000 volts under the following conditions:

(a) Conductors shall have insulation resistant to electric discharge and surface tracking, or the insulated conductor(s) shall be covered with a material resistant to ozone, electric discharge and surface tracking.

(b) Where used in wet locations the insulated conductor(s) shall have an overall nonmetallic jacket or a continuous metallic sheath suitable for the purpose.

(c) Where operated at 5001 to 8000 volts, the insulated conductor(s) shall have a nonmetallic jacket over the insulation. The insulation shall have a specific inductive capacity no greater than 3.6 and the jacket shall have a specific inductive capacity no greater than 10 and no less than 6.

(d) Insulation and jacket thicknesses shall be in accordance with Table 310-33.

ARTICLE 318 — CABLE TRAYS

318-1. Scope. A cable tray system is a unit or assembly of units or sections, and associated fittings, made of metal or other noncombustible materials forming a rigid structural system used to support cables. Cable tray systems include ladders, troughs, channels, solid bottom trays, and other similar structures.

It is not the intent of this Article to require that cables be installed in cable tray systems or to recognize the use of all conductors described in Article 310 in cable tray systems for general wiring.

318-2. Uses Permitted.

(a) The following shall be permitted to be installed in cable tray systems under the conditions described in the Article for each:

1. Mineral-insulated metal-sheathed cable, (Article 330); 2. aluminum-sheathed cable, (Article 331); 3. copper-sheathed cable, (Article 332); 4. metal-clad cable, (Article 334); 5. nonmetallic-sheathed cable, (Article 336); 6. shielded nonmetallic-sheathed cable, (Article 337); 7. multiple-conductor service-entrance cable, (Article 338); 8. multiple-conductor underground feeder and branch-circuit cable, (Article 339); 9. power and control tray cable, (Article 340); 10. other factory-assembled, multiple-conductor control, signal, or power cables, which are specifically approved for installation in cable trays; or 11. any approved conduit or raceway with its contained conductors.

(b) In industrial establishments only, where conditions of maintenance and supervision assure that only competent individuals will service the installed cable tray system, any of the following sizes and types of cables shall be permitted to be installed in ladder, ventilated trough, or 4-inch ventilated channel-type cable trays:

(1) **Single Conductor.** Sizes 250 MCM and larger, Types RHH and RHW without outer braids, Types MV, USE, THW, and other types which are specifically approved for installation in cable trays. Where exposed to direct rays of the sun, cables shall be sunlight-resistant.

(2) **Multiconductor.** Type MV cables, (Article 310) where exposed to direct rays of the sun, cables shall be sunlight-resistant.

(c) The metal in cable trays, as defined in Table 318-6(b)(2), shall be permitted to be used as equipment grounding conductors in commercial and industrial establishments only, where continuous maintenance and supervision assure that only competent individuals will service the installed cable tray system.

(d) Cable tray systems shall be permitted to be used in hazardous locations where the contained cables are specifically approved for such use. See Sections 501-4, 502-4, and 503-3.

318-3. Uses Not Permitted. Cable tray systems shall not be used in hoistways or where subjected to severe physical damage.

318-4. Construction Specifications. Cable trays shall be approved for the purpose and shall comply with the following:

(a) Shall have suitable strength and rigidity to provide adequate support for all contained wiring.

(b) Shall not present sharp edges, burrs or projections injurious to the insulation or jackets of the wiring.

(c) If made of metal, shall be adequately protected against corrosion or shall be made of corrosion-resistant material.

(d) Shall have side rails or equivalent structural members.

(e) Shall include fittings or other suitable means for changes in direction and elevation of runs.

318-5. Installation.

(a) Cable trays shall be installed as a complete system. Field bends or modifications shall be so made that the electrical continuity of the cable tray system and support for the cables shall be maintained.

(b) Each run of cable tray shall be completed before the installation of cables.

(c) Supports shall be provided to prevent stress on cables where they enter another raceway or enclosure from cable tray systems.

(d) In portions of runs where additional protection is required, non-combustible covers or enclosures providing the required protection shall be used.

(e) Installations involving different electrical systems shall comply with Section 300-3. Where barriers are required to separate cables of different systems in cable trays, the barriers shall be solid and non-combustible.

(f) Cable trays shall be permitted to extend transversely through partitions and walls or vertically through platforms and floors in wet or dry locations where the installations, complete with installed cables, are made in accordance with the requirements of Section 300-21.

(g) Cable trays shall be exposed and accessible except as permitted by Section 318-5(f).

(h) Sufficient space shall be provided and maintained about cable trays to permit adequate access for installing and maintaining the cables.

318-6. Grounding.

(a) Metallic cable trays which support electrical conductors shall be grounded as required for conductor enclosures in Article 250.

(b) Where steel or aluminum cable tray systems are used as equipment grounding conductors, all of the following provisions shall be complied with:

(1) The cable tray sections and fittings shall be approved for the purpose.

(2) The minimum cross-sectional area of cable trays shall conform to the requirements in Table 318-6(b) (2).

(3) All cable tray sections and fittings shall be legibly and durably marked to show the cross-sectional area of metal in channel-type cable trays or cable trays of one-piece construction, and the total cross-sectional area of both side rails for ladder or trough-type cable trays.

(4) Cable tray sections, fittings and connected raceways shall be bonded in accordance with Section 250-75 using bolted mechanical connectors approved for the purpose or bonding jumpers sized and installed in accordance with Section 250-79.

Table 318-6(b) (2)
Metal Area Requirements for Cable Trays
Used as Equipment Grounding Conductors

Ampere Rating or Setting of Largest Automatic Overcurrent Device Protecting Any Circuit in the Cable Tray System	Minimum Cross-Sectional Area of Metal* in Square Inches	
	Steel Cable Trays	Aluminum Cable Trays
0- 60	0.20	0.20
61- 100	0.40	0.20
101- 200	0.70	0.20
201- 400	1.00	0.40
401- 600	1.50**	0.40
601-1000	—	0.60
1001-1200	—	1.00
1201-1600	—	1.50
1601-2000	—	2.00**

* Total cross-sectional area of both side rails for ladder or trough-type cable trays; or the minimum cross-sectional area of metal in channel type cable trays or cable trays of one-piece construction.

** Steel cable trays shall not be used as equipment grounding conductors for circuits protected above 600 amperes. Aluminum cable trays shall not be used for equipment grounding conductors for circuits protected above 2000 amperes.

318-7. Cable Installation.

(a) Cable splices made and insulated by approved methods shall be permitted to be located within a cable tray provided they are accessible and do not project above the side rails.

(b) In other than horizontal runs, the cables shall be fastened securely to transverse members of the cable trays.

(c) A box shall not be required where cables or conductors are installed in bushed conduit used for support or for protection against physical damage.

(d) Where single conductor cables comprising each phase or neutral of a circuit are connected in parallel as permitted in Section 310-4, the conductors shall be installed in groups consisting of not more than one conductor per phase or neutral, to prevent current unbalance in the paralleled conductors due to inductive reactance.

Single conductors shall be securely bound in circuit groups to prevent excessive movement due to fault current magnetic forces.

Exception: Where single conductors are twisted together, such as triplexed assemblies.

318-8. Number of Multiple-Conductor Cables in Cable Trays. The number of multiple-conductor cables permitted in a single cable tray shall not exceed the requirements of this Section.

(a) Where ladder or ventilated trough cable trays contain multiple-conductor power or lighting cables, or any mixture of multiple-conductor power, lighting, control, and signal cables, the maximum number of cables shall conform to the following:

(1) Where all of the cables are 4/0 AWG or larger, the sum of the diameters of all cables shall not exceed the cable tray width, and the cables shall be installed in a single layer.

(2) Where all of the cables are smaller than 4/0 AWG, the sum of the cross-sectional areas of all cables shall not exceed the maximum allowable cable fill area in Column 1 of Table 318-8, for the appropriate cable tray width.

(3) Where 4/0 AWG or larger cables are installed in the same cable tray with cables smaller than 4/0 AWG, the sum of the cross-sectional areas of all cables smaller than 4/0 AWG shall not exceed the maximum allowable fill area resulting from the computation in Column 2 of Table 318-8, for the appropriate cable tray width. The 4/0 AWG and larger cables shall be installed in a single layer and no other cables shall be placed on them.

(b) Where a ladder or ventilated trough cable tray, having a usable inside depth of 6 inches or less, contains multiple-conductor control and/or signal cables only, the sum of the cross-sectional areas of all cables at any cross section shall not exceed 50 percent of the interior cross-sectional area of the cable tray. A depth of 6 inches shall be used to compute the allowable interior cross-sectional area of any cable tray which has a usable inside depth of more than 6 inches.

(c) Where solid bottom cable trays contain multiple-conductor power or lighting cables, or any mixture of multiple-conductor power, lighting, control, and signal cables, the maximum number of cables shall conform to the following:

(1) Where all of the cables are 4/0 AWG or larger, the sum of the diameters of all cables shall not exceed 90 percent of the cable tray width, and the cables shall be installed in a single layer.

(2) Where all of the cables are smaller than 4/0 AWG, the sum of the cross-sectional areas of all cables shall not exceed the maximum

allowable cable fill area in Column 3 of Table 318-8, for the appropriate cable tray width.

(3) Where 4/0 AWG or larger cables are installed in the same cable tray with cables smaller than 4/0 AWG, the sum of the cross-sectional areas of all cables smaller than 4/0 AWG shall not exceed the maximum allowable fill area resulting from the computation in Column 4 of Table 318-8, for the appropriate cable tray width. The 4/0 AWG and larger cables shall be installed in a single layer and no other cables shall be placed on them.

(d) Where a solid bottom cable tray, having a usable inside depth of 6 inches or less, contains multiple-conductor control and/or signal cables only, the sum of the cross-sectional areas of all cables at any cross section shall not exceed 40 percent of the interior cross-sectional area of the cable tray. A depth of 6 inches shall be used to compute the allowable interior cross-sectional area of any cable tray which has a usable inside depth of more than 6 inches.

(e) Where ventilated channel-type cable trays contain multiple-conductor cables of any type, the combined cross-sectional area of all cables shall not exceed 1.3 square inches in 3-inch wide channel trays, or 2.5 square inches in 4-inch wide channel trays.

Exception: Where only one multiple-conductor cable is installed in a ventilated channel-type tray the cross-sectional area of the cable shall not exceed 2.3 square inches in a 3-inch wide channel tray, or 4.5 square inches in a 4-inch wide channel tray.

Table 318-8. Allowable Cable Fill Area for Multiple-Conductor Cables in Ladder, Ventilated Trough, or Solid Bottom Cable Trays

Maximum Allowable Fill Area in Square Inches for Multiple-Conductor Cables				
Inside Width of Cable Tray (Inches)	Ladder or Ventilated Trough Cable Trays, Section 318-8(a)		Solid Bottom Cable Trays, Section 318-8(c)	
	Column 1 Applicable for Section 318-8(a) (2) Only (Square Inches)	Column 2* Applicable for Section 318-8(a) (3) Only (Square Inches)	Column 3 Applicable for Section 318-8(c) (2) Only (Square Inches)	Column 4* Applicable for Section 318-8(c) (3) Only (Square Inches)
6	7	7—(1.2 Sd)**	5.5	5.5—Sd**
12	14	14—(1.2 Sd)	11.0	11.0—Sd
18	21	21—(1.2 Sd)	16.5	16.5—Sd
24	28	28—(1.2 Sd)	22.0	22.0—Sd
30	35	35—(1.2 Sd)	27.5	27.5—Sd
36	42	42—(1.2 Sd)	33.0	33.0—Sd

* The maximum allowable fill areas in Columns 2 and 4 shall be computed. For example, the maximum allowable fill, in square inches, for a 6 inch wide cable tray in Column 2 shall be: 7 minus (1.2 multiplied by Sd).

** The term Sd in Columns 2 and 4 is equal to the sum of the diameters, in inches, of all 4/0 AWG and larger multiple-conductor cables in the same cable tray with smaller cables.

318-9. Number of Single Conductor Cables in Cable Trays. The number of single conductor cables permitted in a single cable tray section shall not exceed the requirements of this section. The single conductors, or conductor assemblies, shall be evenly distributed across the cable tray.

(a) Where ladder or ventilated trough cable trays contain single conductor cables, the maximum number of single conductors shall conform to the following:

(1) Where all of the cables are 1000 MCM or larger, the sum of the diameters of all single conductor cables shall not exceed the cable tray width.

(2) Where all of the cables are smaller than 1000 MCM, the sum of the cross-sectional areas of all single conductor cables shall not exceed the maximum allowable cable fill area in Column 1 of Table 318-9, for the appropriate cable tray width.

(3) Where 1000 MCM or larger single conductor cables are installed in the same cable tray with single conductor cables smaller than 1000 MCM, the sum of the cross-sectional areas of all cables smaller than 1000 MCM shall not exceed the maximum allowable fill area resulting from the computation in Column 2 of Table 318-9, for the appropriate cable tray width.

(b) Where 4-inch wide ventilated channel-type cable trays contain single conductor cables, the sum of the diameters of all single conductors shall not exceed the inside width of the channel.

Table 318-9. Allowable Cable Fill Area for Single Conductor Cables in Ladder or Ventilating Trough Cable Trays

Inside Width of Tray Cable (Inches)	Maximum Allowable Fill Area in Square Inches for Single Conductor Cables in Ladder or Ventilating Trough Cable Trays	
	Column 1 Applicable for Section 318-9(a) (2) Only (Square Inches)	Column 2* Applicable for Section 318-9(a) (3) Only (Square Inches)
6	6.50	6.50—(1.1 Sd) **
12	13.0	13.0—(1.1 Sd)
18	19.5	19.5—(1.1 Sd)
24	26.0	26.0—(1.1 Sd)
30	32.5	32.5—(1.1 Sd)
36	39.0	39.0—(1.1 Sd)

* The maximum allowable fill areas in Column 2 shall be computed. For example, the maximum allowable fill, in square inches, for a 6 inch wide cable tray shall be: 6.5 minus (1.1 multiplied by Sd).

** The term Sd in Column 2 is equal to the sum of the diameters, in inches, of all 1000 MCM and larger single conductor cables in the same ladder or ventilated trough cable tray with smaller cables.

318-10. Ampacity of Cables in Cable Trays.

(a) **Multiple-Conductor Cables.** The ampacity of multiple-conductor cables installed according to the requirements of Section 318-8 shall comply with the allowable ampacities of Tables 310-16 and 310-18.

Exception: Where cable trays are continuously covered for more than six feet with solid unventilated covers, not more than 95 percent of the allowable ampacities of Tables 310-16 and 310-18 shall be permitted for multiple-conductor cables.

(b) **Single Conductor Cables.** The ampacity of single conductor cables, or single conductors twisted together, shall comply with the following:

(1) Where installed according to the requirements of Section 318-9, the ampacities for 600 MCM and larger single conductor cables in uncovered cable trays shall not exceed 75 percent of the allowable ampacities in Tables 310-17 and 310-19. Where cable trays are continuously covered for more than six feet with solid unventilated covers, the ampacities for 600 MCM and larger cables shall not exceed 70 percent of the allowable ampacities in Tables 310-17 and 310-19.

(2) Where installed according to the requirements of Section 318-9, the ampacities for 250 MCM through 500 MCM single conductor cables in uncovered cable trays shall not exceed 65 percent of the allowable ampacities in Tables 310-17 and 310-19. Where cable trays are continuously covered for more than six feet with solid unventilated covers, the ampacities for 250 MCM through 500 MCM cables shall not exceed 60 percent of the allowable ampacities in Tables 310-17 and 310-19.

(3) Where single conductors are installed in a single layer in uncovered cable trays, with a maintained space of not less than one cable diameter between individual conductors, the ampacity of 250 MCM and larger cables shall not exceed the allowable ampacities in Tables 310-17 and 310-19.

ARTICLE 320 — OPEN WIRING ON INSULATORS

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

320-2. Other Articles. Open wiring on insulators shall comply with this Article and also with the applicable provisions of other Articles in this Code, especially Articles 225 and 300.

320-3. Uses Permitted. Open wiring on insulators shall be permitted on systems of 600 volts, nominal or less for industrial or agricultural establishments, indoors or outdoors, in wet or dry locations, where subject to corrosive vapors, and for services.

320-5. Conductors.

(a) **Type.** Conductors shall be of a type specified by Article 310.

(b) **Ampacity.** The ampacity shall comply with Tables 310-17 and 310-19 and all applicable notes to those Tables.

320-6. Conductor Supports. Conductors shall be rigidly supported on noncombustible, nonabsorbent insulating materials and shall not contact any other objects. Supports shall be installed as follows: (1) within 6 inches of each side of each tap or splice; (2) within 12 inches of a dead-end connection to a rosette, lampholder, or receptacle; (3) at intervals not exceeding 4½ feet and at closer intervals sufficient to provide adequate support where likely to be disturbed.

Exception No. 1: Supports for conductors No. 8 or larger installed across open spaces shall be permitted up to 15 feet apart if noncombustible, nonabsorbent insulating spacers are used at least every 4½ feet to maintain at least 2½ inches between conductors.

Exception No. 2: Where not likely to be disturbed in buildings of mill construction, No. 8 and larger conductors shall be permitted to be run across open spaces if supported from each wood cross member on approved insulators maintaining 6 inches between conductors.

320-7. Mounting of Conductor Supports. Where nails are used to mount knobs, they shall not be smaller than 10 penny. Where screws are used to mount knobs, or where nails or screws are used to mount cleats, they shall be of a length sufficient to penetrate the wood to a depth equal to at least one-half the height of the knob and fully the thickness of the cleat. Cushion washers shall be used with nails.

320-8. Tie Wires. No. 8 or larger conductors supported on solid knobs shall be securely tied thereto by tie wires having an insulation equivalent to that of the conductor.

320-9. Conductor Clearances. Conductors shall have clearances not less than specified in Table 320-9.

Table 320-9. Minimum Clearances — Open Wiring on Insulators

Voltage Between Conductors	Distance in Inches Between Conductors	Distance in Inches From Surface Wired Over
300 or less	2½	½ (dry locations)
300 or less	2½	1 (damp or wet locations)
301-600	4	1 (damp, wet, or dry locations)

320-10. Flexible Nonmetallic Tubing. In dry locations where not exposed to severe physical damage, conductors shall be permitted to be separately enclosed in flexible nonmetallic tubing. The tubing shall be in continuous lengths not exceeding 15 feet and secured to the surface by straps at intervals not exceeding 4½ feet.

320-11. Through Walls, Floors, Wood Cross Members, Etc. Open conductors shall be separated from contact with walls, floors, wood cross

members, or partitions through which they pass by tubes or bushings of noncombustible, nonabsorbent insulating material. Where the bushing is shorter than the hole, a waterproof sleeve of noninductive material shall be inserted in the hole and an insulating bushing slipped into the sleeve at each end in such a manner as to keep the conductors absolutely out of contact with the sleeve. Each conductor shall be carried through a separate tube or sleeve.

320-12. Clearance From Piping, Exposed Conductors, Etc. Open conductors shall be separated at least 2 inches from metal conduit, piping, or other conducting material, and from any exposed lighting, power, or signaling conductor, or shall be separated therefrom by a continuous and firmly fixed nonconductor in addition to the insulation of the conductor. Where any insulating tube is used, it shall be secured at the ends. Where practicable, conductors shall pass over rather than under any piping subject to leakage or accumulations of moisture.

320-13. Entering Spaces Subject to Dampness, Wetness, or Corrosive Vapors. Conductors entering or leaving locations subject to dampness, wetness, or corrosive vapors shall have drip loops formed on them and shall then pass upward and inward from the outside of buildings, or from the damp, wet, or corrosive location, through noncombustible, nonabsorbent insulating tubes.

See also Section 230-52.

320-14. Protection From Physical Damage. Conductors within 7 feet from the floor shall be considered exposed to physical damage. Where open conductors cross ceiling joists and wall studs and are exposed to physical damage, they shall be protected by one of the following methods:

(1) By guard strips not less than $\frac{3}{8}$ inch in thickness and at least as high as the insulating supports, placed on each side of and close to the wiring.

(2) By a substantial running board at least $\frac{1}{2}$ inch thick back of the conductors with side protections. Running boards shall extend at least one inch outside the conductors, but not more than 2 inches, and the protecting sides shall be at least 2 inches high and at least $\frac{3}{8}$ inch thick.

(3) By boxing made as above and furnished with a cover kept at least one 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.

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

320-15. Unfinished Attics and Roof Spaces. Conductors in unfinished attics and roof spaces shall comply with (a) or (b) below.

(a) **Accessible by Stairway or Permanent Ladder.** Conductors shall be installed along the side of or through bored holes in floor joists, studs,

or rafters. Where run through bored holes, conductors in the joists and in studs or rafters to a height of not less than 7 feet above the floor or floor joists shall be protected by substantial running boards extending not less than one inch on each side of the conductors. Running boards shall be securely fastened in place. Running boards and guard strips shall not be required for conductors installed along the sides of joists, studs, or rafters.

(b) Not Accessible by Stairway or Permanent Ladder. Conductors shall be installed along the sides of or through bored holes in floor joists, studs, or rafters.

Exception: In buildings completed before wiring is installed and having head room at all points of less than 3 feet.

320-16. Switches. Surface-type snap switches shall be mounted in accordance with Section 380-10(a), and boxes shall not be required. Other type switches shall be installed in accordance with Section 380-4.

ARTICLE 324 — CONCEALED KNOB-AND-TUBE WIRING

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

324-2. Other Articles. Concealed knob-and-tube wiring shall comply with this Article and also with the applicable provisions of other Articles in this Code, especially Article 300.

324-3. Uses Permitted. Concealed knob-and-tube wiring shall be permitted to be used only for extensions of existing installations and elsewhere only by special permission under the following conditions:

(1) In the hollow spaces of walls and ceilings.

(2) In unfinished attic and roof spaces as provided in Section 324-11.

324-4. Uses Not Permitted. Concealed knob-and-tube wiring shall not be used in commercial garages, theaters and similar locations, motion picture studios, or hazardous locations.

324-5. Conductors.

(a) Type. Conductors shall be of a type specified by Article 310.

(b) Ampacity. The ampacity shall comply with Tables 310-17 and 310-19 and all applicable notes to those Tables.

324-6. Conductor Supports. Conductors shall be rigidly supported on noncombustible, nonabsorbent insulating materials and shall not contact any other objects. Supports shall be installed as follows: (1) within 6 inches of each side of each tap or splice, and (2) at intervals not exceeding $4\frac{1}{2}$ feet.

Exception: If it is not practicable to provide supports in dry locations it shall be permissible to fish conductors through hollow spaces if each conductor is individually enclosed in flexible nonmetallic tubing. The tubing shall be in continuous lengths between supports, between boxes, or between a support and a box.

324-7. Tie Wires. Where solid knobs are used, conductors shall be securely tied thereto by tie wires having insulation equivalent to that of the conductor.

324-8. Conductor Clearances. Where practicable, conductors shall be run singly on separate joists, studs, or rafters. A clearance of not less than 3 inches shall be maintained between conductors and of not less than one inch between the conductor and the surface over which it passes.

Exception: Where space is too limited to provide the above minimum clearances, such as at meters, panelboards, outlets, and switch points, the conductors shall be individually enclosed in flexible nonmetallic tubing, which shall be in continuous lengths between the last support or box and the terminal point.

324-9. Through Walls, Floors, Wood Cross Members, Etc. Conductors shall comply with Section 320-11 where passing through holes in structural members. Where passing through wood cross members in plastered partitions, conductors shall be protected by noncombustible, nonabsorbent, insulating tubes extending not less than 3 inches beyond the wood member.

324-10. Clearance from Piping, Exposed Conductors, Etc. Conductors shall comply with Section 320-12 for clearances from other exposed conductors, piping, etc.

324-11. Unfinished Attics and Roof Spaces. Conductors in unfinished attics and roof spaces shall comply with (a) or (b) below.

(a) Accessible by Stairway or Permanent Ladder. Conductors shall be installed along the side of or through bored holes in floor joists, studs, or rafters. Where run through bored holes, conductors in the joists and in studs or rafters to a height of not less than 7 feet above the floor or floor joists shall be protected by substantial running boards extending not less than one inch on each side of the conductors. Running boards shall be securely fastened in place. Running boards and guard strips shall not be required where conductors are installed along the sides of joists, studs, or rafters.

(b) Not Accessible by Stairway or Permanent Ladder. Conductors shall be installed along the sides of or through bored holes in floor joists, studs, or rafters.

Exception: In buildings completed before wiring is installed and having head room at all points of less than 3 feet.

324-12. Splices. Splices shall be soldered unless approved splicing devices are used. In-line or strain splices shall not be used.

324-13. Boxes. Outlet boxes shall comply with Article 370.

324-14. Switches. Switches shall comply with Sections 380-4 and 380-10(b).

ARTICLE 330 — MINERAL-INSULATED METAL-SHEATHED CABLE

Type MI

A. General

330-1. Definition. Type MI mineral-insulated metal-sheathed cable is a factory assembly of one or more conductors insulated with a highly compressed refractory mineral insulation and enclosed in a liquidtight and gastight continuous copper sheath.

330-2. Other Articles. Type MI cable shall comply with this Article and also with the applicable provisions of other Articles in this Code, especially Article 300.

330-3. Uses Permitted. Type MI cable shall be permitted as follows: (1) for services, feeders, and branch circuits; (2) in dry, wet, or continuously moist locations; (3) indoors or outdoors; (4) where exposed or concealed; (5) embedded in plaster, concrete, fill or other masonry, whether above or below grade; (6) in any hazardous location; (7) where exposed to oil and gasoline; (8) where exposed to corrosive conditions not deteriorating to its sheath; (9) in underground runs where suitably protected against physical damage and corrosive conditions.

330-4. Uses Not Permitted. Type MI cable shall not be used where exposed to destructive corrosive conditions.

Exception: Where protected by materials suitable for the conditions.

B. Installation

330-10. Wet Locations. Where installed in wet locations, Type MI cable shall comply with Section 300-6(c).

330-11. Through Joists, Studs, or Rafters. Type MI cable shall comply with Section 300-4 where installed through studs, joists, rafters, or similar wood members.

330-12. Supports. Type MI cable shall be securely supported at intervals not exceeding 6 feet by straps, staples, hangers, or similar fittings so designed and installed as not to damage the cable.

Exception: Where cable is fished in.

330-13. Bends. Bends in Type MI cable shall be so made as not to damage the cable. The radius of the inner edge of any bend shall not be less than 5 times the cable diameter.

330-14. Fittings. Fittings approved for the purpose and conditions of use shall be used for connecting Type MI cable to boxes, cabinets, or other equipment. Where single-conductor cables enter ferrous metal boxes or cabinets, the installation shall comply with Section 300-20 to prevent inductive heating.

330-15. Terminal Seals. Where Type MI cable terminates, an approved seal shall be provided immediately after stripping to prevent the entrance of moisture into the insulation. The conductors extending beyond the sheath shall be individually provided with an approved insulating material.

C. Construction Specifications

330-20. Conductors. Type MI cable conductors shall be of solid copper with a cross-sectional area corresponding to standard AWG sizes.

330-21. Insulation. The conductor insulation in Type MI cable shall be a highly compressed refractory mineral that will provide proper spacing for the conductors.

330-22. Outer Sheath. The outer sheath shall be of a continuous copper construction to provide mechanical protection, a moisture seal, and an adequate path for grounding purposes.

ARTICLE 331 — ALUMINUM-SHEATHED CABLE

Type ALS

A. General

331-1. Definition. Type ALS aluminum-sheathed cable is a factory assembly of one or more conductors, each individually insulated and enclosed in a liquidtight and gastight close-fitting and continuous aluminum sheath.

331-2. Other Articles. Type ALS cable shall comply with this Article and also with the applicable provisions of other Articles in this Code, especially Article 300.

331-3. Uses Permitted. Type ALS cable shall be permitted as follows: (1) in dry or wet locations; (2) where exposed or concealed; (3) in underground runs where suitably protected against physical damage and corrosive conditions.

331-4. Uses Not Permitted. Type ALS cable shall not be used where exposed to destructive corrosive conditions, such as direct burial in the earth, in concrete, or where exposed to cinder fills, strong chlorides, caustic alkalis, or vapors of chlorine or of hydrochloric acids.

Exception: Where protected by materials suitable for the condition.

B. Installation

331-10. Wet Locations. Where installed in wet locations, Type ALS cable shall comply with Section 300-6.

331-11. Through Joists, Studs, or Rafters. Type ALS cable shall comply with Section 300-4 where installed through studs, joists, rafters, or similar wood members.

331-12. Supports. Type ALS cable shall be securely supported at intervals not exceeding 6 feet by straps, staples, hangers, or similar fittings so designed and installed as not to damage the cable.

Exception: Where cable is fished in.

331-13. Bends. All bends shall be so made that the cable will not be damaged and the radius of the curve on the inner edge of any bend shall not be less than:

(a) Ten times the external diameter of the sheath for cable not more than $\frac{3}{4}$ inch in external diameter.

(b) Twelve times the external diameter of the sheath for cable more than $\frac{3}{4}$ inch but not more than $1\frac{1}{2}$ inches in external diameter; and

(c) Fifteen times the external diameter of the sheath for cable more than $1\frac{1}{2}$ inches in external diameter.

Exception: On cables employing a corrugated aluminum sheath, the radius of the curve on the inner edge of any bend shall not be less than 7 times the external diameter of the sheath.

331-14. Fittings. Fittings approved for the purpose and conditions of use shall be used for connecting Type ALS cable to boxes, cabinets, or other equipment. Where single-conductor cables enter ferrous metal boxes or cabinets, the installation shall comply with Section 300-20 to prevent inductive heating.

C. Construction Specifications

331-20. Conductors. The conductors shall be of copper, copper-clad aluminum, or of electrical-conductor-grade aluminum, solid or stranded.

331-21. Insulation. The insulated conductors of Type ALS cable shall be of a type listed in Table 310-13.

331-22. Insulation Covering. The covering over the insulated conductors shall be the same as permitted for lead-sheathed or multiconductor cable.

331-23. Outer Sheath. The outer sheath shall be of a continuous, closely fitting tube of aluminum to provide mechanical protection, a moisture seal, and an adequate path for equipment grounding purposes and shall conform with provisions of Sections 331-3 and 331-4 for uses. The sheath shall not be used as a current-carrying conductor.

ARTICLE 332 — COPPER-SHEATHED CABLE**TYPE CS****A. General**

332-1. Definition. Type CS copper-sheathed cable is a factory assembly of one or more conductors, each individually insulated and enclosed in a liquidtight and gastight close-fitting and continuous copper or bronze sheath.

332-2. Other Articles. Type CS cable shall comply with this Article and also with the applicable provisions of other Articles in this Code, especially Article 300.

332-3. Uses Permitted. Type CS cable shall be permitted to be used as follows:

- (1) In wet or dry locations.
- (2) Where exposed or concealed.
- (3) In corrosive locations where protected by materials suitable for the conditions.

B. Installations

332-10. Wet Locations. Where installed in wet locations, Type CS cable shall comply with Section 300-6.

332-11. Through Joists, Studs or Rafters. Where installed through joists, studs or rafters, Type CS cable shall comply with Section 300-4.

332-12. Supports. Type CS cable shall be securely supported at intervals not exceeding 6 feet by straps, staples, hangers or similar fittings so designed and installed as not to damage the cable.

Exception: Where the cable is fished in.

332-13. Bends. All bends shall be so made that the cable will not be damaged and the radius of the curve on the inner edge of any bend shall not be less than:

- (a) Ten times the external diameter of the sheath for cable not more than $\frac{3}{4}$ inch in external diameter.
- (b) Twelve times the external diameter of the sheath for cable more than $\frac{3}{4}$ inch but not more than $1\frac{1}{2}$ inches in external diameter; and
- (c) Fifteen times the external diameter of the sheath for cable more than $1\frac{1}{2}$ inches in external diameter.

Exception: On cables employing a corrugated copper sheath, the radius of the curve on the inner edge of any bend shall not be less than seven times the external diameter of the sheath.

332-14. Fittings. Fittings approved for the purpose and conditions of use shall be used for connecting Type CS cable to boxes, cabinets or other equipment. Where single conductor cables enter ferrous metal boxes or cabinets, the installation shall comply with Section 300-20 to prevent inductive heating.

C. Construction Specifications

332-20. Conductors. The conductors shall be of copper, copper-clad aluminum, or electrical conductor grade aluminum, solid or stranded.

332-21. Insulation. The insulated conductors of Type CS cable shall be of a type listed in Table 310-13.

332-22. Insulation Covering. The covering over the insulated conductors shall be the same as permitted for lead-sheathed or multi-conductor cable.

332-23. Outer Sheath. The outer sheath shall be of a continuous, closely fitting tube of copper or bronze to provide mechanical protection, a moisture seal and an adequate path for equipment grounding purposes and shall conform with provisions of Section 332-3. The sheath shall not be used as a current-carrying conductor.

ARTICLE 334 — METAL-CLAD CABLE**Type MC and AC Series**

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

See Section 334-4 for construction of cable.

334-2. Other Articles. Metal-clad cable shall comply with this Article and also with the applicable provisions of other Articles in this code, especially Article 300.

Type MC cable shall be permitted for systems in excess of 600 volts. See Section 300-2.

334-3. Marking. The provisions of Section 310-11 shall apply, except that Type AC cable shall have ready identification of the maker by distinctive external markers in the cable sheath throughout its entire length.

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

(a) **Type MC.** Type MC cables are power and control cables in the size range from No. 14 and larger for copper and No. 12 and larger for aluminum and copper-clad aluminum. For conductor sizes and insulation thickness of Type MC cables rated over 600 volts, see Article 310, Part C. The metal enclosures shall be either a covering of interlocking metal tape, or an impervious, close fitting, corrugated tube. Supplemental protection of an outer covering of corrosion-resistant material shall be required where such protection is needed. The cables shall provide adequate path for grounding purposes.

See Section 300-6 for protection against corrosion.

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

334-5. Conductors. Conductors for metal-clad cable shall comply with (a) and (b) below.

(a) **Type MC.** For cables of Type MC, insulated conductors shall be of a type listed in Table 310-13 for rubber, thermoplastic, varnished cloth, asbestos-varnished cloth, or of a type especially approved for the purpose.

(b) **Type AC.** For cables of Type AC, insulated conductors shall be of a type listed in Table 310-13. In addition, the conductors shall have an over-all moisture-resistant and fire-retardant fibrous covering. For Type ACT, a moisture-resistant fibrous covering shall be required only on the individual conductors.

334-6. Use. Except where otherwise specified elsewhere in this Code, and where not subject to physical damage, metal-clad cable shall be permitted for branch circuits and feeders in both exposed and concealed work as in (a) and (b) below.

(a) **Type MC.** This type of cable shall be permitted in partially protected areas, such as in cable trays and the like, in dry locations, and when any of the following conditions are met, it shall be permitted in wet locations:

- (1) The metallic covering is impervious to moisture.
- (2) A lead sheath or moisture impervious jacket is provided under the metal covering.
- (3) The insulated conductors under the metallic covering are approved for use in wet locations.

See Section 300-6 for protection against corrosion.

(b) **Type AC.** Metal-clad cable of the AC type shall be permitted in dry locations; for underplaster extensions as provided in Article 344; and embedded in plaster finish on brick or other masonry, except in damp or wet locations. It shall be permissible to run or fish this cable in the air voids of masonry block or tile walls; where such walls are exposed or subject to excessive moisture or dampness or are below grade line, Type ACL cable shall be used. This cable shall contain lead-covered conductors (Type ACL) if used where exposed to the weather or to continuous moisture; for underground runs in duct or raceway and embedded in masonry, concrete or fill in buildings in course of construction; or where exposed to oil, or other conditions having a deteriorating effect on the insulation.

Type AC metal-clad cable shall not be used where prohibited elsewhere in this Code, including (1) in theaters and similar locations, except as provided in Article 518, Places of Assembly; (2) in motion-picture studios; (3) in any hazardous locations; (4) where exposed to corrosive fumes or vapors; (5) on cranes or hoists, except as provided in Section 610-11 Exception No. 3; (6) in storage battery rooms; (7) in hoistways or on elevators, except as provided in Section 620-21; or (8) commercial garages where prohibited in Article 511.

Type ACL cable shall not be used for direct burial in the earth.

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

(a) Type MC cable shall be secured at intervals not exceeding 6 feet, and within 2 feet from every box or fitting, except where cable is fished. Installation of this cable shall be permitted on metal racks, trays, troughs, or cable trays grounded as required by Article 250. The cables shall be separated from each other by a distance of not less than one-quarter of a cable diameter. There shall be no more than one layer of cables on a rack or other support member; each cable so installed shall be supported at intervals not exceeding 6 feet and within 2 feet from every box or fitting, and each cable shall be attached to the support at intervals of not more than 10 feet horizontally and 2 feet vertically.

(b) Type AC cable shall be secured at intervals of not exceeding 4½ feet and within 12 inches from every outlet box or fitting.

Exception No. 1: Where cable is fished.

Exception No. 2: Lengths of not more than 2 feet at terminals where flexibility is necessary.

334-9. Bends. All bends shall be so made that the cable will not be injured, and the radius of the curve of the inner edge of any bend shall not be less than 7 times the diameter of Type MC cable nor 5 times the diameter of Type AC cable.

334-10. Boxes and Fittings.

(a) At all points where Type MC metal-clad cable terminates, suitable fittings designed for use with the particular wiring cable and the conditions of service shall be used.

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

334-11. Through Studs, Joists and Rafters. Metal-clad cable shall comply with Section 300-4 where installed through studs, joists, rafters, or similar wood members.

334-12. Exposed Work. Exposed runs of cable shall closely follow the surface of the building finish or of running boards.

Exception No. 1: Lengths of not more than 24 inches at terminals where flexibility is necessary.

Exception No. 2: Where suitably supported in accordance with Section 334-8(a).

Exception No. 3: On the underside of floor joists in basements where supported at each joist and so located as not to be subject to physical damage.

334-13. In Accessible Attics. Type AC cables in accessible attics or roof spaces shall be installed as specified in (a) and (b) below.

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

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

ARTICLE 336 — NONMETALLIC-SHEATHED CABLE

Types NM and NMC

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

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

Conductors of Types NM and NMC shall be one of the types listed in Table 310-13 which is suitable for branch-circuit wiring or one which is approved for the purpose. The ampacity of Types NM and NMC cable shall be that of 60° C (140° F) conductors in Tables 310-16 and 310-18.

(a) **Type NM.** The overall covering shall have a flame-retardant and moisture-resistant finish.

(b) **Type NMC.** The overall covering shall be flame-retardant, moisture-resistant, fungus-resistant, and corrosion-resistant.

(c) **Marking.** In addition to the provisions of Section 310-11, the cable shall have a distinctive marking on the exterior for its entire length specifying the cable type.

336-3. Uses Permitted or Not Permitted. Type NM and Type NMC Cables shall be permitted to be used in one and two family dwellings, or multi-family dwellings and other structures not exceeding three floors above grade.

(a) **Type NM.** This type of nonmetallic sheathed cable shall be permitted to be installed for both exposed and concealed work in normally dry locations. It shall be permissible to install or fish type NM cable 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 a shallow chase in masonry or concrete and covered with plaster or similar finish.

(b) **Type NMC.** Type NMC cable shall be permitted for both exposed and concealed work in dry, moist, damp, or corrosive locations, and in outside and inside walls of masonry block or tile.

(c) **Uses Not Permitted for Either Type NM or NMC.** Types NM and NMC cables shall not be used as: (1) service-entrance cable, (2) in commercial garages, (3) in theaters and similar locations, except as provided in Article 518, places of assembly, (4) in motion-picture studios, (5) in storage battery rooms, (6) in hoistways, (7) in any hazardous location, (8) embedded in poured cement, concrete, or aggregate.

336-4. Other Articles. In addition to the provisions of this Article, installations of nonmetallic-sheathed cable shall comply with the other applicable provisions of this Code, especially Article 300.

336-5. Supports. Nonmetallic-sheathed cable shall be secured by staples, straps, or similar fittings so designed and installed as not to injure the cable. Cable shall be secured in place at intervals not exceeding 4½ feet and within 12 inches from every cabinet, box, or fitting.

Exception No. 1: For concealed work in finished buildings or finished panels for prefabricated buildings where such supporting is impracticable, it shall be permissible to fish the cable between access points.

Exception No. 2: A wiring device approved for the purpose, without a separate outlet box, incorporating an integral cable clamp shall be permitted when the cable is secured in place at intervals not exceeding 4½ feet and within 12 inches from the wiring device wall opening, and there shall be at least a 12 inch loop of unbroken cable or 6 inches of a cable end available on the interior side of the finished wall to permit replacement.

336-6. Exposed Work — General. In exposed work, except as provided in Sections 336-8 and 336-9, the cable shall be installed as specified in (a) and (b) below.

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

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

336-7. Through Studs, Joists, and Rafters. The cable shall comply with Section 300-4 where installed through studs, joists, rafters, and similar members.

336-8. In Unfinished Basements. Where the cable is run at angles with joists in unfinished basements, it shall be permissible to secure cables not smaller than two No. 6 or three No. 8 conductors directly to the lower edges of the joists. Smaller cables shall either be run through

bored holes in joists or on running boards. Where run parallel to the joists, cable of any size shall be secured to the sides or faces of the joists.

336-9. In Accessible Attics. The installation of cable in accessible attics or roof spaces shall also comply with Section 334-13.

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

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

Where connections to conductors are by binding-screw terminals, there shall be available as many terminals as conductors.

Exception: Where cables are clamped within the structure, and terminals are of a type approved for multiple conductors.

336-12. Boxes of Insulating Material. Nonmetallic outlet boxes shall be permitted as provided in Section 370-3.

ARTICLE 337 — SHIELDED NONMETALLIC-SHEATHED CABLE

Type SNM

337-1. Definitions. Type SNM, shielded nonmetallic-sheathed cable, is a factory assembly of two or more insulated conductors in an extruded core of moisture-resistant, flame-resistant nonmetallic material, covered with an overlapping spiral metal tape and wire shield and jacketed with an extruded moisture-, flame-, oil-, corrosion-, fungus-, and sunlight-resistant nonmetallic material.

337-2. Other Articles. In addition to the provisions of this Article, installation of Type SNM cable shall conform to other applicable provisions, such as Articles 300, 318, 501, and 502.

337-3. Uses Permitted. Type SNM cable shall be used only as follows:

(1) Where operating temperatures do not exceed the rating marked on the cable.

(2) In cable trays or in raceways.

(3) In hazardous locations where permitted in Articles 500 through 516.

337-4. Bends. Bends in Type SNM cable shall be so made as not to damage the cable or its covering. The radius of the inner edge shall not be less than 5 times the cable diameter.

337-5. Handling. Type SNM cable shall be handled in such a manner as not to damage the cable or its covering.

337-6. Fittings. Fittings for connecting Type SNM cable to enclosures or equipment shall be approved for the purpose.

337-7. Bonding. The wire shield shall be bonded to the frame or enclosure of the utilization equipment and to the ground bus or connection at the power supply point. This bonding shall be accomplished using fittings (Section 337-6) or by other Code-approved bonding methods (Section 501-16(b)).

337-8. Construction. The conductors of Type SNM cable shall be Type TFN, TFFN, THHN or THWN in sizes No. 18 through No. 2 copper and No. 12 through No. 2 in aluminum or copper-clad aluminum. Conductor sizes may be mixed in individual cables. The flat overlapping metal tapes shall be spiraled with a long lay. The shield wires shall have a total cross-sectional area as required by Article 250 and not less than the largest circuit conductor in the cable.

The outer jacket shall be water-, oil-, flame-, corrosion-, fungus-, and sunlight-resistant, and suitable for installation in cable trays.

337-9. Marking. Type SNM cable shall have a distinctive marking on its exterior surface for its entire length indicating its type and maximum operating temperature. It shall comply with the general marking requirements of Section 310-11.

The conductors shall each be numbered for identification from each other by durable marking on two sides 180° apart every 6 inches of length, with alternate legends inverted to facilitate reading from both sides.

ARTICLE 338 — SERVICE-ENTRANCE CABLE

Types SE and USE

338-1. Definition. Service-entrance cable is a single conductor or multiconductor assembly provided with or without an overall covering, primarily used for services and of the following types:

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

(2) Type USE, recognized for underground use, having a moisture-resistant covering, but not required to have a flame-retardant covering

or inherent protection against mechanical abuse. Single-conductor cables having rubber insulation specifically approved for the purpose do not require an outer covering.

Cabled single-conductor Type USE constructions recognized for underground use may have a bare copper conductor cabled with the assembly. Type USE single, parallel, or cabled conductor assemblies recognized for underground use may have a bare copper concentric conductor applied. These constructions do not require an outer overall covering.

See Section 230-40, Exception (2).

(3) If Type SE or USE cable consists of two or more conductors, one shall be permitted to be uninsulated.

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

338-3. Uses Permitted As Branch Circuits or Feeders.

(a) **Grounded Conductor Insulated.** Type SE service-entrance cables shall be permitted in interior wiring systems where all of the circuit conductors of the cable are of the rubber-covered or thermoplastic type.

(b) **Grounded Conductor Not Insulated.** Type SE service-entrance cables without individual insulation on the grounded circuit conductor shall not be used as a branch circuit or as a feeder within a building, except a cable that has a final nonmetallic outer covering and is supplied by alternating current at not over 150 volts to ground shall be permitted: (1) As a branch circuit to supply only a range, wall-mounted oven, counter-mounted cooking unit, or clothes dryer as covered in Section 250-60, or (2) as a feeder to supply only other buildings on the same premises.

Service-entrance cable shall be permitted for interior use where the fully insulated conductors are used for circuit wiring and the uninsulated conductor is used for equipment grounding purposes.

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

338-4. Installation Methods.

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

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

(c) Cables shall comply with Section 300-4 where installed through studs, joists, rafters, or similar members.

338-5. Marking. Service-entrance cable shall be marked as required in Section 310-11. Cable with the neutral conductor smaller than the ungrounded conductors shall be so marked.

ARTICLE 339 — UNDERGROUND FEEDER AND BRANCH-CIRCUIT CABLE

Type UF

339-1. Description and Marking.

(a) **Description.** Underground feeder and branch-circuit cable shall be an approved Type UF cable in sizes No. 14 through No. 4/0. The conductors of Type UF shall be one of the moisture-resistant types listed in Table 310-13 which is suitable for branch-circuit wiring or one which is approved for the purpose. The ampacity of Type UF cable shall be that of 60°C (140°F) conductors in Tables 310-16 and 310-18. In addition to the insulated conductors, the cable shall be permitted to have an approved size of insulated or bare conductor for equipment grounding purposes only. The overall covering shall be flame-retardant, moisture-resistant, fungus-resistant, corrosion-resistant, and suitable for direct burial in the earth.

(b) **Marking.** In addition to the provisions of Section 310-11, the cable shall have a distinctive marking on the exterior for its entire length specifying the cable type.

339-2. Other Articles. In addition to the provisions of this Article, installations of underground feeder and branch-circuit cable (Type UF) shall comply with other applicable provisions of this Code, especially Article 300 and Section 310-13.

339-3. Use.

(a) Uses Permitted.

(1) Type UF cable shall be permitted for use underground, including direct burial in the earth, as feeder or branch-circuit cable where provided with overcurrent protection of the rated ampacity as required in Section 339-4.

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

(3) For underground requirements, see Section 300-5.

(4) Type UF cable shall be permitted for interior wiring in wet, dry, or corrosive locations under the recognized wiring methods of this Code, and where installed as nonmetallic-sheathed cable, the installation shall comply with the provisions of Article 336 and shall be of the multiconductor type.

Exception: Single conductor cables shall be permitted as the non-heating leads for heating cables as provided in Section 424-43.

Type UF cable supported by cable trays shall be of the multiconductor type.

(b) **Uses Not Permitted.** Type UF cable shall not be used: (1) as service-entrance cables; (2) in commercial garages; (3) in theaters; (4) in motion-picture studios; (5) in storage battery rooms; (6) in hoist-ways; (7) in any hazardous location; (8) embedded in poured cement, concrete, or aggregate, except where embedded in plaster as nonheating leads as provided in Article 424; (9) where exposed to direct rays of the sun, unless approved for the purpose.

339-4. Overcurrent Protection. Overcurrent protection shall be provided in accordance with provisions of Section 240-3.

339-5. Rated Ampacity. The ampacities of conductors in Type UF cable shall be according to Tables 310-16 and 310-18.

ARTICLE 340 — POWER AND CONTROL TRAY CABLE

Type TC

340-1. Definition. Type TC power and control tray cable is a factory assembly of two or more insulated conductors, with or without associated bare or covered grounding conductors under a nonmetallic sheath, approved for installation in cable trays, in raceways, or where supported by a messenger wire.

340-2. Other Articles. In addition to the provisions of this article, installations of Type TC tray cable shall comply with other applicable articles of this Code, especially Articles 300 and 318.

340-3. Construction. The insulated conductors of Type TC tray cable shall be in sizes 18 AWG through 1,000 MCM copper and sizes 12 AWG through 1,000 MCM aluminum or copper-clad aluminum. Insulated conductors of size 14 AWG and larger copper and size 12 AWG and larger aluminum or copper-clad aluminum shall be one of the types listed in Table 310-13, which is suitable for branch circuit and feeder circuits or one which is approved for the purpose. Insulated conductors of size 18 and 16 AWG copper shall be in accordance with Article 725-16. The outer sheath shall be a flame-retardant, nonmetallic material. Where installed in wet locations, Type TC cable shall be resistant to moisture and corrosive agents.

340-4. Use Permitted. Type TC tray cable shall be limited to use in industrial establishments where the conditions of maintenance and supervision assure that only competent individuals will service the installation. It shall be permitted to be used:

- (1) For power, lighting, control and signal circuits.
- (2) In cable trays, or in raceways, or where supported in outdoor locations by a messenger wire.

(3) In cable trays in hazardous locations where the cable is specifically approved for the use as permitted in Articles 318 and 501.

340-5. Uses Not Permitted. Type TC tray cable shall not be:

(1) Installed where they will be exposed to physical damage.

(2) Installed as open cable on brackets or cleats.

(3) Used where exposed to direct rays of the sun, unless approved for the purpose.

340-6. Marking. The cable shall be marked in accordance with Section 310-11.

340-7. Ampacity. The ampacities of the conductors of Type TC tray cable shall be determined from Table 400-5 and Section 318-10.

ARTICLE 342 — NONMETALLIC EXTENSIONS

342-1. Definition. Nonmetallic extensions are an assembly of two insulated conductors within a nonmetallic jacket or an extruded thermoplastic covering. The classification includes both surface extensions, intended for mounting directly on the surface of walls or ceilings, and aerial cable, containing a supporting messenger cable as an integral part of the cable assembly.

342-2. Other Articles. In addition to the provisions of this Article, nonmetallic extensions shall be installed in accordance with the applicable provisions of this Code.

342-3. Uses Permitted. Nonmetallic extensions shall be permitted only where all of the following conditions are met:

(1) The extension is from an existing outlet on a 15- or 20-ampere branch circuit in conformity with the requirements of Article 210.

(2) The extension is run exposed and in a dry location.

(3) For nonmetallic surface extensions, the building is occupied for residential or office purposes.

(4) For aerial cable, the building is occupied for industrial purposes, and the nature of the occupancy requires a highly flexible means for connecting equipment.

342-4. Uses Not Permitted. Nonmetallic extensions shall not be used:

(1) As aerial cable to substitute for one of the general wiring methods specified by this Code.

(2) In unfinished basements, attics, or roof spaces.

(3) Where the voltage between conductors exceeds 150 volts for non-metallic surface extension and 300 volts for aerial cable.

(4) Where subject to corrosive vapors.

(5) Where run through a floor or partition, or outside the room in which it originates.

342-5. Splices and Taps. Extensions shall consist of a continuous unbroken length of the assembly, without splices, and without exposed conductors between fittings. Taps shall be permitted where approved fittings completely covering the tap connections are used. Aerial cable and its tap connectors shall be provided with an approved means for polarization. Receptacle-type tap connectors shall be of the locking-type.

342-6. Fittings. Each run shall terminate in a fitting that covers the end of the assembly. All fittings and devices shall be of a type approved for the purpose.

342-7. Installation. Nonmetallic extensions shall be installed as specified in (a) and (b) below.

(a) Nonmetallic Surface Extensions.

(1) One or more extensions shall be permitted to be run in any direction from an existing outlet, but not on the floor or within 2 inches from the floor.

(2) Nonmetallic surface extensions shall be secured in place by approved means at intervals not exceeding 8 inches.

Exception: Where connection to the supplying outlet is made by means of an attachment plug, the first fastening shall be permitted 12 inches or less from the plug.

There shall be at least one fastening between each two adjacent outlets supplied. An extension shall be attached only to woodwork or plaster finish, and shall not be in contact with any metal work or other conductive material other than with metal plates on receptacles.

(3) A bend that reduces the normal spacing between the conductors shall be covered with a cap to protect the assembly from physical damage.

(b) Aerial Cable.

(1) Aerial cable shall be supported by its messenger cable, securely attached at each end with approved clamps and turnbuckles. Intermediate supports shall be provided at not more than 20-foot intervals. Cable tension shall be adjusted to eliminate excessive sag. The cable shall have a clearance of not less than 2 inches from steel structural members or other conductive material.

(2) Aerial cable shall have a clearance of not less than 10 feet above floor areas accessible to pedestrian traffic, and not less than 14 feet above floor areas accessible to vehicular traffic.

(3) Cable suspended over work benches, not accessible to pedestrian traffic, shall have a clearance of not less than 8 feet above the floor.

(4) Aerial cables shall be permitted as a means to support lighting fixtures when the total load on the supporting messenger cable does not exceed that for which the assembly is intended.

(5) The supporting messenger cable, when installed in conformity with the applicable provisions of Article 250 and when properly identified as an equipment grounding conductor, shall be permitted to ground equipment. The messenger cable shall not be used as a branch-circuit conductor.

342-8. Marking. Nonmetallic extensions shall be marked in accordance with Section 110-21.

ARTICLE 344 — UNDERPLASTER EXTENSIONS

344-1. Use. An underplaster extension installed as permitted by this Article shall be permitted only for extending an existing branch circuit in a building of fire-resistive construction.

344-2. Materials. Such extension shall be run in rigid or flexible conduit, Type AC metal-clad 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.

Exception: For a single conductor only, conduit or tubing having not less than 5/16 inch inside diameter, single-conductor Type AC metal-clad cable, or single conductor Type MI cable shall be permitted.

344-3. Boxes and Fittings. Boxes and fittings shall comply with the applicable provisions of Article 370.

344-4. Installation. An underplaster extension shall be laid on the face of masonry or other material and buried in the plaster finish of ceilings or walls. The methods of installation of the raceway or cable for such extension shall be as specified elsewhere in this Code for the particular type of material used.

344-5. Extension to Another Floor. No such extension shall extend beyond the floor on which it originates unless installed in a standard size of rigid metal conduit, intermediate metal conduit, electrical metallic tubing, Type AC metal-clad cable, or Type MI cable.

ARTICLE 345—INTERMEDIATE METAL CONDUIT

A. General

345-1. Definition. Intermediate metal conduit is a metal raceway of circular cross section with integral or associated couplings, connectors and fittings approved for the installation of electrical conductors.

345-2. Other Articles. Installations for intermediate metal conduit shall comply with the provisions of the applicable Sections of Article 300.

345-3. Uses Permitted. Use of intermediate metal conduit shall be permitted under all atmospheric conditions and occupancies. Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action. Intermediate metal conduit shall be permitted as an equipment grounding conductor.
See Section 250-91.

345-4. Uses Not Permitted.

(a) Intermediate metal conduit shall not be used in hazardous locations.

(b) Unless made of material judged suitable for the condition, or unless corrosion protection is provided, intermediate metal conduit, elbows, couplings, and fittings shall not be installed in concrete or in direct contact with the earth, or in areas subject to severe corrosive influences.

(c) Intermediate metal conduit, unless approved 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 not less than two inches thick or unless the conduit is not less than 18 inches under the fill.

B. Installation

345-5. Wet Locations. All supports, bolts, straps, screws, etc. shall be of corrosion resistant materials or protected against corrosion by corrosion resistant materials approved for the purpose.

See Section 300-6 for protection against corrosion.

345-6. Size.

(a) Minimum. Conduit smaller than ½ inch electrical trade size shall not be used.

(b) Maximum. Conduit larger than four inch electrical trade size shall not be used.

345-7. Number of Conductors in Conduit. The number of conductors in a single conduit shall not exceed that permitted by the percentage fill specified in Table 1, Chapter 9, using the conduit dimensions of Table 4, Chapter 9.

345-8. Reaming and Threading. All cut ends of conduit shall be reamed to remove rough edges. Where conduit is threaded in the field, an electrical conduit thread cutting die with a taper shall be used.

345-9. Couplings and Connectors.

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

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

345-10. Bends — How Made. Bends of intermediate metal 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 indicated in 346-10.

Exception: For field bends for conductors without lead sheath and made with a single operation (one shot) bending machine designed for the purpose, the minimum radius shall not be less than that indicated in Table 346-10 Exception.

345-11. Bends — Number in One Run. A run of conduit between outlet and outlet, between fitting and fitting, or between outlet and fitting, shall not contain more than the equivalent of 4 quarter bends (360 degrees, total), including those bends located immediately at the outlet or fitting.

345-12. Supports. Intermediate metal conduit shall be installed as a complete system as provided in Article 300 and shall be securely fastened in place. Conduit shall be firmly fastened within three feet of each outlet box, junction box, cabinet, or fitting. Conduit shall be supported at least every ten feet.

345-13. Boxes and Fittings. See Article 370.

345-14. Splices and Taps. Splices and taps shall be made only in junction, outlet boxes or conduit bodies. Conductors, including splices and taps, shall not fill a conduit body to more than 75 percent of its cross sectional area at any point. All splices and taps shall be made by approved methods.

345-15. Bushings. Where a conduit enters a box or fitting, a bushing shall be provided to protect the wire from abrasion unless the design of the box or fitting is such as to afford equivalent protection. See Section 373-6(c) for the protection of conductors at bushings.

C. Construction Specifications

345-16. General. Intermediate metal conduit shall comply with (a) through (c) below.

(a) Intermediate metal conduit as shipped shall be in standard lengths of ten feet including coupling, one coupling to be furnished with each length. For specific applications or use, it shall be permissible to ship lengths shorter or longer than ten feet, with or without couplings.

(b) Nonferrous conduit of corrosion-resistant material shall have suitable markings.

(c) Marking. Each length shall be clearly and durably identified at 2½ foot intervals with the letters IMC. Each length shall be marked as required in the first sentence of Section 110-21.

ARTICLE 346 — RIGID METAL CONDUIT

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

346-1. Use. The use of rigid metal conduit shall be permitted under all atmospheric conditions and occupancies subject to the following:

(a) Ferrous raceways and fittings protected from corrosion solely by enamel shall be permitted only indoors and in occupancies not subject to severe corrosive influences.

(b) Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.

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

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

A. Installation

346-3. Cinder Fill. Conduit shall not be used in or under cinder fill where subject to permanent moisture.

Exception No. 1: Where of corrosion-resistant material suitable for the purpose.

Exception No. 2: Where protected on all sides by a layer of non-cinder concrete at least 2 inches thick.

Exception No. 3: Where the conduit is at least 18 inches under the fill.

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

See Section 300-6 for protection against corrosion.

346-5. Minimum Size. Conduit smaller than $\frac{1}{2}$ inch electrical trade size shall not be used.

Exception No. 1: For underplaster extensions as permitted in Section 344-2.

Exception No. 2: For enclosing the leads of motors as permitted in Section 430-145(b).

346-6. Number of Conductors in Conduit. The number of conductors permitted in a single conduit shall not exceed the percentage fill specified in Table 1, Chapter 9.

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

346-8. Bushings. Where a conduit enters a box or other fitting, a bushing shall be provided to protect the wire from abrasion unless the design of the box or fitting is such as to afford equivalent protection.

See Section 373-6 (c) for the protection of conductors at bushings.

346-9. Couplings and Connectors.

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

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

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

Table 346-10
Radius of Conduit Bends (Inches)

Size of Conduit (In.)	Conductors Without Lead Sheath (In.)	Conductors With Lead Sheath (In.)
1/2	4	6
3/4	5	8
1	6	11
1 1/4	8	14
1 1/2	10	16
2	12	21
2 1/2	15	25
3	18	31
3 1/2	21	36
4	24	40
4 1/2	27	45
5	30	50
6	36	61

Exception: For field bends for conductors without lead sheath and made with a single operation (one shot) bending machine designed for the purpose, the minimum radius shall not be less than indicated in 346-10 Exception.

346-11. Bends — Number in One Run. A run of conduit between outlet and outlet, fitting and fitting, or 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.

346-12. Supports. Rigid metal conduit shall be installed as a complete system as provided in Article 300 and shall be securely fastened in place. Conduit shall be firmly fastened within 3 feet of each outlet box, junction box, cabinet, or fitting. Conduit shall be supported at least every 10 feet.

Exception No. 1: If made up with threaded couplings, it shall be permissible to support straight runs of rigid metal conduit in accordance with Table 346-12, provided such supports prevent transmission of stresses to termination where conduit is deflected between supports.

Exception No. 2: The distance between supports may be increased to 20 feet for exposed vertical risers from machine tools and the like, provided the conduit is made up with threaded couplings, is firmly supported at the top and bottom of the riser, and no other means of intermediate support is readily available.

Table 346-10 Exception
Radius of Conduit Bends (Inches)

Size of Conduit (In.)	Radius to Center of Conduit (In.)
$\frac{1}{2}$	4
$\frac{3}{4}$	$4\frac{1}{2}$
1	$5\frac{3}{4}$
$1\frac{1}{4}$	$7\frac{1}{4}$
$1\frac{1}{2}$	$8\frac{1}{4}$
2	$9\frac{1}{2}$
$2\frac{1}{2}$	$10\frac{1}{2}$
3	13
$3\frac{1}{2}$	15
4	16
$4\frac{1}{2}$	20
5	24
6	30

Table 346-12. Supports for Rigid Metal Conduit

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

346-13. Boxes and Fittings. Boxes and fittings shall comply with the applicable provisions of Article 370.

346-14. Splices and Taps. Splices and taps shall be made only in junction, outlet boxes or conduit bodies. Conductors, including splices and taps, shall not fill a conduit body to more than 75 percent of its cross sectional area at any point. All splices and taps shall be made by approved methods.

B. Construction Specifications

346-15. General. Rigid metal conduit shall comply with (a) through (d) below.

(a) Rigid metal conduit as shipped shall be in standard lengths of 10 feet including coupling, one coupling to be furnished with each length. Each length shall be reamed and threaded on each end. For specific applications or uses, it shall be permissible to ship lengths shorter or longer than 10 feet, with or without couplings.

(b) Nonferrous conduit of corrosion-resistant material shall have suitable markings.

(c) Each length shall be clearly and durably identified in every 10 feet as required in the first sentence of Section 110-21.

(d) Conduit bodies shall have a cross sectional area at least twice that of the largest conduit to which they are connected.

ARTICLE 347 — RIGID NONMETALLIC CONDUIT

347-1. Description. This Article shall apply to a type of conduit and fittings of suitable nonmetallic material that is resistant to moisture and chemical atmospheres. For use aboveground, it shall also be flame retardant, resistant to impact and crushing, resistant to distortion from heat under conditions likely to be encountered in service, and resistant to low temperature and sunlight effects. For use underground, the material shall be acceptably resistant to moisture and corrosive agents and shall be of sufficient strength to withstand abuse, such as by impact and crushing, in handling and during installation. Where intended for direct burial, without encasement in concrete, the material shall also be capable of withstanding continued loading that is likely to be encountered after installation.

Materials that have been recognized as having suitable physical characteristics when properly formed and treated include fiber, asbestos cement, soapstone, rigid polyvinyl chloride and high-density polyethylene for underground use, and rigid polyvinyl chloride for use aboveground.

347-2. Uses Permitted. The use of rigid nonmetallic conduit and fittings approved for the purpose shall be permitted under the following conditions:

(a) Where the potential is 600 volts or less.

(1) In walls, floors, and ceilings.

(2) In locations subject to severe corrosive influences as covered in Section 300-6 and where subject to chemicals for which the materials are specifically approved.

(3) In cinder fill.

(4) In portions of dairies, laundries, canneries or other wet locations and in locations where walls are frequently washed, the entire conduit system including boxes and fittings used therewith shall be so installed and equipped as to prevent water from entering the conduit. All supports, bolts, straps, screws, etc., shall be of corrosion-resistant

materials or be protected against corrosion by approved corrosion-resistant materials.

(5) In dry and damp locations not prohibited by Section 347-3.

(6) For exposed work where not subject to physical damage if approved for the purpose.

(b) Where the potential is over 600 volts, rigid nonmetallic conduit shall be encased in not less than 2 inches of concrete.

(c) For underground installations see Section 300-5 and 710-3(b).

347-3. Uses Not Permitted. Rigid nonmetallic conduit shall not be used:

(a) In hazardous locations, except as covered in Sections 514-8 and 515-5.

(b) For the support of fixtures or other equipment.

(c) Where subject to physical damage unless approved for the purpose.

(d) Where subject to ambient temperatures exceeding those for which the conduit is approved.

(e) For conductors whose insulation temperature limitations would exceed those for which the conduit is approved.

347-4. Other Articles. Installation of rigid nonmetallic conduit shall comply with the applicable provisions of Article 300. Where equipment grounding is required by Article 250, a separate equipment grounding conductor shall be installed in the conduit.

A. Installations

347-5. Trimming. All cut ends shall be trimmed inside and outside to remove rough edges.

347-6. Joints. All joints between lengths of conduit, and between conduit and couplings, fittings, and boxes shall be made by a method approved for the purpose.

347-8. Supports. Rigid nonmetallic conduit shall be supported as required in Table 347-8. In addition, there shall be a support within 4 feet of each box, cabinet, or other conduit termination.

Table 347-8. Support of Rigid Nonmetallic Conduit

Conduit Size (Inches)	Maximum Spacing between Supports (Feet)	
	Conductors Rated 60°C and Below	Conductors Rated More Than 60°C
½-¾	4	2
1-2	5	2½
2½-3	6	3
3½-5	7	3½
6	8	4

347-9. Expansion Joints. Expansion joints for rigid nonmetallic conduit shall be provided where required to compensate for thermal expansion and contraction.

347-10. Minimum Size. No conduit smaller than ½-inch electrical trade size shall be used.

347-11. Number of Conductors. The number of conductors permitted in a single conduit shall not exceed the percentage fill specified in Table 1, Chapter 9.

347-12. Bushings. Where a conduit enters a box or other fitting, a bushing or adapter shall be provided to protect the wire from abrasion unless the design of the box or fitting is such as to provide equivalent protection.

See Section 373-6(c) for the protection of conductors at bushings.

347-13. Bends, How Made. Bends of rigid nonmetallic 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. Field bends shall be made only with bending equipment intended for the purpose, and the radius of the curve of the inner edge of such bends shall not be less than shown in Table 346-10.

347-14. Bends, Number in One Run. A run of conduit between outlet and outlet, fitting and fitting, or 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.

347-15. Boxes and Fittings. Boxes and fittings shall comply with the applicable provisions of Article 370.

347-16. Splices and Taps. Splices and taps shall be made only in junction, outlet boxes or conduit bodies. Conductors, including splices and taps, shall not fill a conduit body to more than 75 percent of its cross sectional area at any point. All splices and taps shall be made by approved methods.

B. Construction Specifications

347-17. General. Rigid nonmetallic conduit shall comply with (a) through (c) below.

(a) Rigid nonmetallic polyvinyl chloride conduit as shipped shall be in standard lengths of 10 feet including couplings, one coupling to be furnished with each length. For specific applications or uses, it shall be permissible to ship lengths shorter or longer than 10 feet with or without couplings.

(b) High-density polyethylene conduit as shipped shall be in standard lengths of 10 feet. One threaded coupling shall be furnished with each threaded length of high-density polyethylene conduit. For specific applications or uses, it shall be permissible to ship lengths shorter or longer than 10 feet with or without couplings.

(c) Each length of nonmetallic conduit shall be clearly and durably marked at least every 10 feet as required in the first sentence of Section 110-21. The type of material shall also be included in the marking unless

it is visually identifiable. For conduit recognized for use aboveground these markings shall be permanent. For conduit limited to underground use only, these markings shall be sufficiently durable to remain legible until the material is installed.

(d) Conduit bodies shall have a cross sectional area at least twice that of the largest conduit to which they are connected.

ARTICLE 348 — ELECTRICAL METALLIC TUBING

348-1. Use. The use of electrical metallic tubing shall be permitted for both exposed and concealed work. Electrical metallic tubing shall not be used: (1) where during installation or afterward, it will be subject to severe physical damage; (2) where protected from corrosion solely by enamel; (3) in cinder concrete or cinder fill where subject to permanent moisture unless protected on all sides by a layer of noncinder concrete at least 2 inches thick or unless the tubing is at least 18 inches under the fill. Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.

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

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

A. Installation

348-4. Wet Locations. All supports, bolts, straps, screws, etc. shall be of corrosion-resistant materials or protected against corrosion by corrosion-resistant metals approved for the purpose.

See Section 300-6 for protection from corrosion.

348-5. Size.

(a) **Minimum.** Tubing smaller than ½-inch electrical trade size shall not be used.

Exception No. 1: For underplaster extensions as permitted in Section 344-2.

Exception No. 2: For enclosing the leads of motors as permitted in Section 430-145(b).

(b) **Maximum.** The maximum size of tubing shall be the 4-inch electrical trade size.

348-6. Number of Conductors in Tubing. The number of conductors permitted in a single tubing shall not exceed the percentage fill specified in Table 1, Chapter 9.

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

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

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

Exception: For field bends made with a bending machine designed for the purpose, the minimum radius shall not be less than indicated in Table 346-10 Exception.

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

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

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

348-13. Boxes and Fittings. Boxes and fittings shall comply with the applicable provisions of Article 370.

348-14. Splices and Taps. Splices and taps shall be made only in junction, outlet boxes or conduit bodies. Conductors, including splices and taps, shall not fill a conduit body to more than 75 percent of its cross sectional area at any point. All splices and taps shall be made by approved methods.

B. Construction Specifications

348-15. General. Electrical metallic tubing shall comply with (a) through (c) below.

(a) **Cross Section.** The tubing, and elbows and bends for use with the tubing, shall have a circular cross section. Conduit bodies shall have a cross sectional area at least twice that of the largest conduit to which they are connected.

(b) **Finish.** Tubing shall have such a finish or treatment of outer surfaces as will provide an approved durable means of readily distinguishing it, after installation, from rigid metal conduit.

(c) **Connectors.** Where the tubing is coupled together by threads, the connector shall be so designed as to prevent bending of the tubing at any part of the thread.

ARTICLE 350 — FLEXIBLE METAL CONDUIT

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

350-2. Use. Flexible metal conduit shall not be used: (1) in wet locations, unless conductors are of the lead-covered type or of other type approved for the specific conditions; (2) in hoistways, other than provided in Section 620-21; (3) in storage-battery rooms; (4) in any hazardous location other than permitted in Sections 501-4(b), 502-4, and 503-3; (5) where rubber-covered conductors are exposed to oil, gasoline, or other materials having a deteriorating effect on rubber; nor (6) underground or embedded in poured concrete or aggregate.

350-3. Minimum Size. Flexible metal conduit less than ½-inch electrical trade size shall not be used.

Exception No. 1: For underplaster extensions as permitted in Section 344-2.

Exception No. 2: For enclosing the leads of motors as permitted in Section 430-145(b).

Exception No. 3: Flexible metal conduit of ¾-inch nominal trade size shall be permitted in lengths not in excess of 72 inches as a part of an approved assembly or for lighting fixtures.

Table 350-3. Maximum Number of Insulated Conductors in ¾ In. Flexible Metal Conduit.*

Col. A = With fitting inside conduit.
Col. B = With fitting outside conduit.

Size AWG	Types RFH-2, SF-2		Types TF, T, XHHW, AF, TW, RUH, RUW		Types TFN, THHN, THWN		Types FEP, FEPB, PF, PGF	
	A	B	A	B	A	B	A	B
18	..	3	3	7	4	8	5	8
16	..	2	2	4	3	7	4	8
14	..	..	..	4	3	7	3	7
12	..	..	..	3	..	4	..	4
10	..	..	..	..	..	2	..	3

* In addition one uninsulated grounding conductor of the same AWG size shall be permitted.

350-4. Supports. Flexible metal conduit shall be secured by an approved means at intervals not exceeding 4½ feet and within 12 inches on each side of every outlet box or fitting.

Exception No. 1: Where flexible metal conduit is fished.

Exception No. 2: Lengths of not more than 3 feet at terminals where flexibility is necessary.

Exception No. 3: Lengths of not more than 6 feet from a fixture terminal connection for tap connections to lighting fixtures as required in Section 410-67(b)(2).

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

Exception: Flexible metal conduit shall be permitted as a grounding means if the length is 6 feet or less, the conduit is terminated in fittings approved for the purpose, and the circuit conductors contained therein are protected by overcurrent devices rated at 20 amperes or less.

350-6. Bends in Concealed Work. A run of conduit for concealed raceway, between outlet and outlet, fitting and fitting, or outlet and fitting, shall not contain more than the equivalent of four quarter bends (360° total), including those bends located immediately at the outlet or fitting.

Angle connectors shall not be used for concealed raceway installations.

ARTICLE 351 — LIQUIDTIGHT FLEXIBLE METAL CONDUIT

351-1. Scope. This Article covers a type of flexible metal conduit having an outer liquidtight nonmetallic sunlight-resistant jacket.

351-2. Use.

(a) The use of liquidtight flexible metal conduit shall be permitted for both exposed and concealed work:

(1) Where conditions of installation, operation, or maintenance require flexibility or protection from liquids, vapors, or solids.

(2) As permitted by Sections 501-4(b), 502-4, and 503-3, and in other hazardous locations where specifically approved.

(b) Liquidtight flexible metal conduit shall not be used:

(1) Where subject to physical damage.

(2) Where any combination of ambient and/or conductor temperature will produce an operating temperature in excess of that for which the material is approved.

351-3. Size.

(a) **Minimum.** Liquidtight flexible metal conduit smaller than ½-inch electrical trade size shall not be used.

Exception: ⅜-inch size shall be permitted as covered in Section 350-3.

(b) **Maximum.** The maximum size of liquidtight flexible metal conduit shall be the 4-inch trade size.

351-4. Number of Conductors.

(a) The number of conductors permitted in a single conduit, $\frac{1}{2}$ through 4 inch trade sizes, shall not exceed the percentage of fill specified in Table 1, Chapter 9.

(b) The number of conductors permitted in $\frac{3}{8}$ -inch liquidtight flexible metal conduit shall not exceed that permitted in Table 350-3.

351-5. Fittings. Liquidtight flexible metal conduit shall be used only with terminal fittings approved for the purpose.

351-6. Supports. Where liquidtight flexible metal conduit is installed as a fixed raceway, it shall be secured at intervals not exceeding $4\frac{1}{2}$ feet and within 12 inches on each side of every outlet box or fitting.

Exception: Where the conduit is fished.

351-7. Grounding. Liquidtight flexible metal conduit shall be permitted as a grounding conductor where both the conduit and the fittings are approved for the purpose.

Exception: Liquidtight flexible metal conduit shall be permitted as a grounding means in the $1\frac{1}{4}$ inch and smaller trade sizes if the length is 6 feet or less and the conduit is terminated in fittings approved for the purpose.

ARTICLE 352 — SURFACE RACEWAYS

A. Metal Surface Raceways

352-1. Use. The use of surface raceways shall be permitted in dry locations. They shall not be used: (1) where subject to severe physical damage unless approved for the purpose; (2) where 300 volts or more between conductors unless the metal has a thickness of not less than .040 inch; (3) where subject to corrosive vapors; (4) in hoistways; (5) in any hazardous location; nor (6) concealed except as follows:

Exception No. 1: Metal surface raceways approved for the purpose shall be permitted for underplaster extensions.

Exception No. 2: As permitted in Section 645-2(c) (2).

See definition of "Exposed — (As applied to wiring methods)" in Article 100.

352-2. Other Articles. Metal surface raceways shall comply with the applicable provisions of Article 300.

352-3. Size of Conductors. No conductor larger than that for which the raceway is designed shall be installed in metal surface raceway.

352-4. Number of Conductors in Raceways. The number of conductors installed in any raceway shall be no greater than the number for which the raceway is designed.

352-5. Extension through Walls and Floors. It shall be permissible to extend unbroken lengths of metal surface raceways through dry walls, dry partitions, and dry floors.

See Section 353-3 for multioutlet assemblies.

352-6. Combination Raceways. Where combination metal surface raceways are used both for signaling 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.

352-7. Splices and Taps. Splices and taps shall be permitted in metal surface raceway having a removable cover that is accessible after installation. The conductors, including splices and taps, shall not fill the raceway to more than 75 percent of its area at that point. Splices and taps in metal surface raceways without removable covers shall be made only in junction boxes. All splices and taps shall be made by approved methods.

352-8. Construction. Metal surface raceways shall be of such construction as will distinguish them from other raceways. Metal surface raceways and their elbows, couplings, and similar fittings shall be so designed that the sections can be electrically and mechanically coupled together without subjecting the wires to abrasion. Holes for screws or bolts inside the raceway shall be so designed that when screws or bolts are installed the heads will be flush with the metal surface.

Where covers and accessories of nonmetallic materials are used on metal raceways, they shall be approved for the purpose for which they are used.

B. Nonmetallic Surface Raceways

352-21. Description. Part B of this Article shall apply to a type of nonmetallic surface raceway and fittings of suitable nonmetallic material that is resistant to moisture and chemical atmospheres. It shall also be flame-retardant, resistant to impact and crushing, resistant to distortion from heat under conditions likely to be encountered in service, and resistant to low-temperature effects.

352-22. Use. The use of nonmetallic surface raceways shall be permitted in dry locations. They shall not be used (1) where concealed; (2) where subject to severe physical damage unless approved for the purpose; (3) where 300 volts or more between conductors; (4) in hoistways; (5) in any hazardous location; (6) where subject to ambient temperatures exceeding 50°C; nor (7) for conductors whose insulation temperature exceeds 75°C.

352-23. Other Articles. Nonmetallic surface raceways shall comply with the applicable provisions of Article 300.

352-24. Size of Conductors. No conductor larger than that for which the raceway is designed shall be installed in nonmetallic surface raceway.

352-25. Number of Conductors in Raceways. The number of conductors installed in any raceway shall be no greater than the number for which the raceway is designed.

352-26. Combination Raceways. Where combination nonmetallic surface raceways are used both for signaling and for lighting and power circuits, the different systems shall be run in separate compartments, identified by printed legend or by sharply contrasting colors of the in-

terior finish, and the same relative position of compartments shall be maintained throughout the premises.

352-27. General. Nonmetallic surface raceways shall be of such construction as will distinguish them from other raceways. Nonmetallic surface raceways and their elbows, couplings, and similar fittings shall be so designed that the sections can be mechanically coupled together without subjecting the wires to abrasion. Holes for screws or bolts inside the raceway shall be so designed that when screws or bolts are installed the heads will be flush with the nonmetallic surface.

ARTICLE 353 — MULTIOUTLET ASSEMBLY

353-1. Other Articles. A multioutlet assembly shall comply with applicable provisions of Article 300.

See definition in Article 100.

353-2. Use. The use of multioutlet assembly shall be permitted in dry locations. It shall not be installed: (1) where concealed, except that it shall be permissible to surround the back and sides of a metal multioutlet assembly by the building finish or recess a nonmetallic surface raceway in a baseboard; (2) where subject to severe physical damage unless approved for the purpose; (3) where 300 volts or more between conductors unless the assembly is of metal having a thickness of not less than .040 inch; (4) where subject to corrosive vapors; (5) in hoistways; nor (6) in any hazardous locations.

353-3. Metal Multioutlet Assembly Through Dry Partitions. It shall be permissible to extend a metal multioutlet assembly through (not run within) dry partitions, if arrangements are made for removing the cap or cover on all exposed portions and no outlet is located within the partitions.

ARTICLE 354 — UNDERFLOOR RACEWAYS

354-1. Other Articles. Underfloor raceways shall comply with the applicable provisions of Article 300.

354-2. Use. The installation of underfloor raceways shall be permitted beneath the surface of concrete or other flooring material or in office occupancies, where laid flush with the concrete floor and covered with linoleum or equivalent floor covering. Underfloor raceways shall not be installed (1) where subject to corrosive vapors, nor (2) in any hazardous location. Unless made of a material judged suitable for the condition or unless corrosion protection approved for the condition is provided, ferrous or nonferrous metal underfloor raceways, junction boxes, and fittings shall not be installed in concrete; or in areas subject to severe corrosive influences.

354-3. Covering. Raceway coverings shall comply with (a) through (d) below.

(a) Raceways Not Over 4 Inches Wide. Half-round and flat-top raceways not over 4 inches in width shall have not less than $\frac{3}{4}$ inch of concrete or wood above the raceway.

Exception: As permitted in (c) below for flat-top raceways.

(b) Raceways Over 4 Inches Wide But Not Over 8 Inches Wide. Flat top raceways over 4 but not over 8 inches wide with a minimum of one inch spacing between raceways shall be covered with concrete to a depth of not less than one inch. Raceways spaced less than one inch apart shall be covered with concrete to a depth of $1\frac{1}{2}$ inches.

(c) Trench-Type Raceways Flush with Concrete. Trench-type flush raceways with removable covers shall be permitted to be laid flush with the floor surface. Such approved raceways shall be so designed that the cover plates will provide adequate mechanical protection and rigidity equivalent to junction box covers.

(d) Other Raceways Flush with Concrete. In office occupancies, approved metal flat-top raceways, if not over 4 inches in width, shall be permitted to be laid flush with the concrete floor surface provided they are covered with substantial linoleum not less than $\frac{1}{16}$ inch in thickness or with equivalent floor covering. Where more than one and not more than three single raceways are each installed flush with the concrete they shall be contiguous with each other and joined to form a rigid assembly.

354-4. Size of Conductors. No conductor larger than that for which the raceway is designed shall be installed in underfloor raceways.

354-5. Maximum Number of Conductors in Raceway. The combined cross-sectional area of all conductors or cables shall not exceed 40 percent of the interior cross-sectional area of the raceway.

354-6. Splices and Taps. Splices and taps shall be made only in junction boxes.

For the purposes of this Section, so-called loop wiring (continuous, unbroken conductor connecting the individual outlets) shall not be considered to be a splice or tap.

354-7. Discontinued Outlets. When an outlet is abandoned, discontinued, or removed, the sections of circuit conductors supplying the outlet shall be removed from the raceway. No splices or reinsulated conductors, such as would be the case with abandoned outlets on loop wiring, shall be allowed in raceways.

354-8. Laid in Straight Lines. Underfloor raceways shall be laid so that a straight line from the center of one junction box to the center of the next junction box will coincide with the center line of the raceway system. Raceways shall be firmly held in place to prevent disturbing this alignment during construction.

354-9. Markers at Ends. A suitable marker shall be installed at or near each end of each straight run of raceways to locate the last insert.

354-10. Dead Ends. Dead ends of raceways shall be closed.

354-13. Junction Boxes. Junction boxes shall be leveled to the floor grade and sealed to prevent the free entrance of water or concrete. Junction boxes used with metal raceways shall be metal and shall be electrically continuous with the raceways.

354-14. Inserts. Inserts shall be leveled and sealed to prevent the entrance of concrete. 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 remain in the raceway, and tools shall be used that are so designed as to prevent the tool from entering the raceway and injuring conductors that may be in place.

354-15. Connections to Cabinets and Wall Outlets. Connections between raceways and distribution centers and wall outlets shall be made by means of flexible metal conduit when not installed in concrete, rigid metal conduit, intermediate metal conduit, electrical metallic tubing, or fittings approved for the purpose.

ARTICLE 356 — CELLULAR METAL FLOOR RACEWAYS

356-1. Definitions. For the purposes of this Article, a "cellular metal floor raceway" shall be defined as the hollow spaces of cellular metal floors, together with suitable fittings, which may be approved as enclosures for electric 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 electric conductors, providing access to predetermined cells of a cellular metal floor, thereby permitting the installation of electric conductors from a distribution center to the cells.

356-2. Use. Conductors shall not be installed in cellular metal floor raceways (1) where subject to corrosive vapor; (2) in any hazardous location; nor (3) in commercial garages, other than for supplying ceiling outlets or extensions to the area below the floor but not above. No electric conductors shall be installed in any cell or header that contains a pipe for steam, water, air, gas, drainage, or any service other than electrical.

356-3. Other Articles. Cellular metal floor raceways shall comply with the applicable provisions of Article 300.

A. Installation

356-4. Size of Conductors. No conductor larger than No. 1/0 shall be installed, except by special permission.

356-5. Maximum Number of Conductors in Raceway. The combined cross-sectional area of all conductors or cables shall not exceed 40 percent of the interior cross-sectional area of the cell or header.

356-6. Splices and Taps. Splices and taps shall be made only in header access units or junction boxes.

For the purposes of this Section, so-called loop wiring (continuous unbroken conductor connecting the individual outlets) shall not be considered to be a splice or tap.

356-7. Discontinued Outlets. When an outlet is abandoned, discontinued, or removed, the sections of circuit conductors supplying the outlet shall be removed from the raceway. No splices or reinsulated conductors, such as would be the case with abandoned outlets on loop wiring, shall be allowed in raceways.

356-8. Markers. A suitable number of markers shall be installed for the future locating of cells.

356-9. Junction Boxes. Junction boxes shall be leveled to the floor grade and sealed against the free entrance of water or concrete. Junction boxes used with these raceways shall be of metal and shall be electrically continuous with the raceway.

356-10. Inserts. Inserts shall be leveled to the floor grade and sealed against the entrance of concrete. 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 remain in the raceway, and tools shall be used that are designed to prevent the tool from entering the cell and injuring the conductors.

356-11. Connection to Cabinets and Extensions from Cells. Connections between raceways and distribution centers and wall outlets shall be made by means of flexible metal conduit when not installed in concrete, rigid metal conduit, intermediate metal conduit, electrical metallic tubing, or fittings approved for the purpose.

B. Construction Specifications

356-12. General. Cellular metal floor raceways shall be so constructed that adequate electrical and mechanical continuity of the complete system will be secured. They shall provide a complete enclosure for the conductors. The interior surfaces shall be free from burrs and sharp edges, and surfaces over which conductors are drawn shall be smooth. Suitable bushings or fittings having smooth rounded edges shall be provided where conductors pass.

ARTICLE 358 — CELLULAR CONCRETE FLOOR RACEWAYS

358-1. Scope. Approved precast cellular concrete floor raceways shall comply with the applicable provisions of Article 300. For the purpose of this Article, "precast cellular concrete floor raceways" shall be de-

defined as the hollow spaces in floors constructed of precast cellular concrete slabs, together with suitable metal fittings designed to provide access to the floor cells in an approved manner. A "cell" shall be defined as a single, enclosed tubular space in a floor made of precast cellular concrete slabs, the direction of the cell being parallel to the direction of the floor member. A "header" shall be defined as transverse metal raceways for electric conductors, providing access to predetermined cells of a precast cellular concrete floor, thereby permitting the installation of electric conductors from a distribution center to the floor cells.

358-2. Use. Conductors shall not be installed in precast cellular concrete floor raceways (1) where subject to corrosive vapor; (2) in hazardous locations; nor (3) in commercial garages, other than for supplying ceiling outlets or extensions to the area below the floor but not above. No electric conductors shall be installed in any cell or header that contains a pipe for steam, water, air, gas, drainage, or any service other than electrical.

358-3. Header. The header shall be installed in a straight line, at right angles to the cells. The header shall be mechanically secured to the top of the precast cellular concrete floor. The end joints shall be closed by a metallic closure fitting and sealed against the entrance of concrete. The header shall be electrically continuous throughout its entire length and shall be electrically bonded to the enclosure of the distribution center.

358-4. Connection to Cabinets and Other Enclosures. Connections from headers to cabinets and other enclosures shall be made by means of metal raceways and fittings approved for the purpose.

358-5. Junction Boxes. Junction boxes shall be leveled to the floor grade and sealed against the free entrance of water or concrete. Junction boxes shall be of metal and shall be mechanically and electrically continuous with the header.

358-6. Markers. A suitable number of markers shall be installed for the future locating of cells.

358-7. Inserts. Inserts shall be leveled and sealed against the entrance of concrete. Inserts shall be of metal and shall be fitted with receptacles of the grounded type. A grounding conductor shall connect the insert receptacles to a positive ground connection provided on the header. In cutting through the cell wall for setting inserts or other purposes (such as providing access openings between header and cells), chips and other dirt shall not be allowed to remain in the raceway, and the tool used shall be so designed as to prevent the tool from entering the cell and injuring the conductors.

358-8. Size of Conductors. No conductor larger than No. 1/0 shall be installed, except by special permission.

358-9. Maximum Number of Conductors. The combined cross-sectional area of all conductors or cables shall not exceed 40 percent of the cross-sectional area of the cell or header.

358-10. Splices and Taps. Splices and taps shall be made only in header access units or junction boxes.

For the purpose of this Section, so-called loop wiring (continuous unbroken conductor connecting the individual outlets) shall not be considered to be a splice or tap.

358-11. Discontinued Outlets. When an outlet is abandoned, discontinued, or removed, the sections of circuit conductors supplying the outlet shall be removed from the raceway. No splices or reinsulated conductors, such as would be the case with abandoned outlets on loop wiring, shall be allowed in raceways.

ARTICLE 362 — WIREWAYS

362-1. Definition. Wireways are sheet-metal troughs with hinged or removable covers for housing and protecting electric wires and cable and in which conductors are laid in place after the wireway has been installed as a complete system.

362-2. Use. Wireways shall be permitted only for exposed work. Wireways intended for outdoor use shall be of approved raintight construction. Wireways shall not be installed: (1) where subject to severe physical damage or corrosive vapor; nor (2) in any hazardous location, except Class II, Division 2 locations as permitted in Section 502-4(b).

362-3. Other Articles. Installations of wireways shall comply with the applicable provisions of Article 300.

362-4. Size of Conductors. No conductor larger than that for which the wireway is designed shall be installed in any wireway.

362-5. Number of Conductors. Wireways shall not contain more than 30 current-carrying conductors at any cross section. The sum of the cross-sectional areas of all contained conductors at any cross section of a wireway shall not exceed 20 percent of the interior cross-sectional area of the wireway.

Exception No. 1: As provided in Section 620-32 for elevators, dumb-waiters, etc.

The correction factors specified in Note 8 to Tables 310-16 through 310-19 shall not be considered applicable to the foregoing.

Exception No. 2: Conductors for signaling circuits or controller conductors between a motor and its starter and used only for starting duty shall not be considered as current-carrying conductors.

Exception No. 3: When the correction factors specified in Note 8 of Tables 310-16 through 310-19 are applied, the number of current-carrying conductors shall not be limited, but the sum of the cross-sectional areas of all contained conductors at any cross section of the wireway shall not exceed 20 percent of the interior cross-sectional area of the wireway.

Exception No. 4: As provided in Section 520-5 for theaters and similar locations.

362-6. Splices and Taps. Splices and taps shall be permitted within a wireway provided they are accessible. The conductors, including splices and taps, shall not fill the wireway to more than 75 percent of its area at that point.

362-7. Supports. Wireways shall be securely supported at intervals not exceeding 5 feet, unless specially approved for supports at greater intervals, but in no case shall the distance between supports exceed 10 feet.

Exception: Vertical runs of wireways shall be securely supported at intervals not exceeding 15 feet and shall have not more than one joint between supports. Adjoining wireway sections shall be securely fastened together to provide a rigid joint.

362-8. Extension Through Walls. Unbroken lengths of wireway shall be permitted to pass transversely through walls if in unbroken lengths where passing through.

362-9. Dead Ends. Dead ends of wireways shall be closed.

362-10. Extensions From Wireways. Extensions from wireways shall be made with rigid or flexible metal conduit, intermediate metal conduit, electrical metallic tubing, metal surface raceway, or metal-clad cable.

362-11. Marking. Wireways shall be marked so that their manufacturer's name or trademark will be visible after installation.

ARTICLE 363 — FLAT CABLE ASSEMBLIES

Type FC

363-1. Definition. Type FC, a flat cable assembly, is an assembly of parallel conductors formed integrally with an insulating material web specifically designed for field installation in metal surface raceway approved for the purpose.

363-2. Other Articles. In addition to the provisions of this Article, installation of Type FC cable shall conform with the applicable provisions of Articles 210, 220, 250, 300, 310 and 352.

363-3. Uses Permitted. Flat cable assemblies shall be permitted only as branch circuits to supply suitable tap devices for lighting, small appliances, or small power loads. Flat cable assemblies shall be installed for exposed work only. Flat cable assemblies shall be installed in locations where they will not be subjected to severe physical damage.

363-4. Uses Not Permitted. Flat cable assemblies shall not be installed: (1) where subject to corrosive vapors unless specifically approved for the purpose; (2) in hoistways; (3) in any hazardous location; or (4) outdoors or in wet or damp locations unless specifically approved for the purpose.

363-5. Installation. Flat cable assemblies shall be installed in the field only in metal surface raceways approved for the purpose. The channel portion of the metal surface raceway systems shall be installed as complete systems before the flat cable assemblies are pulled into the raceways.

363-6. Number of Conductors. The flat cable assemblies shall consist of either 2, 3, or 4 conductors.

363-7. Size of Conductors. Flat cable assemblies shall have conductors of No. 10 special stranded copper wires.

363-8. Conductor Insulation. The entire flat cable assembly shall be formed to provide a suitable insulation covering all of the conductors and using one of the materials recognized in Table 310-13 for general branch-circuit wiring.

363-9. Splices. Splices shall be made in approved junction boxes using approved terminal blocks.

363-10. Taps. Taps shall be made only between any phase conductor and the neutral by means of devices and fittings approved for the purpose. Tap devices shall be rated at not less than 15 amperes or more than 300 volts, and they shall be color-coded in accordance with the requirements of Section 363-20.

363-11. Dead Ends. Each flat cable assembly dead end shall be terminated in an end-cap device approved for the purpose.

The dead-end fitting for the enclosing metal surface raceway shall be approved for the purpose.

363-12. Fixture Hangers. Fixture hangers installed with the flat cable assemblies shall be approved for the purpose.

363-13. Fittings. Fittings to be installed with flat cable assemblies shall be designed and installed to prevent physical damage to the cable assemblies.

363-14. Extensions. All extensions from flat cable assemblies shall be made from the terminal blocks enclosed within the junction boxes, installed at either end of the flat cable assembly runs.

All extensions shall be made with wiring methods approved for the purpose.

363-15. Supports. The flat cable assemblies shall be supported by means of their special design features, within the metal surface raceways with which they are specifically approved to be used.

The metal surface raceways shall be supported as required for the specific raceway to be installed.

363-16. Rating. The rating of the branch circuit shall not exceed 30 amperes.

363-17. Marking. In addition to the provisions of Section 310-11, Type FC cable shall have the temperature rating durably marked on the surface at intervals not exceeding 24 inches.

363-18. Protective Covers. When a flat cable assembly is installed less than 8 feet from the floor, it shall be protected by a metal cover approved for the purpose.

363-19. Identification. The neutral conductor shall be identified throughout its length by means of a distinctive and durable white or natural gray marking.

363-20. Terminal Block Identification. Terminal blocks approved for the purpose shall have distinctive and durable markings for color or word coding. The neutral section shall have a white marking or other suitable designation. The next adjacent section of the terminal block shall have a black marking or other suitable designation. The next section shall have a red marking or other suitable designation. The final or outer section, opposite the neutral section of the terminal block, shall have a blue marking or other suitable designation.

ARTICLE 364 — BUSWAYS

A. General Requirements

364-1. Other Articles. Installations of busways shall comply with the applicable provisions of Article 300.

364-2. Use.

(a) Use Permitted. Busways may be installed only where located in the open and are visible.

Exception: Busways shall be permitted to be installed behind panels if means of access are provided and if all the following conditions are met:

(1) No overcurrent devices are installed on the busway other than for an individual fixture.

(2) The space behind the access panels is not used for air handling purposes.

(3) The busway is totally enclosed, non-ventilating type.

(4) Busway is so installed that the joints between sections and fittings are accessible for maintenance purposes.

(b) Use Prohibited. Busways shall not be installed: (1) where subject to severe physical damage or corrosive vapors; (2) in hoistways; (3) in any hazardous location, unless specifically approved for such use (see Section 501-4(b)); nor (4) outdoors or in wet or damp locations unless specifically approved for the purpose.

Where secondary systems are operated ungrounded, a combination ground detector and potentializer plug shall be permitted to be used as an auxiliary fitting for busway systems to establish a definite potential difference between the busbars and the grounded casing of the busways. This will serve to drain off any static or other charge from the entire busway system, including its connected apparatus, supply, and branch-circuit conductors.

364-3. Support. Busway shall be securely supported at intervals not exceeding 5 feet.

Exception No. 1: Horizontally mounted busway approved for the purpose and so marked shall be securely supported at intervals not exceeding 10 feet.

Exception No. 2: Vertically mounted busway approved for the purpose and so marked shall be securely supported at each floor but in no case at intervals exceeding 16 feet.

364-4. Through Walls and Floors. It shall be permissible to extend unbroken lengths of busway through dry walls. It shall be permissible to extend busways vertically through dry floors if totally enclosed (unventilated) where passing through and for a minimum distance of 6 feet above the floor to provide adequate protection from physical damage.

364-5. Dead Ends. A dead end of a busway shall be closed.

364-7. Branches from Busways. Branches from busways shall be made with busways, rigid or flexible metal conduit, electrical metallic tubing, metal surface raceway or metal-clad cable; or with suitable cord assemblies approved for hard usage for the connection of portable equipment or for the connection of stationary equipment to facilitate their interchange.

364-8. Overcurrent Protection. Overcurrent protection shall be provided in accordance with Sections 364-9 through 364-13.

364-9. Rating of Overcurrent Protection — Feeders and Sub-Feeders. Where the allowable current rating of the busway does not correspond to a standard rating of the overcurrent device, the next higher rating shall be permitted.

364-10. Reduction in Size of Busway. Omission of overcurrent protection shall be permitted 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 $1/3$ the rating or setting of the overcurrent device next back on the line, and provided further that such busway is free from contact with combustible material.

364-11. Sub-Feeder or Branch Circuits. Where a busway is used as a feeder, devices or plug-in connections for tapping off sub-feeder or branch circuits from the busway shall contain the overcurrent devices required for the protection of the sub-feeder or branch circuits. The plug-in device shall consist of an externally operable circuit breaker or an externally operable fusible switch. Where such devices are mounted out of reach and contain disconnecting means, suitable means such as ropes, chains or sticks shall be provided for operating the disconnecting means from the floor.

Exception No. 1: As permitted in Section 240-21 for taps.

Exception No. 2: For fixed or semi-fixed lighting fixtures, where the branch-circuit overcurrent device is part of the fixture cord plug on cord-connected fixtures.

Exception No. 3: Where fixtures without cords are plugged directly into the busway and the overcurrent device is mounted on the fixture.

364-12. Rating of Overcurrent Protection — Branch Circuits. A busway shall be permitted as a branch circuit of any one of the types described in Article 210. When so used, the rating or setting of the overcurrent device protecting the busway shall determine the ampere rating of the

branch circuit, and the circuit shall in all respects conform with the requirements of Article 210 that apply to branch circuits of that rating.

364-13. Length of Busways Used As Branch Circuits. Busways which are used as branch circuits and which are so designed that loads can be connected at any point shall be limited to such lengths as will provide that in normal use the circuits will not be overloaded.

364-14. Marking. Busways shall be marked with the voltage and current rating for which they are designed, and with the manufacturer's name or trademark in such manner as to be visible after installation.

B. Requirements For Over 600 Volts, Nominal

364-21. Identification. Each bus run shall be provided with a permanent nameplate on which the following information shall be provided:

(a) Rated voltage.

(b) Rated continuous current; if bus is forced-cooled, both the normal forced-cooled rating and the self-cooled (not forced-cooled) rating for the same temperature rise shall be given.

(c) Rated frequency.

(d) Rated impulse withstand voltage.

(e) Rated 60-Hz withstand voltage (dry).

(f) Rated momentary current.

(g) Manufacturer's name or trademark.

Metal-enclosed buses shall be constructed and tested in accordance with ANSI C37.20 1969.

364-22. Grounding. Metal-enclosed bus shall be grounded in accordance with Article 250.

364-23. Adjacent and Supporting Structures. Metal-enclosed busways shall be installed so that temperature rise from induced circulating currents in any adjacent metallic parts will not be hazardous to personnel or constitute a fire hazard.

364-24. Neutral. Neutral bus, where required, shall be sized to carry all neutral load current, including harmonic currents, and shall have adequate momentary and short-circuit rating consistent with system requirements.

364-25. Barriers and Seals. Bus runs having sections located both inside and outside of buildings shall have a vapor seal at the building wall to prevent interchange of air between indoor and outdoor sections.

Exception: Vapor seals not required in forced-cooled bus. Fire barriers shall be provided where fire walls, floors, or ceilings are penetrated.

364-26. Drain Facilities. Drain plugs, filter drains, or similar methods shall be provided to remove condensed moisture from low points in bus run.

364-27. Ventilated Bus Enclosures. Ventilated bus enclosures shall be installed in accordance with Article 710 Part D, unless designed so that foreign objects inserted through any opening will be deflected from energized parts.

364-28. Terminations and Connections. Where bus enclosures terminate at machines cooled by flammable gas, seal-off bushings, baffles, or other means shall be provided to prevent accumulation of flammable gas in the bus enclosures.

Flexible or expansion connections shall be provided in long, straight runs of bus to allow for temperature expansion or contraction, or where the bus run crosses building vibration insulation joints.

All conductor termination and connection hardware shall be accessible for installation, connection, and maintenance.

364-29. Switches. Switching devices or disconnecting links provided in the bus run shall have the same momentary rating as the bus. Disconnecting links shall be plainly marked to be removable only when bus is de-energized. Switching devices which are not load break shall be interlocked to prevent operation under load and disconnecting link enclosures shall be interlocked to prevent access to energized parts.

364-30. Low-Voltage Wiring. Secondary control devices and wiring which are provided as part of the metal-enclosed bus run shall be insulated by fire-retardant barriers from all primary circuit elements with the exception of short lengths of wire, such as at instrument transformer terminals.

ARTICLE 365 — CABLEBUS

365-1. Definition. Cablebus is an approved assembly of insulated conductors with fittings and conductor terminations in a completely enclosed, ventilated protective metal housing. The assembly is designed to carry fault current and to withstand the magnetic forces of such current. Cablebus shall be permitted at any voltage or current for which the spaced conductors are rated.

Cablebus is ordinarily assembled at the point of installation from components furnished or specified by the manufacturer in accordance with instructions for the specific job.

365-2. Use. Cablebus shall be installed only for exposed work. Cablebus installed outdoors or in corrosive, wet, or damp locations shall be approved for the purpose. Cablebus shall not be installed in hoistways or in hazardous locations unless specifically approved for such use. Cablebus may be used for branch circuits, feeders, and services.

Cablebus framework, where adequately bonded, shall be permitted as the equipment grounding conductor for branch circuits and feeders.

365-3. Conductors.

(a) Types of Conductors. The current-carrying conductors in cablebus shall have an insulation rating of 75°C or higher of an approved type and suitable for the application in accordance with Articles 310 and 710.

(b) Ampacity of Conductors. The ampacity of conductors in cablebus shall be in accordance with Tables 310-17 and 319-19.

(c) **Size and Number of Conductors.** The size and number of conductors shall be that for which the cablebus is designed, and in no case smaller than No. 1/0.

(d) **Conductor Supports.** The insulated conductors shall be supported on blocks or other mounting means designed for the purpose.

The individual conductors in a cablebus shall be supported at intervals not greater than 3 feet for horizontal runs and 1½ feet for vertical runs. Vertical and horizontal spacing between supported conductors shall not be less than one conductor diameter at the points of support.

365-5. Overcurrent Protection. When the allowable ampacity of cablebus conductors does not correspond to a standard rating of an overcurrent device, the next higher ampere rated overcurrent device shall be permitted.

365-6. Support and Extension Through Walls and Floors.

(a) Cablebus shall be securely supported at intervals not exceeding 12 feet.

Exception: Where spans longer than 12 feet are required, the structure shall be specifically designed for the required span length.

(b) It shall be permissible to extend cablebus transversely through partitions or walls, other than fire walls, provided the section within the wall is continuous, protected against physical damage, and unventilated.

(c) Except where fire stops are required, it shall be permissible to extend cablebus vertically through dry floors and platforms, provided the cablebus is totally enclosed at the point where it passes through the floor or platform and for a distance of 6 feet above the floor or platform.

(d) Except where fire stops are required, it shall be permissible to extend cablebus vertically through floors and platforms in wet locations where (1) there are curbs or other suitable means to prevent waterflow through the floor or platform opening, and (2) where the cablebus is totally enclosed at the point where it passes through the floor or platform and for a distance of 6 feet above the floor or platform.

365-7. Fittings. A cablebus system shall include approved fittings for:

(a) Changes in horizontal or vertical direction of the run.

(b) Dead ends.

(c) Terminations in or on connected apparatus or equipment or the enclosures for such equipment.

(d) Additional physical protection where required, such as guards for severe mechanical exposure.

365-8. Conductor Terminations. Terminating means approved for the purpose shall be used for connections to cablebus conductors.

365-9. Grounding. Sections of cablebus shall be electrically bonded either by inherent design of the mechanical joints or by applied bonding means.

See Section 250-75 for bonding of metal noncurrent-carrying parts.

A cablebus installation shall be grounded in accordance with Sections 250-32 and 250-33.

365-10. Marking. Each section of cablebus shall be marked with the manufacturer's name or trade designation and the maximum diameter, number, voltage rating, and ampacity of the conductors to be installed. Markings shall be so located as to be visible after installation.

ARTICLE 366 — ELECTRICAL FLOOR ASSEMBLIES

A. General

366-1. Scope. This Article covers a field-installed wiring system using electrically conductive panels and receptacle housing units for branch circuits, signaling circuits and communication circuits. The wiring system provides access into the panels and simultaneous conduction of power, signaling and communication.

366-2. Other Articles. In addition to the provisions of this Article, installation of the assembly shall conform with the applicable provisions of Articles 210, 220, 250, and 310.

The signaling and communication circuits used in conjunction with this assembly shall also conform to Article 725 and to Article 800.

366-3. Definitions.

(a) **Panels.** Laminated panels containing sheets of electrical conducting material separated by insulating material(s).

(b) **Receptacle Housing Unit.** A special housing designed for insertion into the panels and containing power and/or signaling/communication outlets and filtering as required.

(c) **Signaling/Communications Receptacle Outlet.** An outlet whose use is specifically limited to signaling and/or communications circuits.

(d) **Termination Unit.** A special unit which presents the proper impedance to the high-frequency signaling and communication circuits within the electrical floor assemblies without affecting the 60 Hertz power.

(e) **Base Unit.** That portion of the receptacle housing unit which contains terminal probes and means for terminating the various receptacle outlets.

(f) **Terminal Probe.** A special probe which makes contact only with the conductive sheet(s) with which it is designed to do so.

(g) **Inter-Panel Connector.** Connectors specifically designed with three conductors, one each for phase, neutral and grounding connections to interconnect the panels, and/or panel input units to panels, and/or termination units to panels.

(h) **Panel Input Unit.** A unit specifically designed to permit connections between panels and the power branch circuit and the signaling/communication circuits or for only power branch circuits whenever signaling/communications circuits are not used.

(i) **Holddown Bar.** A bar designed specifically to secure the floor panels in place on the floor.

366-4. Uses Permitted. Electrical floor assemblies shall be used only: (1) as branch circuits to supply lighting, small appliances, and small power loads; (2) to supply signaling circuits; and (3) to supply communication circuits.

366-5. Uses Not Permitted. Electrical floor assemblies shall not be installed: (1) where subject to corrosive vapors; (2) outdoors or in a wet or damp location; or (3) in any hazardous location.

366-6. Branch Circuit. The rating of the branch circuit shall not exceed 20 amperes, 120 volts, 2 wire, single phase.

B. Installation

366-10. Panels. The panels shall be installed on surfaces which are flat and smooth. The panels shall be installed in a secure fashion. The holddown bar shall be permitted for this purpose.

366-11. All Circuits.

(a) **From the Distribution Panelboards.** All 15- and 20-ampere branch circuits shall be extended from their respective branch-circuit panelboards.

(b) **From Signaling and/or Communication Equipment.** All circuits for signaling and/or communication shall be extended from Class 2 sources.

(c) **Wiring.** The branch circuit conductors shall be installed in rigid metal conduit or raceways specifically approved for grounding purposes.

(d) **Terminations.** Termination for combination of 15- or 20-ampere branch circuits and signaling and/or communications circuits shall be within a panel input unit.

366-12. Circuits.

(a) **Branch Circuits.** A maximum length of 200 feet of panels shall be permitted to be connected in series. Any number of panels shall be permitted to be connected to form a single branch circuit provided the total area does not exceed 1024 square feet.

(b) **Signaling/Communication Circuits.** Signaling/communication circuits shall be permitted to feed any number of panels. A termination unit shall be permitted at the end of each series set of panels.

366-13. Receptacle Units. All receptacle units shall be installed or removed using suitable tools.

366-14. Grounding. The section of the branch circuit extended from the branch-circuit panelboard to the panel input unit shall have an equipment grounding conductor. This shall be a separate, continuous, copper equipment grounding conductor, not smaller than No. 12. This equipment grounding conductor shall be installed with the branch circuit conductors in the approved metal raceway. The equipment ground-

ing conductor shall be connected to a properly identified terminal screw in the panel input unit and in the branch circuit panelboard.

C. Construction

366-20. Marking.

(a) All markings shall be durable and shall be placed on the surface of all components in a readily recognizable location.

(b) All panels, receptacle housing units, base units, panel input units, and tools shall be marked to indicate the following information:

(1) The maximum working voltage and current.

(2) The manufacturer's name, trademark, or other distinctive marking by which the organization responsible for the component can be readily identified.

366-21. Identification.

(a) **Neutral.** All neutral connections points and terminations shall be identified by means of a distinctive, durable white or natural gray marking.

(b) **Grounding.** All grounding connection points and terminations shall be identified as required by Section 200-10.

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

A. Scope and General

370-1. Scope. This Article covers the installation and use of boxes containing outlets, receptacles, switches or devices; junction or pull boxes and conduit bodies as required by Section 300-15. Fittings referred to in Section 300-15 used as outlet, junction or pull boxes shall conform with the provisions of this Article depending on their use.

Installations in hazardous locations shall conform to Articles 500 through 517.

For systems over 600 volts, nominal, see Part D of this Article.

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

370-3. Nonmetallic Boxes. Nonmetallic boxes approved for the purpose shall be permitted only with open wiring on insulators, concealed knob-and-tube wiring, nonmetallic-sheathed cable, and with approved rigid nonmetallic conduit.

370-4. Metal Boxes. Where used with knob-and-tube wiring or non-metallic-sheathed cable, and mounted on or in contact with metal or metal lath ceilings, walls, or metallic surfaces, metal boxes shall be grounded.

B. Installation

370-5. Damp or Wet Locations. In damp or wet locations, boxes and fittings shall be so placed or equipped as to prevent moisture from entering or accumulating within the box or fitting. Boxes and fittings installed in wet locations shall be approved for the purpose.

For boxes in floors, see Section 370-17(b).

For protection against corrosion, see Section 300-6.

370-6. Number of Conductors in Switch, Outlet, Receptacle, Device, and Junction Boxes. Boxes shall be of sufficient size to provide free space for all conductors enclosed in the box.

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

Boxes and conduit bodies containing conductors, size #4 or larger, shall also comply with the provisions of Section 370-18.

(a) Standard Boxes. The maximum number of conductors, not counting fixture wires permitted in standard boxes, shall be as is listed in Table 370-6(a). See Section 370-18 where boxes or conduit bodies are used as junction or pull boxes.

Table 370-6(a). Boxes

Box Dimension, Inches Trade Size or Type	Min. Cu. In. Cap.	Maximum Number of Conductors				
		#14	#12	#10	#8	#6
4 x 1¼ Round or Octagonal	12.5	6	5	5	4	0
4 x 1½ Round or Octagonal	15.5	7	6	6	5	0
4 x 2¼ Round or Octagonal	21.5	10	9	8	7	0
4 x 1¼ Square	18.0	9	8	7	6	0
4 x 1½ Square	21.0	10	9	8	7	0
4 x 2¼ Square	30.3	15	13	12	10	6*
4 11/16 x 1¼ Square	25.5	12	11	10	8	0
4 11/16 x 1½ Square	29.5	14	13	11	9	0
4 11/16 x 2¼ Square	42.0	21	18	16	14	6
3 x 2 x 1½ Device	7.5	3	3	3	2	0
3 x 2 x 2 Device	10.0	5	4	4	3	0
3 x 2 x 2¼ Device	10.5	5	4	4	3	0
3 x 2 x 2½ Device	12.5	6	5	5	4	0
3 x 2 x 2¾ Device	14.0	7	6	5	4	0
3 x 2 x 3½ Device	18.0	9	8	7	6	0
4 x 2¼ x 1½ Device	10.3	5	4	4	3	0
4 x 2¼ x 1¾ Device	13.0	6	5	5	4	0
4 x 2¼ x 2½ Device	14.5	7	6	5	4	0
3¾ x 2 x 2½ Masonry Box/gang	14.0	7	6	5	4	0
3¾ x 2 x 3½ Masonry Box/gang	21.0	10	9	8	7	0
FS — Minimum Internal Depth 1¾ Single Cover/Gang	13.5	6	6	5	4	0
FD — Minimum Internal Depth 2¾ Single Cover/Gang	18.0	9	8	7	6	3
FS — Minimum Internal Depth 1¾ Multiple Cover/Gang	18.0	9	8	7	6	0
FD — Minimum Internal Depth 2¾ Multiple Cover/Gang	24.0	12	10	9	8	4

* Not to be used as a pull box. For termination only.

(1) Table 370-6(a) shall apply where no fittings or devices, such as fixture studs, cable clamps, hickeyes, switches, or receptacles, are contained in the box and where no grounding conductors are part of the wiring within the box. Where one or more fixture studs, cable clamps, or hickeyes are contained in the box, the number of conductors shall be one less than shown in the Tables; an additional deduction of one conductor shall be made for each strap containing one or more devices; and a further deduction of one conductor shall be made for one or more grounding conductors entering the box. A conductor running through the box shall be counted as one conductor, and each conductor originating outside of the box and terminating inside the box is counted as one conductor. Conductors, no part of which leaves the box, shall not be counted. The volume of a wiring enclosure (box) shall be the total volume of the assembled sections, and where used, the space provided by plaster rings, domed covers, extension rings, etc. that are marked with their volume in cubic inches.

(2) For combinations of conductor sizes shown in Table 370-6(a), the volume per conductor listed in Table 370-6(b) shall apply. The maximum number and size of conductors listed in Table 370-6(a) shall not be exceeded.

(b) **Other Boxes.** Boxes 100 cubic inches or less other than those described in Table 370-6(a) and conduit bodies having provision for more than two conduit entries shall be durably and legibly marked by the manufacturer with their cubic inch capacity and the maximum number of conductors permitted shall be computed using the volume per conductor listed in Table 370-6(b). Boxes described in Table 370-6(a) that have a larger cubic inch capacity than is designated in the Table shall be permitted to have their cubic inch capacity marked as required by this Section and the maximum number of conductors permitted shall be computed using the volume per conductor listed in Table 370-6(b).

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

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

Where #6 conductors are installed the minimum wire bending space required in Table 373-6(a) shall be provided.

(c) **Conduit Bodies.** Conduit bodies enclosing #6 conductors or smaller shall have a cross-sectional area not less than twice the cross-sectional area of the largest conduit to which it is attached. The

maximum number of conductors permitted shall be the maximum number permitted by Table I, Chapter 9, for the conduit to which it is attached.

Conduit bodies having provisions for no more than two conduit entries shall not contain splices, taps, or devices.

370-7. Conductors Entering Boxes or Fittings. Conductors entering boxes or fittings shall be protected from abrasion, and shall comply with (a) through (d) below.

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

(b) **Metal Boxes and Fittings.** Where metal outlet boxes or fittings are installed with open wiring or concealed knob-and-tube wiring, conductors shall enter through insulating bushings or, in dry places, through flexible tubing extending from the last insulating support and firmly secured to the box or fitting. Where raceway or cable is installed with metal outlet boxes or fittings, the raceway or cable shall be secured to such boxes and fittings.

(c) **Nonmetallic Boxes.** Where nonmetallic boxes are used with open wiring or concealed knob-and-tube wiring, 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 shall not be required where supported within 8 inches of the box. Where rigid nonmetallic conduit is installed with nonmetallic boxes or fittings, the conduit shall be secured to such boxes and fittings in an approved manner.

(d) **Conductors No. 4 AWG or Larger.** Installation shall comply with Section 373-6(c).

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

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

370-10. In Wall or Ceiling. In walls or ceilings of concrete, tile, or other noncombustible material, boxes and fittings shall be so installed that the front edge of the box or fitting will not set back of the finished

surface more than $\frac{1}{4}$ inch. In walls and ceilings constructed of wood or other combustible material, outlet boxes and fittings shall be flush with the finished surface or project therefrom.

370-11. Repairing Plaster. Plaster surfaces that are broken or incomplete shall be repaired so there will be no gaps or open spaces at the edge of the box or fitting.

Exception: On walls or ceilings of concrete, tile, or other noncombustible material.

370-12. Exposed Surface Extensions. In making an exposed surface extension from an existing outlet of concealed wiring, a box or an extension ring shall be mounted over the original box and electrically and mechanically secured to it.

370-13. Supports. Boxes shall be securely and rigidly fastened to the surface upon which they are mounted, or securely and rigidly embedded in concrete or masonry. Boxes shall be supported from a structural member of the building either directly or by using a substantial and approved metal or wooden brace, or shall be supported as is otherwise provided in this Section. If of wood, the brace shall not be less than nominal one-inch thickness. If of metal it shall be corrosion-resistant and shall not be less than No. 24 MSG.

Where mounted in new walls in which no structural members are provided or in existing walls in previously occupied buildings, boxes not over 100 cubic inches in size, specifically approved for the purpose, shall be affixed with approved anchors or clamps so as to provide a rigid and secure installation.

Threaded boxes or fittings not over 100 cubic inches in size that do not contain devices or support fixtures shall be considered adequately supported if two or more conduits are threaded into the box wrench-tight and are supported within 3 feet of the box on two or more sides as is required by this Section.

Threaded boxes or fittings not over 100 cubic inches in size shall be considered to be adequately supported if two or more conduits are threaded into the box wrench-tight and are supported as required by this Section within 18 inches of the box.

370-14. Depth of Outlet Boxes. No box shall have an internal depth of less than $\frac{1}{2}$ inch. Boxes intended to enclose flush devices shall have an internal depth of not less than $1 \frac{5}{16}$ inch.

370-15. Covers and Canopies. In completed installations each outlet box shall have a cover, faceplate, or fixture canopy.

(a) Nonmetallic or metal covers and plates shall be permitted with nonmetallic outlet boxes. Where metal covers or plates are used, they shall comply with the grounding requirements of Section 250-42.

See Section 410-18 for metal faceplates.

(b) Where a fixture canopy or pan is used, any combustible wall or ceiling finish exposed between the edge of the canopy or pan and the outlet box shall be covered with noncombustible material.

(c) Covers of outlet boxes having holes through which flexible cord pendants pass shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear. So-called hard-rubber or composition bushings shall not be used.

370-16. Fastened to Gas Pipes. Outlet boxes used where gas outlets are present shall be so fastened to the gas pipes as to be mechanically secure.

370-17. Outlet Boxes.

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

(b) **Floor Boxes.** Floor boxes especially approved for the purpose shall be used for receptacles located in the floor.

Exception: Standard approved types of flush receptacle boxes shall be permitted where receptacles are located in elevated floors of show windows or other locations when the authority having jurisdiction judges them to be free from physical damage, moisture, and dirt.

370-18. Pull and Junction Boxes. Boxes and conduit bodies used as pull or junction boxes shall comply with (a) through (c) of this Section.

(a) **Minimum Size.** For raceways $\frac{3}{4}$ inch trade size or larger, containing conductors of #4 or larger, and for cables containing conductors of #4 or larger, the minimum dimensions of pull or junction boxes installed in a raceway or cable run shall comply with the following:

(1) **Straight Pulls.** In straight pulls the length of the box shall not be less than 8 times the trade diameter of the largest raceway.

(2) **Angle or U Pulls.** Where angle or U pulls are made, the distance between each raceway entry inside the box and the opposite wall of the box shall not be less than 6 times the trade diameter of the largest raceway. This distance shall be increased for additional entries by the amount of the sum of the diameters of all other raceway entries on the same wall of the box. The distance between raceway entries enclosing the same conductor shall not be less than 6 times the trade diameter of the larger raceway.

Exception: Where a conduit or cable entry is in the wall of a box or conduit body opposite to a removable cover and where the distance from that wall to the cover is in conformance with the Column for one wire per terminal in Table 373-6(a).

When transposing cable size into raceway size in (a)(1) and (a)(2)

above, the minimum trade size raceway required for the number and size of conductors in the cable shall be used.

(3) Boxes of dimensions less than those required in (a)(1) and (a)(2) above shall be permitted for installations of combinations of conductors that are less than the maximum conduit fill (of conduits being used) permitted by Table 1, Chapter 9, provided the box has been approved for and is permanently marked with the maximum number and maximum size of conductors permitted.

Exception: Terminal housings supplied with motors which shall comply with the provisions of Section 430-12.

(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 373-6(c) for insulation of conductors at bushings.

(c) **Covers.** All pull boxes, junction boxes, and fittings shall be provided with covers approved for the purpose. Where metal covers are used, they shall comply with the grounding requirements of Section 250-42.

(d) Where permanent barriers are installed in a box, each section shall be considered as a separate box.

370-19. Junction, Pull and Outlet Boxes to Be Accessible. Junction, pull and outlet boxes shall be so installed that the wiring contained in them can be rendered accessible without removing any part of the building or in underground circuits without excavating sidewalks, paving earth or other substance that is to be used to establish the finished grade.

Exception: Boxes approved for the purpose shall be permitted where covered by gravel, light aggregate, or noncohesive granulated soil if their location is effectively identified and accessible for excavation.

C. Construction Specifications

370-20. Metal Outlet, Switch and Junction Boxes, and Fittings. Metal outlet, switch and junction boxes, and fittings shall comply with (a) through (c) below.

(a) **Corrosion Resistant.** Metal boxes and fittings shall be corrosion-resistant or shall be well galvanized, enameled, or otherwise properly coated inside and out to prevent corrosion.

See Section 300-6 for limitation in the use of boxes and fittings protected from corrosion solely by enamel.

(b) **Thickness of Metal.** Sheet metal boxes and fittings not over 100 cubic inches in size shall be made from metal not less than No. 14 MSG. Cast-metal boxes of other than malleable iron shall have a wall thickness not less than $\frac{1}{8}$ inch. Boxes of malleable iron shall have a wall thickness of not less than $\frac{3}{32}$ inch.

(c) **Boxes Over 100 Cubic Inches.** Boxes of over 100 cubic inches in size shall be composed of metal and shall comply with the requirements for cabinets and cutout boxes.

Exception: It shall be permissible for covers to consist of single flat sheets secured to the box proper by screws or bolts instead of hinges. Boxes having covers of this form shall be used only for enclosing joints in conductors or to facilitate the drawing in of wires and cables. They shall not be used to enclose switches, cutouts, or other control devices.

370-21. Covers. Metal covers shall be of a thickness not less than that specified for the walls of the box or fitting of the same material and with which they are designed to be used, or shall be lined with firmly attached insulating material not less than 1/32 inch in thickness. Covers of porcelain or other approved insulating material shall be permitted if of such form and thickness as to afford the required protection and strength.

370-22. Bushings. Covers of outlet boxes and outlet fittings having holes through which flexible cord pendants may pass, shall be provided with approved bushings or shall have smooth, well-rounded surfaces, upon which the cord may bear. Where conductors other than flexible cord may pass through a metal cover, a separate hole equipped with a bushing of suitable insulating material shall be provided for each conductor.

370-23. Nonmetallic Boxes. Provisions for supports or other mounting means for nonmetallic boxes shall be outside of the box, or the box shall be so constructed as to prevent contact between the conductors in the box and the supporting screws.

370-24. Marking. All boxes and conduit bodies, covers, extension rings, plaster rings, and the like shall be durably and legibly marked with the manufacturer's name or trademark.

D. Pull and Junction Boxes for Use on Systems Over 600-Volts, Nominal

370-50. General. In addition to the generally applicable provisions of Article 370, the rules in 370-51 and 370-52 shall apply.

370-51. Size of Pull and Junction Boxes. Pull and junction boxes shall provide adequate space and dimensions for the installation of conductors in accordance with the following:

(a) **For Straight Pulls.** The length of the box shall be not less than 48 times the outside diameter, over sheath, of the largest conductor or cable entering the box.

(b) **For Angle or U Pulls.** The distance between each cable or conductor entry inside the box and the opposite wall of the box shall not be less than 36 times the outside diameter, over sheath, of the largest cable or conductor. This distance shall be increased for additional entries by the amount of the sum of the outside diameters, over sheath, of all other cables or conductor entries through the same wall of the box.

The distance between a cable or conductor entry and its exit from the box shall be not less than 36 times the outside diameter, over sheath, of that cable or conductor.

Exception No. 1: Where a conductor or cable entry is in the wall of a box opposite to a removable cover and where the distance from that wall to the cover is in conformance with the provisions of 300-34.

Exception No. 2: Terminal housings supplied with motors which shall comply with the provisions of Section 430-12.

(c) One or more sides of any pull box shall be removable.

370-52. Construction and Installation Requirements.

(a) Boxes shall be made of material inherently resistant to corrosion or shall be suitably protected, both internally and externally, by enameling, galvanizing, plating or other means.

(b) Suitable bushing, shields, or fittings having smooth rounded edges shall be provided where conductors or cables pass through partitions and at other locations where necessary.

(c) Boxes shall provide a complete enclosure for the contained conductors or cables.

(d) Boxes shall be so installed that the wiring is accessible without removing any part of the building. Working space shall be provided in accordance with Article 710-34.

(e) Boxes shall be closed by suitable covers securely fastened in place. Underground box covers that weigh over one hundred pounds shall be considered as meeting this requirement. Covers for boxes shall be permanently marked "HIGH VOLTAGE." The marking shall be on the outside of the box cover and shall be readily visible. Letters shall be block type at least $\frac{1}{2}$ inch in height.

(f) Boxes and their covers shall be capable of withstanding the handling to which they may be subjected.

ARTICLE 373 — CABINETS AND CUTOUT BOXES

373-1. Scope. This Article covers the installation of cabinets and cutout boxes. Installations in hazardous locations shall comply with Articles 500 through 517.

A. Installation

373-2. Damp or Wet Locations. In damp or wet locations, cabinets and cutout boxes of the surface type shall be so placed or equipped as to

prevent moisture or water from entering and accumulating within the cabinet or cutout box, and shall be mounted so there is at least $\frac{1}{4}$ -inch air space between the enclosure and the wall or other supporting surface. Cabinets or cutout boxes installed in wet locations shall be weatherproof.

For protection against corrosion, see Section 300-6.

373-3. Position in Wall. In walls of concrete, tile, or other noncombustible material, cabinets shall be so installed that the front edge of the cabinet will not set back of the finished surface more than $\frac{1}{4}$ inch. In walls constructed of wood or other combustible material, cabinets shall be flush with the finished surface or project therefrom.

373-4. Unused Openings. Unused openings in cabinet or cutout boxes shall be effectively closed to afford protection substantially equivalent to that of the wall of the cabinet or cutout box. Where metal plugs or plates are used with nonmetallic cabinets or cutout boxes, they shall be recessed at least $\frac{1}{4}$ inch from the outer surface.

373-5. Conductors Entering Cabinets or Cutout Boxes. Conductors entering cabinets or cutout boxes shall be protected from abrasion and shall comply with (a) and (b) below.

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

(b) **Metal Cabinets and Cutout Boxes.** Where metal cabinets or cutout boxes are installed with open wiring or concealed knob-and-tube wiring, 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.

(c) **Cables.** Where cable is used, each cable shall be secured to the cabinet or cutout box.

373-6. Deflection of Conductors. Conductors at terminals or conductors entering or leaving cabinets or cutout boxes and the like shall comply with (a) through (c) below.

(a) **Width of Wiring Gutters.** Conductors shall not be deflected within a cabinet or cutout box unless a gutter having a width in accordance with Table 373-6(a) is provided. Conductors in parallel in accordance with Section 310-4 shall be judged on the basis of the number of conductors in parallel.

(b) **Wire Bending Space at Terminals.** Conductors shall not be deflected at a terminal unless bending space in accordance with Table 373-6(a) is provided.

(c) **Insulated Bushings.** Where ungrounded conductors of No. 4 or larger enter a raceway in a cabinet, pull box, junction box, or auxiliary gutter, the conductors shall be protected by a substantial bushing providing a smoothly rounded insulating surface, unless the conductors are separated from the raceway fitting by substantial insulating material securely fastened in place. Where conduit bushings are constructed wholly of insulating material, a locknut shall be installed both inside and outside the enclosure to which the conduit is attached. The insulating bushing or insulating material shall have a temperature rating not less than the insulation temperature rating of the installed conductors.

Table 373-6(a) — Minimum Wire Bending Space at Terminals and Minimum Width of Wiring Gutters in Inches.

AWG or Circular-Mil Size of Wire	Wires per Terminal				
	1	2	3	4	5
14-8	Not Specified	—	—	—	—
6	1½	—	—	—	—
4-3	2	—	—	—	—
2	2½	—	—	—	—
1	3	—	—	—	—
0-00	3½	5	7	—	—
000-0000	4	6	8	—	—
250 MCM	4½	6	8	10	—
300-350 MCM	5	8	10	12	—
400-500 MCM	6	8	10	12	14
600-700 MCM	8	10	12	14	16
750-900 MCM	8	12	14	16	18
1,000-1,250 MCM	10	—	—	—	—
1,500-2,000 MCM	12	—	—	—	—

Bending space at terminals shall be measured in a straight line from the end of the lug or wire connector (in the direction that the wire leaves the terminal) to the wall or barrier.

373-7. Space in Enclosures. Cabinets and cutout boxes shall have sufficient space to accommodate all conductors installed in them without crowding.

373-8. Enclosures for Switches or Overcurrent Devices. Enclosures for switches or overcurrent devices shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to other switches or overcurrent devices.

Exception: Where adequate space is provided so that the conductors do not fill the wiring space at any cross section to more than 40 percent of the cross-sectional area of the space, and so that the conductors, splices, and taps do not fill the wiring space at any cross section to more than 75 percent of the cross-sectional area of the space.

373-9. Side or Back Wiring Spaces or Gutters. Cabinets and cutout boxes shall be provided with back wiring spaces, gutters, or wiring compartments as required by Sections 373-11(c) and (d).

B. Construction Specifications

373-10. Material. Cabinets and cutout boxes shall comply with (a) through (c) below.

(a) Metal Cabinets and Cutout Boxes. Metal cabinets and cutout boxes shall be protected both inside and outside against corrosion and shall be approved for the purpose.

For protection against corrosion, see Section 300-6.

(b) **Strength.** The design and construction of cabinets and cutout boxes shall be such as to secure ample strength and rigidity. If constructed of sheet steel, the metal shall be of not less than No. 16 MSG.

(c) **Nonmetallic Cabinets.** Nonmetallic cabinets shall be submitted for approval prior to installation.

373-11. Spacing. The spacing within cabinets and cutout boxes shall comply with (a) through (d) below.

(a) **General.** Spacing within cabinets and cutout boxes shall be sufficient to provide ample room for the distribution of wires and cables placed in them, and for a separation between metal parts of devices and apparatus mounted within them as follows:

(1) **Base.** Other than at points of support, there shall be an air space of at least 1/16 inch between the base of the device and the wall of any metal cabinet or cutout box in which the device is mounted.

(2) **Doors.** There shall be an air space of at least one inch between any live metal part, including live metal parts of enclosed fuses, and the door.

Exception: Where the door is lined with an approved insulating material or is of a thickness of metal not less than No. 12 MSG, the air space shall not be less than 1/2 inch.

(3) **Live Parts.** There shall be an air space of at least 1/2 inch between the walls, back, gutter partition, if of metal, or door of any cabinet or cutout box and the nearest exposed current-carrying part of devices mounted within the cabinet where the voltage does not exceed 250. This spacing shall be increased to at least one inch where the voltage exceeds 250.

Exception: As permitted in (1) or (2) above.

(b) **Switch Clearance.** Cabinets and cutout boxes shall be deep enough to allow the closing of the doors when 30-ampere branch-circuit panelboard switches are in any position; when combination cutout switches are in any position; or when other single-throw switches are opened as far as their construction will permit.

(c) **Wiring Space.** Cabinets and cutout boxes that contain devices or apparatus connected within the cabinet or box to more than 8 conductors, including those of branch circuits, meter loops, sub-feeder circuits, power circuits, and similar circuits, but not including the supply circuit or a continuation thereof, shall have back-wiring spaces or one or more side-wiring spaces, side gutters, or wiring compartments.

(d) **Wiring Space — Enclosure.** Side-wiring spaces, side gutters, or side-wiring compartments of cabinets and cutout boxes shall be made tight enclosures by means of covers, barriers, or partitions extending from the bases of the devices, contained in the cabinet to the door, frame, or sides of the cabinet.

Exception: Where the enclosure contains only those conductors that are led from the cabinet at points directly opposite their terminal connections to devices within the cabinet.

Partially enclosed back-wiring spaces shall be provided with covers to complete the enclosure. Wiring spaces that are required by (c) above, and that are exposed when doors are open, shall be provided with

covers to complete the enclosure. Where adequate space is provided for feed-through conductors and for splices as required in Section 373-8 Exception, additional barriers shall not be required.

ARTICLE 374 — AUXILIARY GUTTERS

374-1. Use. Auxiliary gutters shall be permitted to supplement wiring spaces at meter centers, distribution centers, switchboards, and similar points of wiring systems and may enclose conductors or busbars, but shall not be used to enclose switches, overcurrent devices, appliances, or other similar equipment.

374-2. Extension Beyond Equipment. An auxiliary gutter shall not extend a greater distance than 30 feet beyond the equipment which it supplements.

Exception: As provided in Section 620-35 for elevators.

For wireways, see Article 362. For busways, see Article 364.

374-3. Supports. Gutters shall be supported throughout their entire length at intervals not exceeding 5 feet.

374-4. Covers. Covers shall be securely fastened to the gutter.

374-5. Number of Conductors. Auxiliary gutters shall not contain more than 30 current-carrying conductors at any cross section. The sum of the cross-sectional areas of all contained conductors at any cross section of an auxiliary gutter shall not exceed 20 percent of the interior cross-sectional area of the auxiliary gutter.

Exception No. 1: As provided in Section 620-35 for elevators.

Exception No. 2: Conductors for signaling circuits or controller conductors between a motor and its starter and used only for starting duty shall not be considered as current-carrying conductors.

Exception No. 3: Where the correction factors specified in Note 8 to Tables 310-16 through 310-19 are applied, there shall be no limit on the number of current-carrying conductors, but the sum of the cross-sectional area of all contained conductors at any cross section of the auxiliary gutter shall not exceed 20 percent of the interior cross-sectional area of the auxiliary gutter.

374-6. Ampacity of Conductors. Where the number of current-carrying conductors contained in the auxiliary gutter is 30 or less, the correction factors specified in Note 8 of Tables 310-16 through 310-19 shall not apply. The current carried continuously in bare copper bars in auxiliary gutters shall not exceed 1000 amperes per square inch of cross section of the conductor. For aluminum bars, the current carried continuously shall not exceed 700 amperes per square inch of cross section of the conductor.

374-7. Clearance of Bare Live Parts. Bare conductors shall be securely and rigidly supported so that the minimum clearance between bare current-carrying metal parts of opposite polarities mounted on the same surface will not be less than 2 inches, nor less than one inch for parts

that are held free in the air. A clearance not less than one inch shall be secured between bare current-carrying metal parts and any metal surface. Adequate provisions shall be made for the expansion and contraction of busbars.

374-8. Splices and Taps. Splices and taps shall comply with (a) through (d) below.

(a) Splices or taps shall be permitted within gutters when they are accessible by means of removable covers or doors. The conductors, including splices and taps, shall not fill the gutter to more than 75 percent 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 as required in Section 240-21.

374-9. Construction and Installation. Auxiliary gutters shall comply with (a) through (f) below.

(a) Gutters shall be so constructed and installed that adequate electrical and mechanical continuity of the complete system will be secured.

(b) Gutters shall be of substantial construction and shall provide a complete enclosure for the contained conductors. All surfaces, both interior and exterior, shall be suitably protected from corrosion. Corner joints shall be made tight and where the assembly is held together by rivets or bolts, these shall be spaced not more than 12 inches apart.

(c) Suitable bushings, shields, or fittings having smooth rounded edges shall be provided where conductors pass between gutters, through partitions, around bends, between gutters and cabinets or junction boxes, and at other locations where necessary to prevent abrasion of the insulation of the conductors.

(d) Gutters shall be constructed of sheet metal of a thickness not less than is specified in Table 374-9(d).

Table 374-9(d)

**Maximum Width of the Widest Surface of Gutters
Thickness (Manufacturers Standard Gage)**

Up to and including 6 inches	No. 16
Over 6 in. and not over 18 in.	No. 14
Over 18 in. and not over 30 in.	No. 12
Over 30 inches	No. 10

(e) Where insulated conductors are deflected within an auxiliary gutter, either at the ends or where conduits, fittings, or other raceways enter or leave the gutter, or where the direction of the gutter is deflected greater than 30 degrees, dimensions corresponding to Section 373-6 shall apply.

(f) Auxiliary gutters intended for outdoor use shall be of approved raintight construction.

ARTICLE 380 — SWITCHES**A. Installation**

380-1. Scope. The provisions of this Article shall apply to all switches, switching devices, and circuit breakers where used as switches.

380-2. Switch Connections.

(a) **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. Where in metal enclosures, wiring between switches and outlets shall be run with both polarities in the same enclosure.

(b) **Grounded Conductors.** Switches or circuit breakers shall not disconnect the grounded conductor of a circuit.

Exception No. 1: Where the switch or circuit breaker simultaneously disconnects all conductors of the circuit.

Exception No. 2: Where the switch or circuit breaker is so arranged that the grounded conductor cannot be disconnected until all the ungrounded conductors of the circuit have been disconnected.

380-3. Enclosure. Switches and circuit breakers shall be of the externally operable type enclosed in boxes or cabinets approved for the purpose.

Exception: Pendant- and surface-type snap switches and knife switches mounted on an open-face switchboard or panelboard.

380-4. Wet Locations. A switch or circuit breaker in a wet location or outside of a building shall be enclosed in a weatherproof enclosure or cabinet that shall comply with Section 373-2.

380-5. Time Switches, Flashers, and Similar Devices. Time switches, flashers, and similar devices need not be of the externally operable type. They shall be enclosed in metal boxes or cabinets.

Exception No. 1: Where mounted on switchboards or control panels.

Exception No. 2: Where enclosed in approved individual housings.

380-6. Position of Knife Switches. Single-throw knife switches shall be so placed that gravity will not tend to close them. Double-throw knife switches shall be permitted to be mounted so that the throw will be either vertical or horizontal. Where the throw is vertical, a locking device shall be provided that will insure the blades remaining in the open position when so set.

380-7. Connection of Knife Switches. Single-throw knife switches shall be so connected that the blades are dead when the switch is in the open position.

380-8. Accessibility and Grouping.

(a) All switches and circuit breakers used as switches shall be located that they may be operated from a readily accessible place. They shall be so installed that the center of the grip of the operating handle of the

switch or circuit breaker, when in its highest position, will not be more than 6½ feet above the floor or working platform.

Exception No. 1: On busway installations, fused switches and circuit breakers shall be permitted to be located at the same level as the busway. Suitable means shall be provided to operate the handle of the device from the floor.

Exception No. 2: Switches installed adjacent to motors, appliances or other equipment which they supply shall be permitted to be located higher than specified in the foregoing and to be accessible by portable means.

Exception No. 3: Hookstick operable isolating switches shall be permitted at heights of more than 6 feet, 6 inches.

380-9. Faceplates for Flush-Mounted Snap Switches. Flush snap switches, that are mounted in ungrounded metal boxes and located within reach of conducting floors or other conducting surfaces, shall be provided with faceplates of nonconducting, noncombustible material. Metal faceplates shall be of ferrous metal not less than 0.030 inch in thickness or of nonferrous metal not less than 0.040 inch in thickness. Faceplates of insulating material shall be noncombustible and not less than 0.10 inch in thickness but they shall be permitted to be less than 0.10 inch in thickness if formed or reinforced to provide adequate mechanical strength.

380-10. Mounting of Snap Switches.

(a) **Surface-Type.** Snap switches used with open wiring on insulators shall be mounted on insulating material that will separate the conductors at least ½ inch from the surface wired over.

(b) **Box Mounted.** Flush-type snap switches mounted in boxes that are set back of the wall surface as permitted in Section 370-10 shall be installed so that the extension plaster ears are seated against the surface of the wall. Flush-type snap switches mounted in boxes that are flush with the wall surface or project therefrom shall be so installed that the mounting yoke or strap of the switch is seated against the box.

380-11. Circuit Breakers as Switches. A hand-operable circuit breaker equipped with a lever or handle, or a power-operated circuit breaker capable of being opened by hand in the event of a power failure, shall be permitted to serve as a switch if it has the required number of poles.

380-12. Grounding of Enclosures. Enclosures for switches or circuit breakers on circuits of over 150 volts to ground shall be grounded as specified in Article 250. Where nonmetallic enclosures are used with metal-sheathed cables or metallic conduits, provision shall be made for grounding continuity.

380-13. Knife Switches.

(a) Knife switches rated at over 1200 amperes at 250 volts or less, and at over 600 amperes at 251 to 600 volts, shall be used only as isolating switches and shall not be opened under load.

(b) To interrupt currents over 1200 amperes at 250 volts or less, or over 600 amperes at 251 to 600 volts, a circuit breaker or a switch of special design approved for such purpose shall be used.

(c) Knife switches of ratings less than specified in (a) and (b) above shall be considered general-use switches.

See definition of general-use switch in Article 100.

(d) Motor-circuit switches shall be permitted to be of the knife-switch type.

See definition of a motor-circuit switch in Article 100.

380-14. Rating and Use of Snap Switches. Snap switches shall be used within their ratings and as follows:

(a) **AC General-Use Snap Switch.** A form of general-use snap switch suitable only for use on alternating-current circuits for controlling the following:

(1) Resistive and inductive loads, including electric-discharge lamps, not exceeding the ampere rating of the switch at the voltage involved.

(2) Tungsten-filament lamp loads not exceeding the ampere rating of the switch at 120 volts.

(3) Motor loads not exceeding 80 percent of the ampere rating of the switch at its rated voltage.

(b) **AC-DC General-Use Snap Switch.** A form of general-use snap switch suitable for use on either AC or DC circuits for controlling the following:

(1) Resistive loads not exceeding the ampere rating of the switch at the voltage applied.

(2) Inductive loads not exceeding 50 percent of the ampere rating of the switch at the applied voltage. Switches rated in horsepower are suitable for controlling motor loads within their rating at voltage applied.

(3) Tungsten-filament lamp loads not exceeding the ampere rating of the switch at the applied voltage if "T" rated.

For switches on signs and outline lighting, see Section 600-2.

For switches controlling motors, see Sections 430-83, 430-109, and 430-110.

B. Construction Specifications

380-15. Marking. Switches shall be marked with the current and voltage and, if horsepower rated, the maximum rating for which they are designed.

380-16. 600-Volt Knife Switches. Auxiliary contacts of a renewable or quick-break type or the equivalent, shall be provided on all 600-volt knife switches designed for use in breaking currents over 200 amperes.

380-17. Fused Switches. A fused switch shall not have fuses in parallel.

ARTICLE 384 — SWITCHBOARDS AND PANELBOARDS

384-1. Scope. This Article covers (1) all switchboards, panelboards, and distribution boards installed for the control of light and power circuits, and (2) battery-charging panels supplied from light or power circuits.

Exception: Switchboards or portions thereof used exclusively to control signaling circuits operated by batteries.

384-2. Other Articles. Switches, circuit breakers, and overcurrent devices used on switchboards, panelboards, and distribution boards, and their enclosures, shall comply with the requirements of Articles 240, 250, 370, 380, and other Articles that apply. Switchboards and panelboards in hazardous locations shall comply with the requirements of Articles 500 through 517.

384-3. Support and Arrangement of Busbars and Conductors.

(a) Conductors and busbars on a switchboard, panelboard, or control board shall be so located as to be free from physical damage and shall be held firmly in place. Other than the required interconnections and control wiring, only those conductors that are intended for termination in a vertical section of a switchboard shall be located in that section.

(b) The arrangement of busbars and conductors shall be such as to avoid overheating due to inductive effects.

(c) Each switchboard, switchboard section, or panelboard, if used as service equipment, shall be provided with a main bonding jumper sized in accordance with Section 250-79(c) or the equivalent placed within the service disconnect section for connecting the grounded service conductor on its supply side to the switchboard or panelboard frame. All sections of a switchboard shall be bonded together using an equipment grounding conductor sized in accordance with Table 250-95.

(d) Load terminals in switchboards and panelboards shall be so located that it will be unnecessary to reach across or beyond an ungrounded line bus in order to make load connections.

(e) On a switchboard or a panelboard supplied from a 4-wire delta-connected system, where the mid-point of one phase is grounded, that phase busbar or conductor having the higher voltage to ground shall be marked.

(f) The phase arrangement on three phase buses shall be A, B, C from front to back, top to bottom, or left to right, as viewed from the front of the switchboard or panelboard. The B phase shall be that phase having the higher voltage to ground. Other busbar arrangements shall be permitted for additions to existing installations and shall be marked.

A. Switchboards

384-4. Location of Switchboards. Switchboards that have any exposed live parts shall be located in permanently dry locations and then only where under competent supervision and accessible only to qualified per-

sons. Switchboards shall be so located that the probability of damage from equipment or processes is reduced to a minimum.

384-5. Wet Locations. Where a switchboard is in a wet location or outside of a building, it shall be enclosed in a weatherproof enclosure or cabinet installed to comply with Section 373-2.

384-6. Location Relative to Easily Ignitable Material. Switchboards shall be so placed as to reduce to a minimum the probability of communicating fire to adjacent combustible materials.

384-7. Clearance From Ceiling. A space of 3 feet or more shall be provided between the top of any switchboard and any nonfireproof ceiling.

Exception: Where a fireproof shield is provided between the switchboard and the ceiling.

384-8. Clearances Around Switchboards. Clearances around switchboards shall comply with the provisions of Section 110-16.

384-9. Conductor Covering. Insulated conductors where closely grouped, as on the rear of switchboards, shall each have a flame-retardant outer covering. The conductor covering shall be stripped back to avoid contact with the terminals. Insulated conductors used for instrument and control wiring on the rear of switchboards shall be flame-retardant, either inherently or by means of an outer covering, such as one of the following types: RH, RHH, RHW, V, ALS, AVA, AVB, SIS, T, TA, TBS, TW, THHN, THWN, THW, MI, XHHW, or other types approved for the purpose.

384-10. Clearance for Conductors Entering Bus Enclosures. Where conduits or other raceways enter a switchboard, floor standing panelboard, or similar enclosure at the bottom, sufficient space shall be provided to permit installation of conductors in the enclosure. The wiring space shall not be less than shown in the following table where the conduit or raceways enter or leave the enclosure below the busbars, their supports, or other obstructions. The conduit or raceways, including their end fittings shall not rise more than 3 inches above the bottom of the enclosure.

**Minimum Spacing Between
Bottom of Enclosure and
Busbars, their Supports, or other
Obstructions (Inches)**

Conductor

Insulated busbars, their supports, or other obstructions . . .	8
Noninsulated busbars	10

384-11. Grounding Switchboard Frames. Switchboard frames and structures supporting switching equipment shall be grounded.

Exception: Frames of direct-current single-polarity switchboards shall not be required to be grounded if effectively insulated.

384-12. Grounding of Instruments, Relays, Meters, and Instrument Transformers on Switchboards. Instruments, relays, meters, and instrument transformers located on switchboards shall be grounded as specified in Sections 250-121 through 250-125.

B. Panelboards

384-13. General. All panelboards shall have a rating not less than the minimum feeder capacity required for the load computed in accordance with Article 220. Panelboards shall be durably marked by the manufacturer with the voltage and the current rating and the number of phases for which they are designed and with the manufacturer's name or trademark in such a manner as to be visible after installation, without disturbing the interior parts or wiring.

384-14. Lighting and Appliance Branch-Circuit Panelboard. For the purposes of this Article, a lighting and appliance branch-circuit panelboard is one having more than 10 percent of its overcurrent devices rated 30 amperes or less, for which neutral connections are provided.

384-15. Number of Overcurrent Devices on One Panelboard. Not more than 42 overcurrent devices (other than those provided for in the mains) of a lighting and appliance branch-circuit panelboard shall be installed in any one cabinet or cutout box.

A lighting and appliance branch-circuit panelboard shall be provided with physical means to prevent the installation of more overcurrent devices than that number for which the panelboard was designed, rated, and approved.

For the purposes of this Article, a 2-pole circuit breaker shall be considered two overcurrent devices; a 3-pole breaker shall be considered three overcurrent devices.

384-16. Overcurrent Protection.

(a) Each lighting and appliance branch-circuit panelboard shall be individually protected on the supply side by not more than two main circuit breakers or two sets of fuses having a combined rating not greater than that of the panelboard.

Exception No. 1: Individual protection for a lighting and appliance panelboard shall not be required if the panelboard feeder has overcurrent protection not greater than that of the panelboard.

Exception No. 2: Individual protection for lighting and appliance branch-circuit panelboards is not required where such panelboards are used as service equipment in supplying an individual residential occupancy and where any bus supplying 15- or 20-ampere circuits is protected on the supply side by an overcurrent device.

(b) Panelboards equipped with snap switches rated at 30 amperes or less, shall have overcurrent protection not in excess of 200 amperes.

(c) The total load on any overcurrent device located in a panelboard shall not exceed 80 percent of its rating where in normal operation the load will continue for 3 hours or more.

Exception: Where the assembly including the overcurrent device is approved for continuous duty at 100 percent of its rating.

(d) Where a panelboard is supplied through a transformer, the overcurrent protection required in (a) and (b) above shall be located on the secondary side of the transformer.

Exception: A panelboard supplied by the secondary side of a single-phase transformer having a two-wire (single-voltage) secondary shall

be considered as protected by overcurrent protection provided on the primary (supply) side of the transformer, provided this protection is in accordance with Section 450-3(b)(1) and does not exceed the value determined by multiplying the panelboard rating by the secondary-to-primary voltage ratio.

384-17. Panelboards in Damp or Wet Locations. Panelboards in damp or wet locations shall be installed to comply with Section 373-2.

384-18. Enclosure. Panelboards shall be mounted in cabinets, cutout boxes, or enclosures approved for the purpose and shall be dead front.

Exception: Panelboards other than of the dead front externally operable type shall be permitted where accessible only to qualified persons.

384-19. Relative Arrangement of Switches and Fuses. In panelboards, fuses of any type shall be installed on the load side of any switches.

Exception: As provided in Section 230-94 for use as service equipment.

C. Construction Specifications

384-20. Panels. The panels of switchboards shall be made of moisture-resistant, noncombustible material.

384-21. Busbars. Bare busbars shall be permitted if they are rigidly mounted.

384-22. Protection of Instrument Circuits. Instruments, pilot lights, potential transformers, and other switchboard devices with potential coils shall be supplied by a circuit that is protected by standard overcurrent devices rated 15 amperes or less.

Exception No. 1: Where the operation of the overcurrent device might introduce a hazard in the operation of devices.

Exception No. 2: For ratings of 2 amperes or less, special types of enclosed fuses shall be permitted.

384-23. Component Parts. Switches, fuses, and fuseholders used on panelboards shall comply with the applicable requirements of Articles 240 and 380.

384-24. Knife Switches. Exposed blades of knife switches shall be dead when open.

384-25. Color Coding. On switchboards or panelboards that are provided with color markings to indicate the main busbars to which branch-circuit busbars are connected, the colors shall conform to the color coding of Section 210-5.

384-26. Minimum Spacings. The distance between bare metal parts, busbars, etc., shall not be less than specified in Table 384-26.

Exception No. 1: At switches or circuit breakers.

Exception No. 2: Inherent spacings in listed components.

Where close proximity does not cause excessive heating, parts of the same polarity at switches, enclosed fuses, etc. shall be permitted to be placed as close together as convenience in handling will allow.

Table 384-26. Minimum Spacings Between Bare Metal Parts

	Opposite Polarity Where Mounted on the Same Surface	Opposite Polarity Where Held Free in Air	*Live Parts to Ground
Not over 125 volts	3/4 inch	1/2 inch	1/2 inch
Not over 250 volts	1 1/4 inch	3/4 inch	1/2 inch
Not over 600 volts	2 inches	1 inch	1 inch

* For spacing between live parts and doors of cabinets, see Section 373-11(a) (1), (2), and (3).

384-27. Grounding of Panelboards. Panelboard cabinets shall be grounded in the manner specified in Article 250 or Section 384-3(c). An approved terminal bar for equipment grounding conductors shall be provided and secured inside of the cabinet for the attachment of all the feeder and branch-circuit equipment grounding conductors, where the panelboard is used with nonmetallic raceway or cable, or where separate grounding conductors are provided. The terminal bar shall be bonded to the cabinet or panelboard frame and shall not be connected to the neutral bar in other than service equipment.

Exception: When an isolated ground conductor is provided as in Section 250-74, Exception No. 4, the insulated ground conductor which is run with the circuit conductors shall be permitted to pass through the panelboard without being connected to the panelboard grounding terminal bar.

Chapter 4. Equipment for General Use

ARTICLE 400 — FLEXIBLE CORDS AND CABLES

A. General

400-1. Scope. This Article covers general requirements, applications, and construction specifications for flexible cords and flexible cables.

400-2. Other Articles. Flexible cords and flexible cables shall comply with this Article and with the applicable provisions of other Articles of this Code.

400-3. Suitability. Flexible cords and cables and their associated fittings shall be suitable for the conditions of use and location.

400-4. Types. Flexible cords and flexible cables shall conform to the description in Table 400-4. Types of flexible cords and flexible cables other than those listed in the Table shall be the subject of special investigations and shall not be used before being approved.

400-5. Ampacity of Flexible Cords and Cables. Table 400-5 gives the allowable ampacity for not more than 3 current-carrying conductors in a cord. If the number of current-carrying conductors in a cord is from 4 to 6, the allowable ampacity of each conductor shall be reduced to 80 percent of the values for not more than 3 current-carrying conductors in the Table. A conductor used for equipment grounding and a neutral conductor which carries only the unbalanced current from other conductors, as in the case of normally balanced circuits of 3 or more conductors, shall not be considered as current-carrying conductors.

Where a single conductor is used for both equipment grounding and to carry unbalanced current from other conductors, as provided for in Section 250-60 for electric ranges and electric clothes dryers, it shall not be considered as a current-carrying conductor.

Notes to Table 400-4

1. Except for Types SP-1, SP-2, SP-3, SPT-1, SPT-2, SPT-3, HPN, TP, TPT, SRD (3-conductor) and SRDT (3-conductor) individual conductors are twisted together.

2. Cables constructed differently than specified herein and listed as component parts of a data processing system shall be permitted.

3. Types TP, TPT, TS, and TST shall be permitted in lengths not exceeding 8 feet when attached directly, or by means of a special type

of plug, to a portable appliance rated at 50 watts or less and of such nature that extreme flexibility of the cord is essential.

4. Rubber-filled or varnished cambric tapes shall be permitted as a substitute for the inner braids.

5. Types S, SO, ST, and STO shall be permitted for use on theater stages, in garages, and elsewhere where flexible cords are permitted by this Code.

6. Traveling cables for operating,

(Notes continued on page 237)

Table 400-4. Flexible Cords and Cables
(See Section 400-4)

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Nominal * Insulation Thickness		Braid on Each Conductor	Outer Covering		Use	
					AWG	Mils					
Parallel Tinsel Cord	TP See Note 3	27	2	Rubber	27	30	None	Rubber	Attached to an Appliance	Damp Places	Not Hard Usage
	TPT See Note 3	27	2	Thermo-plastic			None	Thermo-plastic	Attached to an Appliance	Damp Places	Not Hard Usage
Jacketed Tinsel Cord	TS See Note 3	27	2	Rubber	27	15	None	Rubber	Attached to an Appliance	Damp Places	Not Hard Usage
	TST See Note 3	27	2	Thermo-plastic			None	Thermo-plastic	Attached to an Appliance	Damp Places	Not Hard Usage
Asbestos-Covered Heat-Resistant Cord	AFC	18-10	2 or 3	Impreg-nated Asbestos	18-14	30	Cotton or Rayon	None	Pendant	Dry Places	Not Hard Usage
			2		12-10	45	None	Cotton, Rayon or Saturated Asbestos			
	AFPD		2 or 3								

See Notes 1 through 9 preceding and following table.

* See Note 9.

Table 400-4 (Continued)

Cotton-Covered Heat-Resistant Cord		18-10	2 or 3	Impreg-nated Cotton	18-14	30	Cotton or Rayon	None	Pendant	Dry Places	Not Hard Usage
			2		12-10	45	None	Cotton or Rayon			
	CFPD		2 or 3								
All Rubber Parallel Cord	SP-1 See Note 7	18	2 or 3	Rubber	18	30	None	Rubber	Pendant or Portable	Damp Places	Not Hard Usage
	SP-2 See Note 7	18-16			18-16	45					
	SP-3 See Note 7	18-12		Rubber	18-16 14 12 10	60 80 95 110	None	Rubber	Refrigerators or Room Air Conditioners	Damp Places	Not Hard Usage
All Plastic Parallel Cord	SPT-1 See Note 7	18	2 or 3	Thermo-plastic	18	30	None	Thermoplastic	Pendant or Portable	Damp Places	Not Hard Usage
	SPT-2 See Note 7	18-16			18-16	45					
	SPT-3 See Note 7	18-10		Thermo-plastic	18-16 14 12 10	60 80 95 110	None	Thermoplastic	Refrigerators or Room Air Conditioners	Damp Places	Not Hard Usage

* See Note 9.

See Notes 1 through 9 preceding and following table.

Table 400-4 (Continued)

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Nominal * Insulation Thickness		Braid on Each Conductor	Outer Covering		Use	
					AWG	Mils					
Lamp Cord	C	18-10	2 or more	Rubber	18-16	30	Cotton	None	Pendant or Port.	Dry Places	Not Hard Usage
Twisted Portable Cord	PD	18-10	2 or more	Rubber	14-10	45	Cotton	Cotton or Rayon	Pendant or Port.	Dry Places	Not Hard Usage
Vacuum Cleaner Cord	SV See Note 7	18	2 or 3	Rubber	18	15	None	Rubber	Pendant or Portable	Damp Places	Not Hard Usage
	SVO, SVT See Note 7	18-17		Thermopl	18-17	15		Oil-Resistant Thermoplastic Compound			
	SVTO See Note 7	18			18	15		Oil-Resistant Thermoplastic			
Junior Hard Service Cord	SJ	18-14	2, 3, or 4	Rubber	18-14 (Rubber)	30	None	Rubber	Pendant or Portable	Damp Places	Hard Usage
	SJO				18-14 (Latex)	15		Oil-Resistant Compound			
	SIT			Thermopl or Rubber	18-14	30		Thermoplastic			
	SITO							Oil-Resistant Thermoplastic			

See Notes 1 through 9 preceding and following table.

* See Note 9.

Table 400-4 (Continued)

Hard Service Cord	S See Note 5	18-2	2 or more	Rubber	18-16 (Rubber)	30	None	Rubber	Pendant or Portable	Damp Places	Extra Hard Usage
	SO			18-16 (Latex)	15	Oil Resist. Compound					
				14-10 (Rubber)	45						
				14-10 (Latex)	18						
				8- 2 (Rubber)	60						
	ST			Thermopl' or Rubber	18-16	30		Thermoplastic			
	STO				14-10	45		Oil Resistant Thermoplastic			
				8- 2	60						
Rubber-Jacketed Heat-Resistant Cord	AFSJ	18-16	2 or 3	Impreg-nated Asbestos	18-14	30	None	Rubber	Portable Heaters	Damp Places	Hard ' Usage
	AFS	18-16-14									Extra Hard Usage
Heater Cord	HPD	18-12	2, 3 or 4	Rubber or ther-moplas-tic with Asbestos or All Neo-prene	(Rubber or Thermo-plastic	15	None	Cotton or Rayon	Portable Heaters	Dry Places	Not Hard Usage
					18-16							14-12	30

See Notes 1 through 9 preceding and following table.

* See Note 9.

Table 400-4 (Continued)

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Nominal * Insulation Thickness		Braid on Each Conductor	Outer Covering		Use	
					AWG	Mils					
Rubber Jacketed Heater Cord	HSJ	18-16	2, 3 or 4	Rubber or thermoplastic with Asbestos or All Neoprene	(All Neoprene)		None	Cotton and Rubber	Portable Heaters	Damp Places	Hard Usage
Jacketed Heater Cord	HSJO	18-16	2, 3 or 4	Rubber with Asbestos or All Neoprene	18-16	30	None	Cotton and Oil Resistant Compound	Portable	Damp Places	Hard ⁹ Usage
	HS	14-12			14-12	45		Cotton and Rubber or Neoprene			Extra Hard Usage
	HSO	14-12						Cotton and Oil Resistant Compound			
Parallel Heater Cord	HPN See Note 7	18-12	2 or 3	Thermosetting	18-16 14 12	45 80 95	None	Thermosetting	Portable	Damp Places	Not Hard Usage
Range, Dryer Cable	SRD	10-4	3 or 4	Rubber	10-4	45	None	Rubber or Neoprene	Portable	Damp Places	Ranges, Dryers
	SRDT	10-4	3 or 4	Thermoplastic			None	Thermoplastic	Portable	Damp Places	Ranges, Dryers

See Notes 1 through 9 preceding and following table.

* See Note 9.

Table 400-4 (Continued)

Data Processing Cable	DP See Note 2	32 Min.	2 or more	Thermoplastic, Rubber or Cross-linked Synthetic Polymer	32-27 (50V) 26-23 (50V) 22-20 (50V) 32-16 (300V) 14-10 (300V) 8- 2 (300V)	8 12 16 20 30 60	None	Thermoplastic, Rubber or Cross-linked Synthetic Polymer	Data Processing Systems	Dry Places	Power and Signaling Circuits
Elevator Cable	E See Note 6	18-14	2 or more	Rubber	18-16	20	Cotton	Three Cotton, Outer one Flame-Retardant & Moisture-Resist. See Note 4	Elevator Lighting and Control	Non-Hazardous Locations	
	EO See Note 6	18-14	2 or more	Rubber	14	30	Cotton	One Cotton and a Neoprene Jacket See Note 4	Elevator Lighting and Control	Hazardous Locations	
Elevator Cable	EN See Note 6	18-14	2 or more	Rubber	18-16	20	Flexible Nylon Jacket	Three Cotton, Outer one Flame-Retardant & Moisture-Resist. See Note 4	Non-Hazardous Locations		
								One Cotton and a Neoprene or Thermoplastic Jacket See Note 4	Elevator Lighting and Control	Hazardous Locations	

See Notes 1 through 9 preceding and following table.

* See Note 9.

Table 400-4 (Continued)

Trade Name	Type Letter	Size AWG	No. of Conductors	Insulation	Nominal * Insulation Thickness		Braid on Each Conductor	Outer Covering		Use
					AWG	Mils				
Elevator Cable	ET See Note 6			Thermoplastic	14	30	Rayon	Three Cotton, Outer one Flame-Retardant & Moisture-Resist. See Note 4		Non-Hazardous Locations
	ETLB See Note 6						None			
	ETP See Note 6			Thermoplastic			Rayon	Thermoplastic		Hazardous Locations
	ETT See Note 6			Thermoplastic			None	One Cotton and a Thermoplastic Jacket		

See Notes 1 through 9 preceding and following table.

* See Note 9.

(Continued from page 229)

control and signaling circuits shall have one or more nonmetallic fillers or shall have a supporting filler of stranded steel wires having its own protective braid or cover. Cables exceeding 100 feet between supports shall have steel supporting fillers, except in locations subject to excessive moisture or corrosive vapors or gases. Where steel supporting fillers are used, they shall run straight through the center of the cable assembly and shall not be cabled with the copper strands of any conductor.

Types E, EO, EN, ET, ETP, ETLB, and ETT cables shall be permitted to incorporate in the construction No. 20 conductors formed as a pair, and covered with suitable shielding for telephone and other audio or higher frequency communication circuits. The insulation of the conductors shall be rubber or thermoplastic of thickness specified for the other conductors of the particular type of cable. The shield shall

have its own protective covering. Where used, this component shall be permitted to be incorporated in any layer of the cable assembly, and shall not run straight through the center.

7. A third conductor in these cables is for grounding purposes only.

8. The individual conductors of all cords, except those of heat-resistant cords (Types AFC, AFPD, AFS, AFSJ, and CFPD), shall have a rubber or thermoplastic insulation, except that the grounding conductor where used shall be in accordance with Section 400-23(b). A rubber compound shall be vulcanized, except for heater cords (Types HPD and HSJ).

9. Where the voltage between any two conductors exceeds 300, but does not exceed 600, flexible cord of No. 10 and smaller shall have rubber or thermoplastic insulation on the individual conductors at least 45 mils in thickness, unless Type S, SO, ST, or STO cord is used.

400-6. Marking. Flexible cords and cables shall be marked by means of a printed tag attached to the coil reel or carton. The tag shall contain the information required in Section 310-11(a).

Types SJ, SJO, SJT, SJTO, S, SO, ST, and STO flexible cords shall be durably marked on the surface at intervals not exceeding 24 inches with the type designation, size, and number of conductors.

400-7. Uses Permitted.

(a) Flexible cords and cables shall 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) connection of stationary equipment to facilitate their frequent interchange; or (7) prevention of the transmission of noise or vibration; or (8) fixed or stationary appliances where the fastening means and mechanical connections are designed to permit removal for maintenance and repair; or (9) data processing cables as permitted by Section 645-2.

(b) Where used as permitted in sub-sections (a)(3), (a)(6), and (a)(8) of this Section, each flexible cord shall be equipped with an attachment plug and shall be energized from an approved receptacle outlet.

400-8. Uses Not Permitted. Flexible cords and cables shall not be used (1) as a substitute for the fixed wiring of a structure; (2) where run through holes in walls, ceilings, or floors; (3) where run through doorways, windows, or similar openings; (4) where attached to building surfaces; or (5) where concealed behind building walls, ceilings, or floors.

Table 400-5. Ampacity of Flexible Cords and Cables

(Based on Ambient Temperature of 30°C (86°F) See Section 400-13 and Table 400-4)

Size AWG	Rubber Types TP, TS	Rubber Types C, PD, E, EO, EN, S, SO, SRD, SJ, SJO, SV, SVO, SP		Types AFS, AFSJ, HPD, HSJ, HSJO, HS, HSO, HPN	Cotton Types CFPD*
	Thermo- plastic Types TPT, TST	Thermo- plastic Types ET, ETT, ETLB, ETP, ST, STO, SRDT, SJT, SJTO, SVT, SVTO, SPT			Asbestos Types AFC* AFPD*
27**	0.5	A†	B†		
18	..	7	10	10	6
17	..		12		
16	..	10	13	15	8
15	..			17	
14	..	15	18	20	17
12	..	20	25	30	23
10	..	25	30	35	28
8	..	35	40	..	..
6	..	45	55	..	..
4	..	60	70	..	..
2	..	80	95	..	..

* These types are used almost exclusively in fixtures where they are exposed to high temperatures and ampere ratings are assigned accordingly.

** Tinsel Cord.

† The ampacities under sub-heading A apply to 3-conductor cords and other multiconductor cords connected to utilization equipment so that only 3 conductors are current carrying. The ampacities under sub-heading B apply to 2-conductor cords and other multiconductor cords connected to utilization equipment so that only 2 conductors are current carrying.

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

400-9. Splices. Flexible cord shall be used only in continuous lengths without splice or tap when initially installed in applications permitted by Section 400-7(a). The repair of hard-service flexible cords No. 12 and larger shall be permitted if conductors are spliced in accordance with Section 110-14(b) and the completed splice retains the insulation, outer sheath properties, flexibility, and usage characteristics of the cord being spliced.

400-10. Pull at Joints and Terminals. Flexible cords shall be so connected to devices and to fittings that tension will not be transmitted to joints or terminal screws. This shall be accomplished by a knot in the cord, winding with tape, by a special fitting designed for that purpose, or by other approved means which will prevent a pull on the cord from being directly transmitted to joints or terminal screws.

400-11. In Show Windows and Show Cases. Flexible cords used in show windows and show cases shall be Type S, SO, SJ, SJO, ST, STO, SJT, SJTO, or AFS.

Exception No. 1: For the wiring of chain-supported lighting fixtures.

Exception No. 2: As supply cords for portable lamps and other merchandise being displayed or exhibited.

400-12. Minimum Size. The individual conductors of a flexible cord or cable shall not be smaller than the sizes in Table 400-4.

400-13. Overcurrent Protection. Flexible cords not smaller than No. 18, and tinsel cords or cords having equivalent characteristics of smaller size approved for use with specific appliances, shall be considered as protected against overcurrent by the overcurrent devices described in Section 240-4.

B. Construction Specifications

400-20. Labels. Flexible cords shall be examined and tested at the factory and labeled before shipment.

400-21. Nominal Insulation Thickness. The nominal thickness of insulation for conductors of flexible cords and cables shall not be less than specified in Table 400-4.

400-22. Grounded-Conductor Identification. One conductor of flexible cords which is intended to be used as a grounded circuit conductor shall have a continuous marker readily distinguishing it from the other conductor or conductors. The identification shall consist of one of the methods indicated in (a) through (f) below.

(a) Colored Braid. A braid finished to show a white or natural gray color and the braid on the other conductor or conductors finished to show a readily distinguishable solid color or colors.

(b) Tracer in Braid. A tracer in a braid of any color contrasting with that of the braid and no tracer in the braid of the other conductor or conductors. No tracer shall be used in the braid of any conductor of a flexible cord which contains a conductor having a braid finished to show white or natural gray.

Exception: In the case of Types C and PD, and cords having the braids on the individual conductors finished to show white or natural gray. In such cords the identifying marker shall be permitted to consist of the solid white or natural gray finish on one conductor, provided there is a colored tracer in the braid of each other conductor.

(c) Colored Insulation. A white or natural gray insulation on one conductor and insulation of a readily distinguishable color or colors on the other conductor or conductors for cords having no braids on the individual conductors.

Exception: Cords which have insulation on the individual conductors integral with the jacket.

It shall be permissible to cover the insulation with an outer finish to provide the desired color.

(d) Colored Separator. A white or natural gray separator on one conductor and a separator of a readily distinguishable solid color on the other conductor or conductors of cords having insulation on the individual conductors integral with the jacket.

(e) Tinned Conductors. One conductor having the individual strands tinned and the other conductor or conductors having the individual strands untinned for cords having insulation on the individual conductors integral with the jacket.

For jacketed cords furnished with appliances, one conductor having the individual strands tinned and its insulation colored light blue, with the other conductors having their individual strands untinned and insulation of a readily distinguishable color other than white or natural gray.

(f) Surface Marking. One or more stripes, ridges, or grooves so located on the exterior of the cord as to identify one conductor for cords having insulation on the individual conductors integral with the jacket.

400-23. Grounding-Conductor Identification. A conductor intended to be used as a grounding conductor shall have a continuous identifying marker readily distinguishing it from the other conductor or conductors. Conductors having a continuous green color or a continuous green color with one or more yellow stripes shall not be used for other than grounding purposes. The identifying marker shall consist of one of the methods in (a) or (b) below.

(a) Colored Braid. A braid finished to show a continuous green color or a continuous green color with one or more yellow stripes.

(b) Colored Insulation or Covering. For cords having no braids on the individual conductors, an insulation of a continuous green color or a continuous green color with one or more yellow stripes.

400-24. Attachment Plugs. Where a flexible cord is provided with a grounding conductor and equipped with an attachment plug, the attachment plug shall comply with Sections 250-59(a) and (b).

C. Portable Cables Over 600 Volts, Nominal

400-30. Scope. This part applies to multiconductor portable cables used to connect mobile equipment and machinery.

400-31. Construction.

(a) Conductors. The conductors shall be No. 8 or larger and shall employ flexible stranding.

(b) Shields. Cables operated at over 2000 volts shall be shielded. Shielding shall be for the purpose of confining the voltage stresses to the insulation.

(c) Grounding Conductor(s). Grounding conductor(s) shall be provided. The total area shall be not less than that of the size of conductor required in Section 250-95.

400-32. Shielding. All shields shall be grounded.

400-33. Grounding. Grounding conductors shall be connected in accordance with Part K of Article 250.

400-34. Minimum Bending Radii. The minimum bending radii for portable cables during installation and handling in service shall be adequate to prevent damage to the cable.

400-35. Fittings. Connectors used to connect lengths of cable in a run shall be of a type which lock firmly together. Provisions shall be made to prevent opening or closing these connectors while energized. Suitable means shall be used to eliminate tension at connectors and terminations.

400-36. Splices and Terminations. Portable cables shall not be operated with splices unless the splices are of the permanent molded, vulcanized, or other approved type. Terminations on high-voltage portable cables shall be accessible only to authorized and qualified personnel.

ARTICLE 402 — FIXTURE WIRES

402-1. Scope. This Article covers general requirements and construction specifications for fixture wires.

402-2. Other Articles. Fixture wires shall comply with this Article and also with the applicable provisions of other Articles of this Code.

For application in lighting fixtures see Article 410.

402-3. Approved Types. Fixture wires shall be of a type listed in Table 402-3, and they shall comply with all requirements of that Table.

402-4. Insulation. The rubber insulations include those made from natural and synthetic rubber, neoprene, and other vulcanized materials.

Thermoplastic insulation may stiffen at temperatures colder than minus 10°C (plus 14°F), requiring care be exercised during installation at such temperatures. Thermoplastic insulation may also be deformed at normal temperatures where subjected to pressure, requiring care be exercised during installation and at points of support.

402-5. Ampacity of Fixture Wires. The ampacity of fixture wire shall not exceed the following:

Size (AWG)	Ampacity
18	6
16	8
14	17

No conductor shall be used under such conditions that its operating temperature will exceed the temperature specified in Table 402-3 for the type of insulation involved.

402-6. Minimum Size. Fixture wires shall not be smaller than No. 18.

Table 402-3. Fixture Wire

Trade Name	Type Letter	Thickness of Insulation		Outer Covering	Max. Operating Temp.	Application Provisions
		Insulation	AWG Mils			
Heat Resistant Rubber-Covered Fixture Wire Solid or 7-Strand	RFH-1	Heat-Resistant Rubber	18 15	Nonmetallic Covering	75°C 167°F	Fixture wiring. Limited to 300 volts.
	RFH-2	Heat-Resistant Rubber	18-16 30	Nonmetallic Covering	75°C 167°F	Fixture wiring, and as permitted in Section 725-16.
		Heat-Resistant Latex Rubber	18-16 18			
Heat Resistant Rubber-Covered Fixture Wire Flexible Stranding	FFH-1	Heat-Resistant Rubber	18 15	Nonmetallic Covering	75°C 167°F	Fixture wiring. Limited to 300 volts.
	FFH-2	Heat-Resistant Rubber	18-16 30	Nonmetallic Covering	75°C 167°F	Fixture wiring, and as permitted in Section 725-16.
		Heat-Resistant Latex Rubber	18-16 18			
Thermoplastic-Covered Fixture Wire—Solid or Stranded	TF	Thermoplastic	18-16 30	None	60°C 140°F	Fixture wiring, and as permitted in Section 725-16.

Table 402-3 (Continued)

Thermoplastic-Covered Fixture Wire—Flexible Stranding	TFF	Thermoplastic 18-16 30	None	60°C 140°F	Fixture wiring, and as permitted in Section 725-16.
Heat Resistant Thermoplastic-Covered Fixture Wire—Solid or Stranded	TFN	Thermoplastic 18-16 15	Nylon Jacketed	90°C 194°F	Fixture wiring, and as permitted in Section 725-16.
Heat Resistant Thermoplastic-Covered Fixture Wire—Flexible Stranded	TFFN	Thermoplastic 18-16 15	Nylon Jacketed	90°C 194°F	Fixture wiring, and as permitted in Section 725-16.
Cotton-Covered, Heat-Resistant, Fixture Wire	CF	Impregnated Cotton 18-14 30	None	90°C 194°F	Fixture wiring. Limited to 300 volts.
Asbestos-Covered, Heat-Resistant, Fixture Wire	AF	Impregnated Asbestos 18-14 30	None	150°C 302°F	Fixture wiring. Limited to 300 volts and Indoor Dry Location.

Table 402-3 (Continued)

Trade Name	Type Letter	Insulation	AWG	Thickness of Insulation Mils	Outer Covering	Max. Operating Temp.	Application Provisions
Silicone Insulated Fixture Wire Solid or 7-Strand	SF-1	Silicone Rubber	18	15	Nonmetallic Covering	200°C 392°F	Fixture wiring. Limited to 300 volts.
	SF-2	Silicone Rubber	18-14	30	Nonmetallic Covering	200°C 392°F	Fixture wiring, and as permitted in Section 725-16.
Silicone Insulated Fixture Wire Flexible Stranding	SFF-1	Silicone Rubber	18	15	Nonmetallic Covering	150°C 302°F	Fixture wiring. Limited to 300 volts.
	SFF-2	Silicone Rubber	18-14	30	Nonmetallic Covering	150°C 302°F	Fixture wiring, and as permitted in Section 725-16.
Fluorinated Ethylene Propylene Fixture Wire Solid or 7 Strand	PF	Fluorinated Ethylene Propylene	18-14	20	None	200°C 392°F	Fixture wiring, and as permitted in Section 725-16.
	PGF		18-14	14	Glass Braid		
Fluorinated Ethylene Propylene Fixture Wire Flexible Stranding	PFF	Fluorinated Ethylene Propylene	18-14	20	None	150°C 302°F	Fixture wiring, and as permitted in Section 725-16.
	PGFF		18-14	14	Glass Braid		

Table 402-3 (Continued)

Extruded Polytetra- fluoroethylene Solid or 7-Strand (Nickel or Nickel Coated Copper)	PTF	Extruded Polytetra- fluoro- ethylene	18-14 20	None	250°C 482°F	Fixture wire, and as permitted in Section 725-16. (Nickel or nickel-coated copper)
Extruded Polytetra- fluoroethylene Flexible Stranding (No. 26- 36 AWG Silver or Nickel Coated Copper)	PTFF	Extruded Polytetra- fluoro- ethylene	18-14 20	None	150°C 302°F	Fixture wire, and as permitted in Section 725-16. (Silver or nickel-coated copper)

402-7. Number of Conductors in Conduit. The number of fixture wires permitted in a single conduit shall be as given in Table 2 of Chapter 9.

402-8. Grounded-Conductor Identification. One conductor of fixture wires which is intended to be used as a grounded conductor shall be identified by means of stripes or by the means described in Sections 400-22(a) through (e).

402-9. Marking.

(a) **Required Information.** All fixture wires shall be marked to indicate the information required in Section 310-11(a).

(b) **Method of Marking.** Thermoplastic-insulated fixture wire shall be durably marked on the surface at intervals not exceeding 24 inches. All other fixture wire shall be marked by means of a printed tag attached to the coil, reel, or carton.

402-10. Uses Permitted. Fixture wires shall be permitted: (1) for installation in lighting fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use; or (2) for connecting lighting fixtures to the branch-circuit conductors supplying the fixtures.

402-11. Uses Not Permitted. Fixture wires shall not be used as branch-circuit conductors.

Exception: As permitted by Section 725-16 for Class 1 circuits.

402-12. Overcurrent Protection.

Overcurrent protection for fixture wires shall be as specified in Section 240-4.

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

A. General

410-1. Scope. This Article covers 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 which shall conform to the provisions of this Article.

Exception: As otherwise provided in this Code.

410-2. Application to Other Articles. Equipment for use in hazardous locations shall conform to Articles 500 through 517.

410-3. Live Parts. Fixtures, lampholders, lamps, rosettes, and receptacles shall have no live parts normally exposed to contact. Exposed accessible terminals in lampholders, receptacles, and switches shall not be installed in metal fixture canopies or in open bases of portable table or floor lamps.

Exception: Cleat-type lampholders, receptacles, and rosettes located at least 8 feet above the floor shall be permitted to have exposed contacts.

B. Fixture Locations

410-4. Fixtures in Specific Locations.

(a) Wet and Damp Locations. Fixtures installed in wet or damp locations shall be approved for the purpose and shall be so constructed or installed that water cannot enter or accumulate in wireways, lampholders, or other electrical parts. All fixtures installed in wet locations shall be marked, "Suitable for Wet Locations." All fixtures installed in damp locations shall be marked, "Suitable for Wet Locations" or "Suitable for Damp Locations."

Installations underground or in concrete slabs or masonry in direct contact with the earth, and locations subject to saturation with water or other liquids, such as locations exposed to weather and unprotected, vehicle washing areas, and like locations, shall be considered to be wet locations with respect to the above requirement.

Interior locations protected from weather but subject to moderate degrees of moisture, such as some basements, some barns, some cold storage warehouses and the like, the partially protected locations under canopies, marquees, roofed open porches, and the like, shall be considered to be damp locations with respect to the above requirement.

See Article 680 for lighting fixtures in swimming pools, fountains, and similar installations.

(b) Corrosive Locations. Fixtures installed in corrosive locations shall be of a type approved for such locations.

See Section 210-7 for receptacles in fixtures.

(c) In Ducts or Hoods. Fixtures in nonresidential occupancies shall not be installed in ducts or hoods used for removal of cooking smoke or grease-laden vapors or located in the path of travel of such exhaust products unless approved for the purpose.

Fixtures in nonresidential occupancies having approved metal enclosures mounted on the outer surface of the hood and separated from exhaust products by tight fitting glass shall be permitted. Fixtures on hoods in nonresidential occupancies shall not be located in concealed spaces unless part of an approved grease extractor.

410-5. Fixtures Near Combustible Material. Fixtures shall be so constructed, or installed, or equipped with shades or guards that combustible material will not be subjected to temperatures in excess of 90°C (194°F).

410-6. Fixtures Over Combustible Material. Lampholders installed over highly combustible material shall be of the unswitched type. Unless an individual switch is provided for each fixture, lampholders shall be located at least 8 feet above the floor, or shall be so located or guarded that the lamps cannot be readily removed or damaged.

410-7. Fixtures in Show Windows. Externally wired fixtures shall not be used in a show window.

Exception: Fixtures of the chain-supported type may be externally wired.

410-8. Fixtures in Clothes Closets.

(a) **Location.** A fixture in a clothes closet shall be installed:

(1) On the wall above the closet door, provided the clearance between the fixture and a storage area where combustible material may be stored within the closet is not less than 18 inches, or

(2) On the ceiling over an area which is unobstructed to the floor, maintaining an 18-inch clearance horizontally between the fixture and a storage area where combustible material may be stored within the closet.

A flush recessed fixture equipped with a solid lens shall be considered outside the closet area.

(b) **Pendants.** Pendants shall not be installed in clothes closets.

410-9. Space for Cove Lighting. Coves shall have adequate space and shall be so located that lamps and equipment can be properly installed and maintained.

C. Provisions at Fixture Outlet Boxes, Canopies, and Pans

410-10. Space for Conductors. Canopies and outlet boxes taken together shall provide adequate space so that fixture conductors and their connecting devices can be properly installed.

410-11. Temperature Limit of Conductors in Outlet Boxes. Fixtures shall be of such construction or so installed that the conductors in outlet boxes shall not be subjected to temperatures greater than that for which the conductors are approved.

Branch-circuit wiring shall not be passed through an outlet box that is an integral part of an incandescent fixture unless the fixture is approved for the purpose.

410-12. Outlet Boxes to be Covered. In a completed installation, each outlet box shall be provided with a cover unless covered by means of a fixture canopy, lampholder, receptacle, rosette, or similar device.

410-13. Covering of Combustible Material at Outlet Boxes. Any combustible wall or ceiling finish exposed between the edge of a fixture canopy or pan and an outlet box shall be covered with noncombustible material.

410-14. Connection of Electric-Discharge Lighting Fixtures. Where electric-discharge lighting fixtures are supported independently of the outlet box, they shall be connected through metal raceways, metal-clad cables, or nonmetallic-sheathed cables. It shall be permissible to suspend cord-equipped fixtures directly below the outlet box, if the cord is continuously visible for its entire length outside the fixture and is not subject to strain or physical damage. Such cord-equipped fixtures shall terminate at the outer end of the cord in a grounding-type attachment plug (cap) or busway plug.

Electric-discharge lighting fixtures provided with mogul-base screw-shell lampholders shall be permitted to be connected to branch circuits of 50 amperes or less by cords complying with Section 240-4. Receptacles and attachment plugs shall be permitted to be of lower ampere

rating than the branch circuit but not less than 125 percent of the fixture full-load current.

Fixtures shall be permitted to be connected in accordance with Section 364-11.

D. Fixture Supports

410-15. Supports — General. Fixtures, lampholders, rosettes, and receptacles shall be securely supported. A fixture that weighs more than 6 pounds or exceeds 16 inches in any dimension shall not be supported by the screw-shell of a lampholder.

410-16. Means of Support.

(a) **Outlet Boxes.** Where the outlet box or fitting will provide adequate support, a fixture shall be attached thereto or be supported as required by Section 370-13 for boxes. A fixture that weighs more than 50 pounds shall be supported independently of the outlet box.

(b) **Suspended Ceilings.** Framing members of suspended ceiling systems used to support fixtures shall be securely fastened to each other and shall be securely attached to the building structure at appropriate intervals. Fixtures so supported shall be securely fastened to the ceiling framing member.

(c) **Raceway Fittings.** Raceway fittings used to support lighting fixtures shall be approved for the purpose.

E. Grounding

410-17. General. Fixtures and lighting equipment shall be grounded as provided in Part E of this Article.

410-18. Exposed Fixture Parts.

(a) The exposed conductive parts of lighting fixtures and equipment directly wired or attached to outlets supplied by a wiring method which provides an equipment ground shall be grounded.

(b) Fixtures directly wired or attached to outlets supplied by a wiring method which does not provide a ready means for grounding shall be made of insulating material and shall have no exposed conductive parts.

Exception: Fixtures mounted on electrically nonconductive ceilings or walls where located not less than 8 feet vertically or 5 feet horizontally from grounded surfaces.

410-19. Equipment Over 150 Volts to Ground.

(a) Metal fixtures, transformers, and transformer enclosures on circuits operating at over 150 volts to ground shall be grounded.

(b) Other exposed metal parts shall be grounded or insulated from ground and other conducting surfaces and inaccessible to unqualified persons.

Exception: Lamp tie wires, mounting screws, clips, and decorative bands on glass lamps spaced not less than 1½ inches from lamp terminals shall not be required to be grounded.

410-21. Methods of Grounding. Equipment shall be considered grounded where mechanically connected in a permanent and effective manner to metal raceway, the armor of armored cable, mineral-insulated metal-sheathed cable, and aluminum-sheathed cable, copper-sheathed cable, the grounding conductor in nonmetallic-sheathed cable, or to a separate grounding conductor sized in accordance with Table 250-95, provided that the raceway, armor, or grounding conductor is grounded in a manner specified in Article 250.

F. Wiring of Fixtures

410-22. Fixture Wiring — General. Wiring on or within fixtures shall be neatly arranged and shall not be exposed to physical damage. Excess wiring shall be avoided. Conductors shall be so arranged that they shall not be subjected to temperatures above those for which they are approved.

410-23. Conductor Size. Fixture conductors shall not be smaller than No. 18.

410-24. Conductor Insulation.

(a) Fixtures shall be wired with conductors having insulation suitable for the current, voltage, and temperature to which the conductors will be subjected.

(b) Where fixtures are installed in damp, wet, or corrosive locations, conductors shall be of a type approved for the purpose.

For ampacity of fixture wire, see Table 402-5.

For maximum operating temperature and voltage limitation of fixture wires, see Section 402-3.

410-25. Conductors for Certain Conditions.

(a) **Mogul-Base Lampholders.** Fixtures provided with mogul-base screw-shell lampholders and operating at not over 300 volts between conductors shall be wired with Type AF, SF-1, SF-2, SFF-1, SFF-2, PF, PGF, PFF, PGFF, PTF, or PTFE fixture wire.

(b) **Other Than Mogul-Base Screw-Shell Lampholders.** Fixtures provided with other than mogul-base screw-shell lampholders and operating at not over 300 volts between conductors shall be wired with Type AF, SF-1, SF-2, PF, PGF, PFF, PGFF, PTF, or PTFE fixture wire or Type AFC or AFPD flexible cord.

Exception No. 1: Where temperatures do not exceed 90°C (194°F), Types CF, TFN and TFFN fixture wire or Type CFPD flexible cord shall be permitted.

Exception No. 2: Where temperatures exceed 60°C (140°F) but are not higher than 75°C (167°C), Types RH and RHW rubber-covered wire and Type RFH-1, RFH-2, FFH-1, and FFH-2 fixture wires shall be permitted.

Exception No. 3: Where temperatures do not exceed 60°C (140°F), Type T thermoplastic wire, Type TF, TFF fixture wires shall be permitted, including fixtures of decorative types on which lamps of not over 60-watt rating are used in connection with imitation candles.

See Table 402-3 and Section 402-3 for fixture wires and conductors; and Table 400-5 for flexible cords.

410-26. Conductors for Movable Parts.

(a) Stranded conductors shall be used for wiring on fixture chains and on other movable or flexible parts.

(b) Conductors shall be so arranged that the weight of the fixture or movable parts will not put a tension on the conductors.

410-27. Pendant Conductors for Incandescent Filament Lamps.

(a) Pendant lampholders with permanently attached leads, where used for other than festoon wiring, shall be hung from separate stranded rubber-covered conductors that are soldered directly to the circuit conductors but supported independently thereof.

(b) Such pendant conductors shall not be smaller than No. 14 for mogul-base or medium-base screw-shell lampholders, nor smaller than No. 18 for intermediate or candelabra-base lampholders.

Exception: Approved Christmas tree and decorative lighting outfits shall be permitted to be smaller than No. 18.

(c) Pendant conductors longer than 3 feet shall be twisted together where not cabled in an approved assembly.

410-28. Protection of Conductors and Insulation.

(a) **Properly Secured.** Conductors shall be secured in a manner that will not tend to cut or abrade the insulation.

(b) **Protection Through Metal.** Conductor insulation shall be protected from abrasion where it passes through metal.

(c) **Cord-Connected Showcases.** Individual showcases, other than fixed, shall be permitted to be connected by flexible cord to permanently installed receptacles, and groups of not more than six such showcases shall be permitted to be coupled together by flexible cord and separable locking-type connectors with one of the group connected by flexible cord to a permanently installed receptacle.

The installation shall comply with the following requirements:

(1) Flexible cord shall be hard-service type, having conductors not smaller than the branch-circuit conductors, having ampacity at least equal to the branch-circuit overcurrent device, and having an equipment grounding conductor.

See Table 250-95 for size of grounding conductor.

(2) Receptacles, connectors, and attachment plugs shall be of an approved grounding type rated 15 or 20 amperes.

(3) Flexible cords shall be secured to the undersides of showcases so that: (1) wiring will not be exposed to mechanical damage; (2) a separation between cases not in excess of 2 inches, nor more than 12 inches between the first case and the supply receptacle will be assured; and (3) the free lead at the end of a group of showcases will have a female fitting not extending beyond the case.

(4) Equipment other than showcases shall not be electrically connected to showcases.

(5) Standpipes of floor receptacles shall allow floor-cleaning equipment to be operated without damage to receptacles.

410-29. Conductor Protection at Lampholders. Where a metal lampholder is attached to a flexible cord, the inlet shall be equipped with

an insulating bushing which, if threaded, shall not be smaller than nominal $\frac{3}{8}$ -inch pipe size. The cord hole shall be of a size appropriate for the cord, and all burrs and fins shall be removed in order to provide a smooth bearing surface for the cord.

Bushings having holes $\frac{9}{32}$ inch in diameter shall be permitted for use with plain pendant cord and holes $\frac{13}{32}$ inch in diameter with reinforced cord.

410-30. Connections, Splices, and Taps.

(a) **Inspection.** Fixtures shall be so installed that the connections between the fixture conductors and the circuit conductors can be inspected without requiring the disconnection of any part of the wiring.

Exception: Fixtures connected by attachment plugs and receptacles.

(b) **Fixture Stems.** Splices and taps shall not be located within fixture arms or stems.

(c) **Splices and Taps.** No unnecessary splices or taps shall be made within or on a fixture.

For approved means of making connections, see Section 110-14.

(d) Electric discharge lighting fixtures surface mounted over concealed outlet, pull, or junction boxes shall be installed with suitable openings in back of the fixture to provide access to the boxes.

410-31. Fixtures As Raceways. Fixtures shall not be used as a raceway for circuit conductors.

Exception No. 1: Fixtures that meet the requirements for raceways.

Exception No. 2: Conductors of a two wire or multiwire branch circuit supplying the fixtures shall be permitted to be carried through:

a. Fixtures designed for end-to-end assembly to form a continuous raceway; or

b. Fixtures connected together by recognized wiring methods.

See Article 100 for definition of multiwire branch circuit.

Branch-circuit conductors within 3 inches of a ballast within the ballast compartment shall be recognized for use at temperatures not lower than 90°C (194°F), such as Types RHH, THW, THHN, FEP, FEPP, SA, XHHW and AVA.

410-32. 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. The identified grounded conductor, where connected to a screw shell lampholder, shall be connected to the screw shell.

G. Construction of Fixtures

410-34. Combustible Shades and Enclosures. Adequate air space shall be provided between lamps and shades or other enclosures of combustible material.

410-35. Fixture Rating.

(a) **Marking.** All fixtures requiring ballasts or transformers shall be plainly marked with their electrical rating and the manufacturer's name, trademark, or other suitable means of identification.

(b) Electrical Rating. The electrical rating shall include the voltage and frequency and shall indicate the current rating of the unit, including the ballast, transformer, or autotransformer.

410-36. Design and Material. Fixtures shall be constructed of metal, wood, or other approved material and shall be so designed and assembled as to secure requisite mechanical strength and rigidity. Wireways, including their entrances, shall be such that conductors may be drawn in and withdrawn without injury.

410-37. Nonmetallic Fixtures. In all fixtures not made entirely of metal or noncombustible material, wireways shall be lined with metal.

Exception: Where armored or lead-covered conductors with suitable fittings are used.

410-38. Mechanical Strength.

(a) Tubing for Arms. Tubing used for arms and stems where provided with cut threads shall not be less than 0.040 inch in thickness and where provided with rolled (pressed) threads shall not be less than 0.025 inch in thickness. Arms and other parts shall be fastened to prevent turning.

(b) Metal Canopies. Metal canopies supporting lampholders, shades, etc., exceeding 8 pounds, or incorporating attachment-plug receptacles, shall not be less than 0.020 inch in thickness. Other canopies shall not be less than 0.016 inch if made of steel and not less than 0.020 inch if of other metals.

(c) Canopy Switches. Pull-type canopy switches shall not be inserted in the rims of metal canopies that are less than 0.025 inch in thickness unless the rims are reinforced by the turning of a bead or the equivalent. Pull-type canopy switches, whether mounted in the rims or elsewhere in sheet metal canopies, shall not be located more than 3½ inches from the center of the canopy. Double set-screws, double canopy rings, a screw ring, or equal method shall be used where the canopy supports a pull-type switch or pendant receptacle.

The above thickness requirements shall apply to measurements made on finished (formed) canopies.

410-39. Wiring Space. Bodies of fixtures, including portable lamps, shall provide ample space for splices and taps and for the installation of devices, if any. Splice compartments shall be of nonabsorbent, noncombustible material.

410-40. Fixture Studs. Fixture studs that are not a part of outlet boxes, hickey, tripods, and crowfeet shall be made of steel, malleable iron, or other approved material.

410-41. Insulating Joints. Insulating joints shall be composed of materials especially approved for the purpose. Those that are not designed to be mounted with screws or bolts shall have a substantial exterior metal casing, insulated from both screw connections.

410-42. Portable Lamps. Portable table and floor lamps shall be wired with flexible cord approved for the purpose as listed in Article 400.

410-43. Portable Handlamps. Handlamps of the portable type supplied through flexible cords shall be of the molded composition or other type approved for the purpose. Metal-shell paper-lined lampholders shall not be used. Handlamps shall be equipped with a handle. Where subject to physical damage or where lamps are likely to come in contact with combustible material, handlamps shall be equipped with a substantial guard attached to the lampholder or the handle.

For garages, see Section 511-6.

410-44. Cord Bushings. A bushing or the equivalent shall be provided where flexible cord enters the base or stem of a portable lamp. The bushing shall be of insulating material unless a jacketed-type of cord is used.

410-45. Tests. All wiring shall be free from short circuits and grounds and shall be tested for these defects prior to being connected to the circuit.

410-46. Live Parts. Exposed live parts within porcelain fixtures shall be suitably recessed and so located as to make it improbable that wires will come in contact with them. There shall be a spacing of at least $\frac{1}{2}$ inch between live parts and the mounting plane of the fixture.

H. Installation of Lampholders

410-47. Screw-Shell Type. Lampholders of the screw-shell type shall be installed for use as lampholders only.

410-48. 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 in accordance with Section 210-10.

410-49. Lampholders in Wet or Damp Locations. Lampholders installed in wet or damp locations shall be of the weatherproof type.

J. Construction of Lampholders

410-50. Insulation. The outer metal shell and the cap shall be lined with insulating material which shall prevent the shell and cap from becoming a part of the circuit. The lining shall not extend beyond the metal shell more than $\frac{1}{8}$ inch, but shall prevent any current-carrying part of the lamp base from being exposed when a lamp is in the lamp-holding device.

410-51. Lead Wires. Lead wires, furnished as a part of weatherproof lampholders and intended to be exposed after installation, shall be of approved stranded, rubber-covered conductors not less than No. 14 and shall be sealed in place or otherwise made raintight.

Exception: No. 18 rubber-covered conductors shall be permitted for candelabra sockets.

410-52. Switched Lampholders. Switched lampholders shall be of such construction that the switching mechanism interrupts the electrical connection to the center contact. The switching mechanism shall also be permitted to interrupt the electrical connection to the screw-shell if the connection to the center contact is simultaneously interrupted.

K. Lamps and Auxiliary Equipment

410-53. Bases, Incandescent Lamps. An incandescent lamp for general use on lighting branch circuits shall not be equipped with a medium base if rated over 300 watts, nor with a mogul base if rated over 1500 watts. Special bases or other devices shall be used for over 1500 watts.

410-54. Enclosures for Electric-Discharge Lamp Auxiliary Equipment. Auxiliary equipment for electric-discharge lamps shall be enclosed in noncombustible cases and treated as sources of heat.

410-55. Arc Lamps. Arc lamps used in theaters shall comply with Section 520-61, and arc lamps used in projection machines shall comply with Section 540-20. Arc lamps used on constant-current systems shall comply with the general requirements of Article 710.

L. Receptacles, Cord Connectors, and Attachment Plugs (Caps)

410-56. Rating and Type.

(a) **Receptacles.** Receptacles installed for the attachment of portable cords shall be rated at not less than 15 amperes, 125 volts, or 15 amperes, 250 volts, and shall be of a type not suitable for use as lamp-holders.

Exception: The use of receptacles of 10 ampere 250 volt rating used in nonresidential occupancies for the supply of equipment other than portable hand tools, portable hand lamps, and extension cords shall be permitted.

(b) **Faceplates.** Metal faceplates shall be of ferrous metal not less than 0.030 inch in thickness or of nonferrous metal not less than 0.040 inch in thickness. Faceplates of insulating material shall be noncombustible and not less than 0.10 inch in thickness but shall be permitted to be less than 0.10 inch in thickness if formed or reinforced to provide adequate mechanical strength.

(c) **Position of Receptacle Faces.** After installation, receptacle faces shall be flush with or project from faceplates of insulating material and shall project a minimum of 0.015 inch from metal faceplates. Faceplates shall be installed so as to seat against mounting surfaces. Boxes shall be installed in accordance with Section 370-10.

(d) **Attachment Plugs.** All 15- and 20-ampere attachment plugs and connectors shall be so constructed that there are no exposed current-carrying parts except the prongs, blades, or pins. The cover for wire terminations shall be a part, which is essential for the operation of an attachment plug or connector (dead-front construction).

Exception: A separate insulating disc which is mechanically secured in place shall be permitted to be used until January 1, 1978.

(e) **Noninterchangeability.** Receptacles, cord connectors and attachment plugs shall be constructed so that the receptacle or cord connectors will not accept an attachment plug with a different voltage or current rating than that for which the device is intended. Nongrounding type receptacles and connectors shall not accept grounding type attachment plugs.

Exception No. 1: A 20-ampere T-slot receptacle or cord connector shall be permitted to accept a 15-ampere attachment plug of the same voltage rating.

410-57. Receptacles in Damp or Wet Locations.

(a) Damp Locations. A receptacle installed outdoors in a location protected from the weather or in other damp locations shall have an enclosure for the receptacle that is weatherproof when the receptacle is covered (attachment plug cap not inserted and receptacle covers closed).

An installation suitable for wet locations shall also be considered suitable for damp locations.

A receptacle shall be considered to be in a location protected from the weather where located under roofed open porches, canopies, marquees, and the like, and will not be subjected to a beating rain or water run-off.

(b) Wet Locations. A receptacle installed outdoors where exposed to weather or in other wet locations shall be in a weatherproof enclosure, the integrity of which is not affected when the receptacle is in use (attachment plug cap inserted).

Exception: An enclosure that is weatherproof only when a self-closing receptacle cover is closed shall be permitted to be used for a receptacle installed outdoors where the receptacle is not likely to be used with other than portable tools or other portable equipment not usually left connected to the outlet indefinitely.

(c) Flush Mounting with Faceplate. The enclosure for a receptacle installed in an outlet box flush-mounted on a wall surface shall be made weatherproof by means of a weatherproof faceplate assembly that provides a watertight connection between the plate and the wall surface.

(d) Installation. A receptacle outlet installed outdoors shall be located so that water accumulation is not likely to touch the outlet cover or plate.

410-58. Grounding-Type Receptacles, Adapters, Cord Connectors, and Attachment Plugs.

(a) Grounding Poles. Grounding-type receptacles, cord connectors, and attachment plugs shall be provided with one fixed grounding pole in addition to the circuit poles.

Exception: The grounding contacting pole of grounding-type attachment plugs on the power supply cords of portable hand-held, hand-guided or hand-supported tools or appliances shall be permitted to be of the movable self-restoring type on circuits operating at not over 150 volts between any two conductors nor over 150 volts between any conductor and ground.

(b) Grounding-Pole Identification. Grounding-type receptacles, adapters, cord connectors, and attachment plugs shall have a means for connection of a grounding conductor to the grounding pole. A terminal for connection to the grounding pole shall be designated by:

- (1) A green-colored hexagonal headed or shaped terminal screw

or nut, not readily removable; or

(2) A green-colored pressure wire connector body (a wire barrel); or

(3) A similar green-colored connection device in the case of adapters. The grounding terminal of a grounding adapter shall be a green-colored rigid ear, lug, or similar device. The grounding connection shall be so designed that it cannot make contact with current-carrying parts of the receptacle, adapter, or attachment plug. The adapter shall be polarized.

(4) If the terminal for the equipment grounding conductor is not visible, the conductor entrance hole shall be marked with the word "Green" or otherwise identified by a distinctive green color.

(c) **Grounding Terminal Use.** A grounding terminal or grounding-type device shall not be used for purposes other than grounding.

(d) **Grounding-Pole Requirements.** Grounding-type attachment plugs and mating cord connectors and receptacles shall be so designed that the grounding connection is made before the current-carrying connections. Grounding-type devices shall be designed so grounding poles of attachment plugs cannot be brought into contact with current-carrying parts of receptacles or cord connectors.

M. Rosettes

410-59. Unapproved Types.

(a) Fusible rosettes shall not be installed.

(b) Separable rosettes that may change polarity shall not be used.

410-60. Rosettes in Damp or Wet Locations. Rosettes installed in damp or wet locations shall be of the weatherproof type.

410-61. Rating. Rosettes shall be rated at 660 watts, 250 volts, with a maximum current rating of 6 amperes.

410-62. Rosettes for Exposed Wiring. Rosettes for exposed wiring shall be provided with bases that shall have at least two holes for supporting screws, shall be high enough to keep the wires and terminals at least $\frac{1}{2}$ inch from the surface wired over, and shall have a lug of insulating material under each terminal to prevent the rosette from being placed over projections that would reduce the separation to less than $\frac{1}{2}$ inch.

410-63. Rosettes for Use with Boxes or Raceways. Rosettes for use with conduit boxes or raceways shall have bases high enough to keep wires and terminals at least $\frac{3}{8}$ inch from the surface wired over.

N. Special Provisions for Flush and Recessed Fixtures

410-64. Approved Type. Fixtures installed in recessed cavities in walls or ceilings shall be of an approved type and shall comply with Sections 410-65 through 410-72.

410-65. Temperature.

(a) **Combustible Material.** Fixtures shall be so constructed or installed that adjacent combustible material will not be subjected to temperatures in excess of 90°C (194°F).

(b) Fire-Resistant Construction. Where a fixture is recessed in fire-resistant material in a building of fire-resistant construction, a temperature higher than 90°C (194°F), but not higher than 150°C (302°F), shall be considered acceptable if the fixture is plainly marked that it is approved for that service.

410-66. Clearance. Recessed portions of enclosures, other than at points of support, shall be spaced at least ½ inch from combustible material. Thermal insulation shall not be installed within 24 inches of the top or within 3 inches of the side of a recessed fixture enclosure, wiring compartment or ballast unless labeled for the purpose.

410-67. Wiring.

(a) General. Conductors having insulation suitable for the temperature encountered shall be used.

(b) Over 60°C. Fixtures having branch-circuit terminal connections that operate at temperatures higher than 60°C (140°F) shall comply with (1) or (2) below.

(1) Branch-circuit conductors having an insulation suitable for the temperature encountered shall be permitted to be run directly to the fixture.

(2) Tap conductors having an insulation suitable for the temperature encountered shall be run from the fixture terminal connection to an outlet box placed at least one foot from the fixture. Such a tap shall be in a suitable metal raceway which shall extend for at least 4 feet but not more than 6 feet.

P. Construction of Flush and Recessed Fixtures

410-68. Temperature. Fixtures shall be so constructed that adjacent combustible material will not be subject to temperatures in excess of 90°C (194°F).

410-69. Enclosure. Sheet metal enclosures shall be protected against corrosion and shall not be less than No. 22 MSG.

Exception: Where a wireway cover is within the No. 22 MSG enclosure, it shall be permitted to be of No. 24 MSG metal.

410-70. Lamp Wattage Marking. Incandescent lamp fixtures shall be marked to indicate the maximum allowable wattage of lamps. The markings shall be permanently installed, in letters at least ¼ inch high, and shall be located where visible during relamping.

410-71. Solder Prohibited. No solder shall be used in the construction of a fixture box.

410-72. Lampholders. Lampholders of the screw-shell type shall be of porcelain or be approved for the purpose. Where used, cements shall be of the high-heat type.

**Q. Special Provisions for Electric-Discharge Lighting
Systems of 1000 Volts or Less**

410-73. General.

(a) Equipment for use with electric-discharge lighting systems and designed for an open-circuit voltage of 1000 volts or less shall be of a type intended for such service.

(b) The terminals of an electric-discharge lamp shall be considered as alive where any lamp terminal is connected to a supply of over 300 volts.

(c) Transformers of the oil-filled type shall not be used.

(d) In addition to complying with the general requirements for lighting fixtures, such equipment shall comply with Part P of this Article.

(e) Integral ballast protection shall be provided for fluorescent fixtures installed indoors.

Exception to (e) above: Fluorescent fixtures with simple reactance ballasts.

410-74. Direct-Current Equipment. Fixtures installed on direct-current circuits shall be equipped with auxiliary equipment and resistors especially designed and for direct-current operation, and the fixtures shall be so marked.

410-75. Voltages — Dwelling Occupancies.

(a) Equipment having an open-circuit voltage exceeding 1000 volts shall not be installed in dwelling occupancies.

(b) Equipment having an open-circuit voltage exceeding 300 volts shall not be installed in dwelling occupancies unless such equipment is so designed that there will be no exposed live parts when lamps are being inserted, are in place, or are being removed.

410-76. Fixture Mounting.

(a) **Exposed Ballasts.** Fixtures having exposed ballasts or transformers shall be so installed that such ballasts or transformers will not be in contact with combustible material.

(b) **Combustible Low-Density Cellulose Fiberboard.** Where a surface-mounted fixture containing a ballast is to be installed on combustible low-density cellulose fiberboard, it shall be approved for this condition or shall be spaced not less than 1½ inches from the surface of the fiberboard. Where such fixtures are partially or wholly recessed, the provisions of Sections 410-64 through 410-72 shall apply.

Combustible low-density cellulose fiberboard includes sheets, panels, and tiles that have a density of 20 pounds per cubic foot or less, and that are formed of bonded plant fiber material; but does not include solid or laminated wood, nor fiberboard that has a density in excess of 20 pounds per cubic foot or is a material that has been integrally treated with fire-retarding chemicals to the degree that the flame spread in any plane of the material will not exceed 25 determined in accordance with tests for surface burning characteristics of building materials. See Method of Test for Surface Burning Characteristics of Building Materials, ANSI A2.5-1970.

410-77. Equipment Not Integral with Fixture.

(a) **Metal Cabinets.** Auxiliary equipment, including reactors, capacitors, resistors, and similar equipment, where not installed as part of a lighting fixture assembly, shall be enclosed in accessible, permanently installed metal cabinets.

(b) **Display Cases.** Where display cases are not permanently installed, no portion of a secondary circuit shall be permitted in more than a single case.

(c) **Separate Mounting.** Separately mounted ballasts that are intended for direct connection to a wiring system shall not be required to be separately enclosed.

410-78. Autotransformers. An autotransformer which is used to raise the voltage to more than 300 volts, as part of a ballast for supplying lighting units, shall be supplied only by a grounded system.

410-79. Switches. Snap switches shall comply with Section 380-14.

R. Special Provisions for Electric-Discharge Lighting Systems of More Than 1000 Volts

410-80. General.

(a) Equipment for use with electric-discharge lighting systems and designed for an open-circuit voltage exceeding 1000 volts shall be of a type intended for such service.

(b) The terminal of an electric-discharge lamp shall be considered as alive when any lamp terminal is connected to a supply of over 300 volts.

(c) In addition to complying with the general requirements for lighting fixtures, such equipment shall comply with Part Q of this Article.

For signs and outline lighting, see Article 600.

410-81. Control.

(a) **Disconnection.** Fixtures or lamp installations shall be controlled either singly or in groups by an externally operable switch or circuit breaker that opens all ungrounded primary conductors.

(b) **Within Sight or Locked Type.** The switch or circuit breaker shall be located within sight from the fixtures or lamps, or it shall be permitted elsewhere if it is provided with a means for locking in the open position.

410-82. Lamp Terminals and Lampholders. Parts that must be removed for lamp replacement shall be hinged or fastened by an approved means. Lamps or lampholders will be so designed that there shall be no exposed live parts when lamps are being inserted or are being removed.

410-83. Transformer Ratings. Transformers and ballasts shall have a secondary open-circuit voltage of not over 15,000 volts with an allowance on test of 1000 volts additional. The secondary-current rating shall not be more than 120 milliamperes if the open-circuit voltage is over 7500 volts, and not more than 240 milliamperes if the open-circuit voltage is 7500 volts or less.

410-84. Transformer Type. Transformers shall be of an approved enclosed type. Transformers of other than the askarel-insulated or dry-type shall not be used.

410-85. Transformer Secondary Connections.

(a) The high-voltage windings of transformers shall not be connected in series or in parallel.

Exception: Two transformers, each having one end of its high-voltage winding grounded and connected to the enclosure, shall be permitted to have their high-voltage windings connected in series to form the equivalent of a mid-point grounded transformer.

(b) The grounded ends of paralleled transformers as permitted in (a) above shall be connected by an insulated conductor not smaller than No. 14.

410-86. Transformer Locations.

(a) Transformers shall be accessible after installation.

(b) Transformers shall be installed as near to the lamps as practicable to keep the secondary conductors as short as possible.

(c) Transformers shall be so located that adjacent combustible materials will not be subjected to temperatures in excess of 90°C (194°F).

410-87. Transformer Loading. The lamps connected to any transformer shall be of such length and characteristics as not to cause a condition of continuous overvoltage on the transformer.

410-88. Wiring Method — Secondary Conductors. Approved gas-tube sign cable suitable for the voltage of the circuit shall be used. Conductors shall be installed in accordance with Section 600-31.

410-89. Lamp Supports. Lamps shall be adequately supported as required in Section 600-33.

410-90. Exposure to Damage. Lamps shall not be located where normally exposed to physical damage.

410-91. Marking. Each fixture or each secondary circuit of tubing having an open-circuit voltage of over 1000 volts shall have a clearly legible marking in letters not less than ¼-inch high reading "Caution volts." The voltage indicated shall be the rated open-circuit voltage.

410-92. Switches. Snap switches shall comply with Section 380-14.

ARTICLE 422 — APPLIANCES

A. General

422-1. Scope. This Article covers electric appliances used in any occupancy. Equipment shall be of a type approved for the purpose and location.

422-2. Live Parts. Appliances shall have no live parts normally exposed to contact.

Exception: Toasters, grills, or other appliances in which the current-carrying parts at high temperatures are necessarily exposed.

422-3. Other Articles. All requirements of this Code shall apply where applicable. Appliances for use in hazardous locations shall comply with Articles 500 through 517.

The requirements of Article 430 shall apply to the installation of motor-operated appliances and the requirements of Article 440 shall apply to the installation of appliances containing hermetic-refrigerant motor-compressor(s), except as specifically amended in this Article.

B. Branch-Circuit Requirements

422-5. Branch-Circuit Sizing. This Section specifies sizes of conductors capable of carrying appliance current without overheating under the conditions specified. This Section shall not apply to conductors that form an integral part of an appliance.

(a) **Individual Circuits.** The rating of an individual branch circuit shall not be less than the marked rating of the appliance or the marked rating of an appliance having combined loads as provided in Section 422-32.

Exception No. 1: For motor-operated appliances not having a marked rating the branch-circuit size shall be in accordance with Part B of Article 430.

Exception No. 2: For an appliance, other than a motor-operated appliance that is continuously loaded, the branch-circuit rating shall not be less than 125 percent of the marked rating; or not less than 100 percent if the branch-circuit device and its assembly is approved for continuous loading at 100 percent of its rating.

Exception No. 3: Branch circuits for household cooking appliances shall be permitted to be in accordance with Table 220-19.

(b) **Circuits Supplying Two or More Loads.** For branch circuits supplying appliance and other loads, the rating shall be determined in accordance with Section 210-23.

422-6. Branch-Circuit Overcurrent Protection. Branch circuits shall be protected in accordance with Section 240-3.

If a protective device rating is marked on an appliance, the branch-circuit overcurrent device rating shall not exceed the protective device rating marked on the appliance.

C. Installation of Appliances

422-7. General. All appliances shall be installed in an approved manner.

422-8. Flexible Cords.

(a) **Heater Cords.** All smoothing irons and portable electrically heated appliances that are rated at more than 50 watts and produce temperatures in excess of 121°C (250°F) on surfaces with which the cord is likely to be in contact shall be provided with one of the types of approved heater cords listed in Table 400-4.

(b) **Other Heating Appliances.** All other portable electrically heated appliances shall be connected with one of the approved types of cord listed in Table 400-4, selected in accordance with the usage specified in that Table.

(c) **Other Appliances.** Flexible cord shall be permitted (1) for connection of portable appliances; (2) for connection of stationary appliances to facilitate their frequent interchange or to prevent the transmission of noise or vibration; or (3) to facilitate the removal or disconnection of fixed appliances for maintenance or repair.

422-9. Portable Immersion Heaters. Electric heaters of the portable immersion type shall be so constructed and installed that current-carry-

ing parts are effectively insulated from electrical contact with the substance in which they are immersed. The authority having jurisdiction may make exceptions for special applications of apparatus if suitable precautions are taken.

422-10. Protection of Combustible Material. Each electrically heated appliance that is intended by size, weight, and service to be located in a fixed position shall be so placed as to provide ample protection between the appliance and adjacent combustible material.

422-11. Stands for Portable Appliances. Each smoothing iron and other portable electrically heated appliance intended to be applied to combustible material shall be equipped with an approved stand, which shall be permitted to be a separate piece of equipment or a part of the appliance.

422-12. Signals for Heated Appliances. In other than dwelling-type occupancies, each electrically heated appliance or group of appliances intended to be applied to combustible material shall be provided with a signal.

Exception: If an appliance is provided with an integral temperature-limiting device.

422-13. Flatirons. Electrically heated smoothing irons intended for use in residences shall be equipped with approved temperature-limiting means.

422-14. Water Heaters.

(a) Storage and Instantaneous Type Water Heaters: Each storage- or instantaneous-type water heater shall be equipped with a temperature-limiting means in addition to its control thermostat to disconnect all ungrounded conductors, and such means shall be: (1) installed to sense maximum water temperature; (2) either a trip-free, manually reset type or a type having a replacement element. Such water heaters shall be marked to require the installation of a temperature and pressure relief valve.

See Listing Requirements for Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems. (ANSI Z 21.22-1972.)

Exception: Water heaters with supply water temperature of 180°F or above and capacity of 60 kW or above, and water heaters with a capacity of one gallon or less, approved for the purpose.

(b) Storage Type Water Heaters. All fixed storage water heaters having a capacity of 120 gallons or less shall be considered a continuous duty load.

Exception: The assembly including the overcurrent device protecting the branch circuit that is approved for continuous operation at 100 percent of its rating shall be permitted to supply its full rated load as provided in Section 210-22(c), Exception No. 3.

422-15. Infrared Lamp Industrial Heating Appliances.

(a) Infrared heating lamps rated at 300 watts or less shall be permitted with lampholders of the medium-base, unswitched porcelain type or other types approved for the purpose.

(b) Screw-shell lampholders shall not be used with infrared lamps over 300 watts rating.

Exception: Lampholders approved for the purpose.

(c) Lampholders shall be permitted to be connected to any of the branch circuits of Article 210 and, in industrial occupancies, shall be permitted to be operated in series on circuits of over 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 infrared lampholders (including the internal wiring of such section, panel, or strip) shall be considered an appliance. The terminal connection block of each such assembly shall be considered an individual outlet.

422-16. Grounding. Metal frames of portable, stationary, and fixed electrically heated appliances, operating on circuits over 150 volts to ground, shall be grounded in the manner specified in Article 250.

Exception: Where this is impracticable, grounding may be omitted by special permission, in which case the frames shall be permanently and effectively insulated from the ground.

Refrigerators and freezers shall comply with the requirements of Sections 250-42, 250-43, and 250-45. Electric ranges, wall-mounted ovens, counter-mounted cooking units and clothes dryers shall comply with the requirements of Sections 250-57 and 250-60.

422-17. Wall-Mounted Ovens and Counter-Mounted Cooking Units.

(a) Wall-mounted ovens and counter-mounted cooking units complete with provisions for mounting and for making electrical connections shall be considered as fixed appliances.

(b) A separable connector or a plug and receptacle combination in the supply line to an oven or cooking unit used only for ease in servicing or for installation shall:

(1) Not be installed as the disconnecting means required by Section 422-20;

(2) Be approved for the temperature of the space in which it is located.

422-18. Other Installation Methods. Appliances employing methods of installation other than covered by this Article may be used only by special permission.

D. Control and Protection of Appliances

422-20. Disconnecting Means. A means shall be provided to disconnect each appliance from all ungrounded conductors as required by the following Sections of Part D. If an appliance is supplied by more than one source, the disconnecting means shall be grouped and identified.

422-21. Disconnection of Fixed Appliances.

(a) For fixed appliances rated at not over 300 volt amperes or $\frac{1}{8}$ hp, the branch-circuit overcurrent device shall be permitted to serve as the disconnecting means.

(b) For fixed appliances of greater rating the branch-circuit switch or circuit breaker may, where readily accessible to the user of the appliance, serve as the disconnecting means.

422-22. Disconnection of Portable Appliances.

(a) For portable appliances, a separable connector or an attachment plug and receptacle shall be permitted to serve as the disconnecting means.

(b) The rating of a receptacle or of a separable connector shall not be less than the rating of any appliance connected thereto.

Exception: Demand factors authorized elsewhere in this Code shall be permitted to be applied.

(c) Attachment plugs and connectors shall conform to the following:

(1) **Live Parts.** They shall be so constructed and installed as to guard against inadvertent contact with live parts.

(2) **Interrupting Capacity.** They shall be capable of interrupting their rated current without hazard to the operator.

(3) **Interchangeability.** They shall be so designed that they will not fit into receptacles of lesser rating.

422-23. Disconnection of Stationary Appliances.

(a) For stationary appliances rated at not over 300 volt amperes or $\frac{1}{8}$ horsepower, the branch-circuit overcurrent device shall be permitted to serve as the disconnecting means.

(b) For stationary appliances of greater rating, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means where readily accessible to the user of the appliance.

(c) For cord-connected appliances, such as free-standing household-type ranges and clothes dryers, a separable connector or an attachment plug and receptacle shall be permitted to serve as the disconnecting means. Attachment plugs and connectors shall comply with Section 422-22(c).

For household electric ranges, an attachment plug and receptacle connection at the rear base of a range, if it is accessible from the front by removal of a drawer, shall be considered as meeting the intent of this rule.

422-24. Unit Switches As Disconnecting Means. Unit switches that are a part of an appliance shall require additional means for disconnection as specified in (a), (b), (c), or (d) below to be acceptable as the disconnecting means required by Part D.

(a) **Multifamily Dwellings.** In multifamily (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 shall be permitted to control lamps and other appliances.

(b) **Two-Family Dwellings.** In two-family dwellings, the disconnecting means shall be permitted to be outside the apartment in which the appliance is installed. In this case an individual switch for the apartment shall be permitted.

(c) **Single-Family Dwellings.** In single-family dwellings, the service disconnecting means shall be permitted to be used.

(d) **Other Occupancies.** In other occupancies, the branch-circuit switch or circuit breaker, where readily accessible to the user of the appliance, shall be permitted for this purpose.

422-25. Switch and Circuit Breaker to Be Indicating. Switches and circuit breakers used as disconnecting means shall be of the indicating type.

422-26. Disconnecting Means for Motor-Driven Appliances. If a switch or circuit breaker serves as the disconnecting means for a stationary or fixed motor-driven appliance of more than $\frac{1}{8}$ horsepower, it shall be located within sight from the motor controller and shall comply with Part H of Article 430.

422-27. Overcurrent Protection.

(a) Appliances shall be considered as protected against overcurrent if supplied by branch circuits as specified in (e) below and in Sections 422-5 and 422-6.

Exception: Motors of motor-operated appliances shall be provided with overload protection in accordance with Part C of Article 430. Hermetic refrigerant motor-compressors in air conditioning or refrigerating equipment shall be provided with overload protection in accordance with Part F of Article 440. When appliance overcurrent protective devices separate from the appliance are required, data for selection of these devices shall be marked on the appliance. The minimum marking shall be that specified in Sections 430-7 and 440-3.

(b) A household-type appliance with surface heating elements having a maximum demand of more than 60 amperes computed in accordance with Table 220-19 shall have its power supply subdivided into two or more circuits, each of which is provided with overcurrent protection rated at not over 50 amperes.

(c) Infrared lamp commercial and heating appliances shall have overcurrent protection not exceeding 50 amperes.

(d) Open-coil or exposed sheathed-coil types of surface heating elements in commercial-type heating appliances shall be protected by overcurrent protective devices rated at not over 50 amperes.

(e) If the branch circuit supplies a single nonmotor-operated appliance, rated at 10 amperes or more, the overcurrent device rating shall not exceed 150 percent of the appliance rating.

(f) Electric heating appliances employing resistance type heating elements rated more than 48 amperes shall have the heating elements subdivided. Each subdivided load shall not exceed 48 amperes and shall be protected at not more than 60 amperes.

These overcurrent protective devices shall be: (1) factory installed within or on the heater enclosure or provided as a separate assembly by the heater manufacturer; and (2) accessible, but need not be readily accessible; and (3) suitable for branch-circuit protection.

The main conductors supplying these overcurrent protective devices shall be considered branch circuit conductors.

Exception: Household type appliances with surface heating elements as covered in Section 422-27(b) and commercial type heating appliances as covered in Section 422-27(d).

E. Marking of Appliances**422-30. Nameplate.**

(a) Each electric appliance shall be provided with a nameplate, giving the identifying name and the rating in volts and amperes, or in volts and watts. If the appliance is to be used on a specific frequency or frequencies, it shall be so marked.

When motor overload protection external to the appliance is required, the appliance shall be so marked.

See Section 422-27(a) Exception for overcurrent protection requirements.

(b) Marking shall be located so as to be visible or easily accessible after installation.

422-31. Marking of Heating Elements. All heating elements that are rated over one ampere, replaceable in the field, and a part of an appliance shall be legibly marked with the ratings in volts and amperes, or in volts and watts, or with the manufacturer's part number.

422-32. Appliances Consisting of Motors and Other Loads. Appliances shall be marked in accordance with (a) or (b) below.

(a) In addition to the marking required in Section 422-30, the marking on an appliance consisting of a motor with other load(s) or motors with or without other load(s) shall specify the minimum circuit size and the maximum rating of the circuit overcurrent protective device.

Exception No. 1: Portable appliances and other appliances, factory-equipped with cords and attachment plugs, complying with Section 422-30.

Exception No. 2: An appliance where both the minimum circuit size and maximum rating of the circuit overcurrent protective device are not more than 15 amperes and complies with Section 422-30.

(b) An alternate marking method shall be permitted to specify the rating of the largest motor in volts and amperes, and the additional load(s) in volts and amperes, or volts and watts in addition to the marking required in Section 422-30.

Exception No. 1: Portable appliances and other appliances, factory-equipped with cords and attachment plugs, complying with Section 422-30.

Exception No. 2: The ampere rating of a motor $\frac{1}{8}$ hp or less or a nonmotor load one ampere or less shall be permitted to be omitted unless such loads constitute the principal load.

ARTICLE 424 — FIXED ELECTRIC SPACE HEATING EQUIPMENT

A. General

424-1. Scope. This Article covers fixed electric equipment used for space heating. Equipment shall be of a type approved for the purpose and location where installed. For the purpose of this Article, heating equipment shall include heating cable, unit heaters, boilers, central systems, or other approved fixed electric space heating equipment. This Article shall not apply to process heating and room air conditioning.

424-2. Other Articles. All requirements of this Code shall apply where applicable. Fixed electric space heating equipment for use in hazardous locations shall comply with Articles 500 through 517. Fixed electric space heating equipment incorporating a hermetic-refrigerant motor-compressor shall also comply with Article 440.

424-3. Branch Circuits.

(a) **Branch-Circuit Requirements.** Individual branch circuits shall be permitted to supply any size fixed electric space heating equipment.

Branch circuits supplying two or more outlets for fixed electric space heating equipment shall be rated 15, 20, or 30 amperes.

Exception: In other than residential occupancies, fixed infrared heating equipment shall be permitted to be supplied from branch circuits rated not more than 50 amperes.

(b) **Branch-Circuit Sizing.** The size of branch-circuit conductors and overcurrent protective devices supplying fixed electric space heating equipment consisting of resistance elements with or without a motor shall be computed on the basis of 125 percent of the total load of the motors and the heaters. A contactor, thermostat, relay, or similar device, approved for continuous operation at 100 percent of its rating, shall be permitted to supply its full rated load as provided in Section 210-22(c), Exception No. 3.

The size of the branch-circuit conductors and overcurrent protective devices supplying fixed electric space heating equipment consisting of mechanical refrigeration with or without resistance units shall be computed in accordance with Sections 440-34 and 440-35.

The provisions of this Section shall not apply to conductors which form an integral part of approved fixed electric space heating equipment.

B. Installation

424-9. General. All fixed electric space heating equipment shall be installed in an approved manner.

424-10. Special Permission. Fixed electric space heating equipment and systems installed by methods other than covered by this Article may be used only by special permission.

424-11. Supply Conductors. Fixed electric space heating equipment requiring supply conductors with over 60°C insulation shall be clearly and permanently marked. This marking shall be plainly visible after

installation and shall be permitted to be adjacent to the field-connection box.

424-12. Locations.

(a) Fixed electric space heating equipment shall not be used where exposed to severe physical damage unless adequately protected.

(b) Heaters and related equipment installed in damp or wet locations shall be approved for such locations and shall be constructed and installed so that water cannot enter or accumulate in or on wired sections, electrical components, or duct work.

See Section 110-11 for equipment exposed to deteriorating agencies.

424-13. Spacing from Combustible Materials. Fixed electric space heating equipment shall be installed to provide the required spacing between the equipment and adjacent combustible material, unless it has been found to be acceptable where installed in direct contact with combustible material.

424-14. Grounding. All exposed metal parts of fixed electric space heating equipment likely to become energized shall be grounded as required in Article 250.

C. Control and Protection of Fixed Electric Space Heating Equipment

424-19. Disconnecting Means. Means shall be provided to disconnect the heater, controller(s), and overcurrent protective device(s) of all fixed electric space heating equipment from all ungrounded conductors. Where heating equipment is supplied by more than one source, the disconnecting means shall be grouped and identified.

(a) **In Sight.** The disconnecting means for fixed electric space heating equipment covered under Section 424-22(c) shall be in sight of the supplementary overcurrent protective device(s). This disconnecting means shall be permitted to serve as the required disconnecting means for the controller(s) and heater under the following conditions:

(1) The disconnecting means provided is also in sight from the controller(s) and the heater, or

(2) The disconnecting means provided shall be capable of being locked in the open position.

Exception: Where a motor(s) is part of the fixed electric space heating and the motor(s) is not within sight of its controller(s), a disconnecting means for the motor(s) in accordance with Section 430-86 shall be permitted.

(b) **Not Over 300 VA or 1/8 HP.** For fixed electric space heating equipment rated at not over 300 volt-amperes or 1/8 horsepower, the branch-circuit overcurrent device shall be permitted to serve as the disconnecting means.

(c) **Over 300 VA or 1/8 HP.** For fixed electric space heating equipment rated over 300 volt-amperes or 1/8 horsepower, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means, where readily accessible to the user of the equipment.

(d) **Motor-Driven Heating Equipment.** A switch or circuit breaker that serves as the disconnecting means for a motor-driven heater having

a motor more than $\frac{1}{8}$ horsepower shall be located within sight of the motor controller.

(e) **Unit Switches as Disconnecting Means.** Unit switches with a marked off position that are part of a fixed heater and disconnect all ungrounded conductors shall be permitted as the disconnecting means required by this Article where other means for disconnection are provided in the following types of occupancies:

(1) **Multifamily Dwellings.** In multifamily (more than two) dwellings, the other disconnecting means shall be within the apartment, or on the same floor as the apartment in which the fixed heater is installed, and shall also be permitted to control lamps and appliances.

(2) **Two-Family Dwellings.** In two-family dwellings, the other disconnecting means shall be permitted either inside or outside of the apartment in which the fixed heater is installed.

(3) **Single-Family Dwellings.** In single-family dwellings, the service disconnecting means shall be permitted to be the other disconnecting means.

(4) **Other Occupancies.** In other occupancies, the branch-circuit switch or circuit breaker, where readily accessible to the user of the fixed heater, shall be permitted as the other disconnecting means.

424-20. Controllers and Disconnecting Means.

(a) Thermostats and thermostatically controlled switching devices that indicate an off position and interrupt line current shall open all ungrounded conductors when the control device is in this off position.

(b) Thermostats and thermostatically controlled switching devices that do not have an off position shall not be required to open all ungrounded conductors.

(c) Remote-control thermostats shall not be required to meet the requirements of (a) and (b) above. These devices shall not be considered as the disconnecting means.

(d) Switching devices consisting of combined thermostats and manually controlled switches that serve both as controllers and disconnecting means shall:

(1) Open all ungrounded conductors when manually placed in the off position.

(2) Be so designed that the circuit cannot be energized automatically after the device has been manually placed in the off position.

424-21. Switch and Circuit Breaker to Be Indicating. Switches and circuit breakers used as disconnecting means shall be of the indicating type.

424-22. Overcurrent Protection.

(a) **Branch-Circuit Devices.** Electric space heating equipment, other than such motor-operated equipment as required by Articles 430 and 440 to have additional overcurrent protection, shall be considered as protected against overcurrent where supplied by one of the branch circuits in Article 210.

(b) **Resistance Elements.** Electric space heating equipment employing resistance-type heating elements rated more than 48 amperes shall have the heating elements subdivided. Each subdivided load shall not exceed 48 amperes and shall be protected at not more than 60 amperes.

Exception No. 1: Water heating boilers, steam boilers, and heat transfer fluid heating boilers employing resistance-type immersion electric heating elements contained in an ASME rated and stamped vessel shall be permitted to be subdivided into circuits not exceeding 120 amperes and protected at not more than 150 amperes.

Exception No. 2: As provided in Section 424-72(a).

(c) Overcurrent Protective Devices. The overcurrent protective devices specified in (b) above shall be: (1) factory-installed within or on the heater enclosure or provided as a separate assembly by the heater manufacturer; (2) accessible, but shall not be required to be readily accessible; and (3) suitable for branch-circuit protection.

Where cartridge fuses are used to provide this overcurrent protection, a single disconnecting means shall be permitted to be used for the several subdivided loads.

See Section 240-40.

(d) Branch-Circuit Conductors. The conductors supplying the supplementary overcurrent protective devices shall be considered branch-circuit conductors.

Exception: For heaters rated 50 kW or more, the conductors supplying the supplementary overcurrent protective devices specified in (c) above shall be permitted to be sized at not less than 100 percent of the nameplate rating of the heater provided all of the following conditions are met:

- 1. The heater is marked with a minimum conductor size, and*
- 2. The conductors are not smaller than the marked minimum size, and*
- 3. A temperature actuated device controls the cyclic operation of the equipment.*

D. Marking of Heating Equipment

424-28. Nameplate.

(a) Marking Required. Each unit of fixed electric space heating equipment shall be provided with a nameplate giving the identifying name and the normal rating in volts and amperes, or in volts and watts.

Electric space heating equipment intended for use on alternating current only or direct current only shall be marked to so indicate. The marking of equipment consisting of motors over $\frac{1}{8}$ horsepower and other loads shall specify the rating of the motor in volts, amperes, and frequency, and the heating load in volts and watts, or volts and amperes.

(b) Location. This nameplate shall be located so as to be visible or easily accessible after installation.

424-29. Marking of Heating Elements. All heating elements that are replaceable in the field and are a part of an electric heater shall be legibly marked with the ratings in volts and amperes, or in volts and watts.

E. Electric Space Heating Cables and Panels

424-34. Heating Cable Construction. Heating cable shall be furnished complete with factory-assembled nonheating leads at least 7 feet in length.

424-35. Marking of Heating Cables and Panels. Each unit shall be marked with the identifying name or identification symbol, catalog number, ratings in volts and watts, or volts and amperes.

(a) **Heating Cables.** Each unit length of heating cable shall have a permanent legible marking on each nonheating lead located within 3 inches of the terminal end. The lead wire shall have the following color identification: 120-volt nominal, yellow; 208-volt nominal, blue; 240-volt nominal, red; and 277-volt nominal, brown.

(b) **Heating Panels.** Heating panels shall be permanently marked in a location that is readily visible prior to application of panel finish.

424-36. Clearances of Wiring in Ceilings. Wiring located above heated ceilings shall be spaced not less than 2 inches above the heated ceiling and shall be considered as operating at an ambient of 50°C. The ampacity of conductors shall be computed on the basis of the correction factors given in Note 13 to Tables 310-16 through 310-19.

Exception: Wiring above heated ceilings and located above thermal insulation having a minimum thickness of 2 inches shall not require correction for temperature.

424-37. Clearances of Branch-Circuit Wiring in Walls.

(a) **Exterior Walls.** Where located in exterior walls, wiring shall be located outside the thermal insulation.

(b) **Interior Walls.** Where located in interior walls or partitions, wiring shall be considered as operating at an ambient of 40°C (104°F); and the ampacity of conductors shall be computed on the basis of the correction factors given in Note 13 to Tables 310-16 through 310-19.

424-38. Area Restrictions.

(a) Heating cables and panels shall not extend beyond the room or area in which they originate.

(b) Cables and panels shall not be installed in closets, over walls or partitions that extend to the ceiling, or over cabinets whose clearance from the ceiling is less than the minimum horizontal dimension of the cabinet to the nearest cabinet edge that is open to the room or area.

Exception: Isolated single runs of cable shall be permitted to pass over partitions where they are embedded.

(c) This provision shall not prevent the use of cable or panels in closet ceilings as low temperature heat sources to control relative humidity, provided they are used only in those portions of the ceiling that are unobstructed to the floor by shelves or other permanent fixtures.

424-39. Clearance from Other Objects and Openings. Panels and cables shall be separated at least 8 inches from the edge of outlet boxes and junction boxes that are to be used for mounting surface lighting fixtures. A clearance of not less than two inches shall be provided from recessed fixtures and their trims, ventilating openings, and other such openings in room surfaces. Sufficient area shall be provided to assure that no heating cable or panel will be covered by any surface mounted lighting units.

424-40. Splices. Embedded cables shall be spliced only where necessary and only by approved means, and in no case shall the length of the heating cable be altered.

424-41. Installation of Heating Cables on Dry Board, in Plaster and on Concrete Ceilings.

(a) Cables shall not be installed in walls.

Exception: Isolated single runs of cable shall be permitted to run down a vertical surface to reach a dropped ceiling.

(b) Adjacent runs of cable not exceeding $2\frac{3}{4}$ watts per foot shall be installed not less than $1\frac{1}{2}$ inches on centers.

(c) Heating cables shall be applied only to gypsum board, plaster lath or other fire-resistant material. With metal lath or other electrically conductive surfaces, a coat of plaster shall be applied to completely separate the metal lath or conductive surface from the cable.

See also (f) below.

(d) All heating cables, the splice between the heating cable and non-heating leads, and 3-inch minimum of the nonheating lead at the splice shall be embedded in plaster or dry board in the same manner as the heating cable.

(e) The entire ceiling surface shall have a finish of thermally non-insulating sand plaster having a nominal thickness of $\frac{1}{2}$ inch, or other noninsulating material approved for the purpose and applied according to specified thickness and directions.

(f) Cables shall be secured at intervals not exceeding 16 inches by means of approved stapling, tape, plaster, nonmetallic spreaders, or other approved means. Staples or metal fasteners that straddle the cable shall not be used with metal lath or other electrically conductive surfaces.

Exception: Cables approved for the purpose shall be permitted to be secured at intervals not to exceed six feet by approved means.

(g) In dry board installations, the entire ceiling below the heating cable shall be covered with gypsum board not exceeding $\frac{1}{2}$ -inch thickness. The void between the upper layer of gypsum board, plaster lath, or other fire-resistant material and the surface layer of gypsum board shall be completely filled with thermally conductive nonshrinking plaster or other approved material of equivalent thermal conductivity.

(h) Cables shall be kept free from contact with metal or other electrical conductive surfaces.

(i) In dry-board applications, cable shall be installed parallel to the joist, leaving a clear space centered under the joist of $2\frac{1}{2}$ inches (width) between centers of adjacent runs of cable. Crossing of joist by cable shall be kept to a minimum. Surface layer of gypsum board shall be mounted so that the nails or other fasteners do not pierce the heating cable.

Where impracticable, cables shall cross joists only at the ends of a room.

424-42. Finished Ceilings. Finished ceilings shall not be covered with decorative panels or beams constructed of materials which have thermal insulating properties, such as wood, fiber, or plastic. Finished ceilings shall be permitted to be covered with paint, wallpaper, or other approved surface finishes.

424-43. Installation of Nonheating Leads of Cables and Panels.

(a) Free nonheating leads of cables and panels shall be installed in

accordance with approved wiring methods from the junction box to a location within the ceiling. Such installations shall be permitted to be single conductors in approved raceways, single or multiconductor Type UF, Type NMC, Type MI, or other approved conductors.

(b) Not less than 6 inches of free nonheating lead shall be within the junction box. The marking of the leads shall be visible in the junction box.

(c) Excess leads shall not be cut but shall be secured to the underside of the ceiling and embedded in plaster or other approved material, leaving only a length sufficient to reach the junction box with not less than 6 inches of free lead within the box.

424-44. Installation of Panels or Cables in Concrete or Poured Masonry Floors.

(a) Panels or heating units shall not exceed 33 watts per square foot of heated area or 16½ watts per linear foot of cable.

(b) The spacing between adjacent runs of cable shall not be less than one inch on centers.

(c) Cables shall be secured in place by nonmetallic frames or spreaders or other approved means while the concrete or other finish is applied.

Cables, units, and panels shall not be installed where they bridge expansion joints unless protected from expansion and contraction.

(d) Spacings shall be maintained between the heating cable and metal embedded in the floor.

Exception: Grounded metal-clad cable shall be permitted to be in contact with metal embedded in the floor.

(e) Leads shall be protected where they leave the floor by rigid metal conduit, electrical metallic tubing, or by other approved means.

(f) Bushings or approved fittings shall be used where the leads emerge within the floor slab.

424-45. Inspection and Tests. 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.

424-46. Panels — General. Sections 424-46 through 424-48 cover only heating panels of less than 25 watts per square foot assembled together in the field to form a heating installation in one room or area using approved methods of interconnection. Such an installation shall be connected by a recognized wiring method.

424-47. Panels to Be Complete Units. Panels shall be installed as complete units unless approved for field cutting in a recognized manner.

424-48. Installation. Panels shall be installed in an approved manner. Nails, staples, or other electrically conductive fasteners shall not be used where they penetrate current-carrying parts.

Exception: Insulated fasteners shall be permitted with systems for which they are recognized.

F. Duct Heaters

424-57. General. Part F shall apply to any heater mounted in the air stream of a forced-air system where the air moving unit is not provided as an integral part of the equipment.

424-58. Approved. Heaters installed in an air duct shall be approved for the purpose and installed in the approved manner.

424-59. Air Flow. Means shall be provided to assure uniform and adequate air flow over the face of the heater.

Heaters installed within 4 feet of a fan outlet, elbows, baffle plates, or other obstruction in duct work may require turning vanes, pressure plates, or other devices on the inlet side of the duct heater to assure an even distribution of air over the face of the heater.

424-60. Elevated Inlet Temperature. Duct heaters intended for use with elevated inlet air temperature (such as heat pumps) shall be approved for the purpose and so marked.

424-61. Installation of Duct Heaters with Heat Pumps and Air Conditioners. Heat pumps and air conditioners having duct heaters closer than 4 feet to the heat pump or air conditioner shall have both the duct heater and heat pump or air conditioner approved for such installation and so marked.

424-62. Condensation. Duct heaters used with air conditioners or other air-cooling equipment that may result in condensation of moisture shall be approved for use with air conditioners.

424-63. Fan Circuit Interlock. Means shall be provided to insure that the fan circuit is energized when the first heater circuit is energized. However, time or temperature controlled delay in energizing the fan motor shall be permitted.

424-64. Limit Controls. Each duct heater shall be provided with an approved, integral, automatic-reset temperature-limiting control or controllers to de-energize the circuit or circuits.

In addition, an integral independent supplementary control or controllers shall be provided in each duct heater that will disconnect a sufficient number of conductors to interrupt current flow. This device shall be manually resettable or replaceable.

424-65. Location of Disconnecting Means. Duct heater controller equipment shall be accessible with the disconnecting means installed at or within sight from the controller.

424-66. Installation. Duct heaters shall be installed in accordance with the manufacturer's instructions in a manner so that operation will not create a hazard to persons or property. Furthermore, duct heaters shall be located with respect to building construction and other equipment so as to permit access to the heater. Sufficient clearance shall be maintained to permit replacement of controls and heating elements and for adjusting and cleaning of controls and other parts requiring such attention. See Section 110-16.

For additional installation information, see Air Conditioning and Ventilating Systems (NFPA No. 90A-1973) and Warm Air Heating and Air Conditioning Systems (NFPA No. 90B-1973).

G. Resistance-Type Boilers

424-70. Scope. The provisions in Part G of this article shall apply to boilers employing resistance-type heating elements. Electrode-type

boilers shall not be considered as employing resistance-type heating elements. See Part H of this Article.

424-71. Approved. Resistance-type boilers shall be approved for the purpose and installed in the approved manner.

424-72. Overcurrent Protection.

(a) A boiler employing resistance-type immersion heating elements contained in an ASME rated and stamped vessel shall have the heating elements subdivided into loads not exceeding 120 amperes and protected at not more than 150 amperes.

(b) A boiler employing resistance-type heating elements rated more than 48 amperes and not contained in an ASME rated and stamped vessel, shall have the heating elements subdivided into loads not exceeding 48 amperes and protected at not more than 60 amperes.

(c) The supplementary overcurrent protective devices as required by Section 424-72(a) and Section 424-72(b) shall be: (1) factory-installed within or on the boiler enclosure or provided as a separate assembly by the boiler manufacturer, and (2) accessible, but need not be readily accessible, and (3) suitable for branch-circuit protection.

Where cartridge fuses are used to provide this overcurrent protection, a single disconnecting means shall be permitted for the several subdivided circuits. See Section 240-40.

(d) The conductors supplying these supplementary overcurrent protective devices shall be considered branch-circuit conductors.

Exception: The heaters rated 50 kW or more, the conductors supplying the overcurrent protective device specified in (c) above, shall be permitted to be sized at not less than 100 percent of the nameplate rating of the heater provided all of the following conditions are met:

1. *The heater is marked with a minimum conductor size, and*
2. *The conductors are not smaller than the marked minimum size, and*
3. *A temperature or pressure actuated device controls the cyclic operation of the equipment.*

424-73. Over-Temperature Limit Control. Each boiler designed so that in normal operation there is no change in state of the heat transfer medium shall be equipped with a temperature sensitive limiting means. It shall be installed to limit maximum liquid temperature and shall directly or indirectly disconnect all ungrounded conductors to the heating elements. Such means shall be in addition to a temperature regulating system and other devices protecting the tank against excessive pressure.

424-74. Over-Pressure Limit Control. Each boiler designed so that in normal operation there is a change in state of the heat transfer medium from liquid to vapor shall be equipped with a pressure sensitive limiting means. It shall be installed to limit maximum pressure and shall directly or indirectly disconnect all ungrounded conductors to the heating elements. Such means shall be in addition to a pressure regulating system and other devices protecting the tank against excessive pressure.

424-75. Grounding. All non-current carrying metal parts shall be grounded in accordance with Article 250. Means for connection of equipment grounding conductor(s) sized in accordance with Table 250-95 shall be provided.

H. Electrode-Type Boilers

424-80. Scope. The provisions in Part H of this article shall apply to boilers in which heat is generated by the passage of current between electrodes through the liquid being heated.

424-81. Approved. Electrode-type boilers shall be approved for the purpose and installed in the approved manner.

424-82. Branch-Circuit Requirements. The size of branch-circuit conductors and overcurrent protective devices shall be calculated on the basis of 125 percent of the total load (motors not included). A contactor, relay or other device, approved for continuous operation at 100 percent of its rating, shall be permitted to supply its full rated load. See Section 210-22(c) Exception No. 3. The provisions of this Section shall not apply to conductors that form an integral part of an approved boiler.

Exception: For an electrode boiler rated 50 kW or more, the conductors supplying the boiler electrode(s) shall be permitted to be sized at not less than 100 percent of the nameplate rating of the electrode boiler provided all the following conditions are met:

- 1. The electrode boiler is marked with a minimum conductor size; and,*
- 2. The conductors are not smaller than the marked minimum size; and,*
- 3. A temperature or pressure actuated device controls the cyclic operation of the equipment.*

424-83. Over-Temperature Limit Control. Each boiler designed so that in normal operation there is no change in state of the heat transfer medium shall be equipped with a temperature sensitive limiting means. It shall be installed to limit maximum liquid temperature and shall directly or indirectly interrupt all current flow through the electrodes. Such means shall be in addition to the temperature regulating system and other devices protecting the tank against excessive pressure.

424-84. Over-Pressure Limit Control. Each boiler designed so that in normal operation there is a change in state of the heat transfer medium from liquid to vapor shall be equipped with a pressure sensitive limiting means. It shall be installed to limit maximum pressure and shall directly or indirectly interrupt all current flow through the electrodes. Such means shall be in addition to a pressure regulating system and other devices protecting the tank against excessive pressure.

424-85. Grounding. All exposed non-current carrying metal parts including the supply and return connecting piping shall be grounded in accordance with Article 250. The pressure vessel containing the electrodes shall be isolated and electrically insulated from ground.

424-86. Markings. All electrode-type boilers shall be marked to show: (1) the manufacturer's name; (2) the normal rating in volts, amperes and kilowatts; (3) the electrical supply required specifying frequency, number of phases and number of wires; (4) the marking: "Electrode-Type Boiler;" (5) a warning marking — "ALL POWER SUPPLIES SHALL BE DISCONNECTED BEFORE SERVICING INCLUDING SERVICING THE PRESSURE VESSEL."

The nameplate shall be located so as to be visible after installation.

ARTICLE 426 — FIXED OUTDOOR ELECTRIC DE-ICING AND SNOW MELTING EQUIPMENT

A. General

426-1. Scope. This Article covers electrically energized heating units, panels, and cables where embedded in driveways, walks, steps, and other areas.

426-2. Other Articles. All requirements of this Code shall apply where applicable.

426-3. Branch-Circuit Requirements. Fixed outdoor electric de-icing and snow melting equipment shall be considered as a continuous load for sizing branch circuits. Fixed outdoor electric de-icing and snow melting installations shall be permitted to be supplied by 15-, 20-, 25-, 30-, 40-, or 50-ampere branch circuits if the circuit supplies no other load.

B. Installation.

426-9. General. Equipment for use with fixed outdoor electric de-icing and snow melting systems shall be of a type approved for such service and for the location where installed.

426-10. Use.

(a) De-icing and snow melting equipment shall be installed only in the specific materials for which they are approved.

(b) De-icing and snow melting units shall be protected from physical damage.

426-11. Complete Units.

(a) Units, panels, and cables shall be installed in their complete sizes or lengths as supplied by the manufacturer.

Exception: Nonheating leads shall be permitted to be shortened if the marking specified in Section 426-26 is retained.

(b) Units without nameplates shall not be installed.

(c) Units shall be suitable for use with approved wiring systems.

426-12. Special Permission. Fixed outdoor electric de-icing and snow melting equipment employing methods of construction or installation

other than that covered by this Article may be used only by special permission.

C. Control and Protection

426-20. Disconnecting Means. All fixed outdoor electric de-icing and snow melting equipment shall be provided with a means for disconnection from all ungrounded conductors. Where readily accessible to the user of the equipment, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means. Switches used as disconnecting means shall be of the indicating type.

426-21. Controllers.

(a) Thermostats and thermostatically controlled switching devices that indicate an off position and interrupt line current shall open all ungrounded conductors when the control device is in the off position, and shall be permitted as the disconnecting means.

(b) Thermostats and thermostatically controlled switching devices shall be so designed that the circuit cannot be energized automatically after the device has been manually placed in the off position.

(c) Thermostats and thermostatically controlled switching devices that do not have an off position shall not be required to open all ungrounded conductors, but they shall not be used as the disconnecting means required in Section 426-20.

426-22. Overcurrent Protection. Fixed outdoor electric de-icing and snow melting equipment shall be considered as protected against overcurrent when supplied by one of the branch circuits specified in Section 426-3.

426-23. Nonheating Leads. Nonheating leads on the cables, panels, or units shall be furnished as part of the factory assembly. The leads shall consist of conductors and wiring approved for general use, or other wiring approved for the purpose.

426-24. Installation of Heating Cables, Units, or Panels.

(a) The operating characteristics of embedded assemblies of fixed outdoor electric de-icing and snow melting equipment depend upon the specific materials involved, and, therefore, embedded equipment shall be installed as designed for use in such materials.

(b) Panels or units shall not exceed 120 watts per square foot of heated area.

(c) The spacings between adjacent cable runs is dependent upon the rating of the cable, and shall not be less than one inch on centers.

(d) Units, panels, and cables shall be installed:

(1) On a substantial asphalt or masonry base at least 2 inches thick and have at least 1½ inches of asphalt or masonry applied over the units, panels, or cables; or

(2) They shall be permitted to be installed over other approved bases and embedded within 3½ inches of masonry or asphalt but not less than 1½ inches from the top surface; or

(3) Equipment that has been specially investigated for other forms of installation shall be installed only in the manner for which it has been investigated.

(e) Cables shall be secured in place by frames or spreaders or other approved means while the masonry or asphalt finish is applied.

(f) Cables, units, and panels shall not be installed where they bridge expansion joints unless adequately protected from expansion and contraction.

426-25. Installation of Nonheating Leads.

(a) Nonheating leads having a grounding sheath or braid shall be permitted to be embedded in masonry or asphalt in the same manner as the heating cable without additional protection.

(b) All but one to 6 inches of nonheating leads of Type TW and other approved types not having a grounding sheath shall be enclosed in conduit, electrical metallic tubing, or other raceways within the asphalt or masonry; and the distance from the factory splice to the raceway shall not be less than one inch nor more than 6 inches.

(c) Insulating bushings shall be used in the asphalt or masonry where leads enter conduit, tubing, or raceway.

(d) Leads shall be protected in expansion joints and where they emerge from masonry or asphalt by conduit, electrical metallic tubing, other raceways; or other approved means.

(e) Not less than 6 inches of free nonheating lead shall be within the junction box.

426-26. Marking. Each heating unit, panel, and cable shall be legibly marked within 3 inches of each end of the nonheating leads with the identification symbol, catalog number, and ratings in volts and watts, or volts and amperes.

426-27. Junction Boxes. All splices other than factory splices shall be made in properly installed boxes approved for the location.

426-28. Grounding.

(a) All exposed metal parts of fixed outdoor electric de-icing and snow melting equipment, raceways, boxes, etc., likely to become energized shall be grounded as required in Article 250.

(b) Grounding means, such as copper braid, lead or copper sheath, or other approved means, shall be provided as part of the heating section of the approved cable, panel, or unit.

(c) All noncurrent-carrying metal parts that are likely to become energized shall be bonded together and positively connected to a continuous (unbroken) No. 14 or larger covered copper wire sized in accordance with Table 250-95 extending to the distribution panelboard. Where the bonding conductor is subject to physical damage, it shall be at least No. 10 copper.

426-29. Inspection. Installations shall be inspected and approved before being covered.

ARTICLE 427 — FIXED ELECTRIC HEATING EQUIPMENT FOR PIPELINES AND VESSELS

A. General

427-1. Scope. The requirements of this Article shall apply to electrically energized heating systems and the installation of these systems used with pipelines and/or vessels. This Article covers electrical heating of pipelines and/or vessels by separate external heating elements, other than the skin electric current tracing or impedance methods.

427-2. Definitions. For the purpose of this Article:

(a) A pipeline is a length of pipe including pumps, valves, flanges, control devices, strainers and/or similar equipment for conveying fluids.

(b) A vessel is a container such as a barrel, drum, or tank for holding fluids or other material.

(c) An integrated heating system is a complete system consisting of components such as pipelines, vessels, heating elements, heat transfer medium, thermal insulation, moisture barrier, nonheating leads, temperature controller, safety signs, junction boxes, conduit and fittings.

427-3. Application of Other Articles. All requirements of this Code shall apply except as specifically amended in this Article. Cord-connected pipe heating assemblies intended for specific uses and approved for the purpose shall be installed according to Article 422. Fixed electric pipeline and vessel heating equipment for use in hazardous locations shall comply with Articles 500 through 516.

427-4. Branch-Circuit Requirements. The minimum size of branch-circuit conductors and overcurrent protective devices supplying fixed electric pipeline and vessel heating equipment shall be calculated on the basis of 125 percent of the total load of the heaters.

B. Installation

427-10. General. Equipment for pipeline and vessel electrical heating shall be of a type compatible with the chemical, thermal and physical environment.

427-11. Use. Electric heating equipment shall be installed in such a manner as to be afforded protection from physical damage.

427-12. Integrated Electrical Heating System.

(a) Accessible external surfaces of pipeline and vessel heating equipment which operate at surface temperatures exceeding 60°C (140°F) shall be physically guarded, isolated, or thermally insulated to protect against contact by personnel in the area. In addition, the area utilizing the pipeline and vessel heating equipment shall be marked as specified in (b) below:

(b) The presence of electric pipeline and vessel heating equipment shall be evident by the posting of appropriate signs or other markings at frequent intervals in the area involved.

(c) Heating element assemblies shall be secured to the surfaces being heated in an approved manner by means other than thermal insulation. The securement means shall employ materials suitable for the environment and temperature involved and be located at not more than 12 inch intervals.

(d) Where the heating element is not in direct contact with the pipeline or vessel being heated, means shall be provided to prevent over-temperature of the heating element unless the design of the heater assembly is such that its temperature limitations will not be exceeded.

(e) Heating elements and assemblies shall not be installed where they bridge expansion joints unless provision is made for expansion and contraction.

(f) Where installed on flexible pipelines, the heater elements and assemblies shall have a flexural capability compatible with the pipeline.

C. Control and Protection

427-20. Disconnecting Means.

(a) Means shall be provided to disconnect all fixed electric pipeline or vessel heating equipment from all ungrounded conductors. The branch-circuit switch or circuit breaker, where readily accessible to the user of the equipment, shall be permitted to serve as the disconnecting means. Switches used as disconnecting means shall be of the indicating type, and shall be provided with a positive lockout in the off position.

(b) The factory-installed attachment plug of cord-connected equipment rated 20 amperes or less and 150 volts or less to ground is an acceptable means of disconnection.

427-21. Controls.

(a) Temperature-controlled switching devices which indicate an off position and which interrupt line current shall open all ungrounded conductors when the control device is in this off position. These devices shall not serve as disconnecting means unless provided with a positive lockout in the off position.

(b) Temperature-controlled switching devices which do not have an off position are not required to open all ungrounded conductors and shall not serve as disconnecting means.

(c) Remote-controlled temperature actuated devices shall not be required to meet the requirements of paragraphs (a) and (b) above. These devices shall not serve as the disconnecting means.

(d) Switching devices consisting of combined temperature actuated devices and manually controlled switches which serve both as controllers and disconnecting means shall:

(1) Open all ungrounded conductors when manually placed in the off position.

(2) Be so designed that the circuit cannot be energized automatically after the device has been manually placed in the off position.

(3) Be provided with a positive lockout in the off position.

427-22. Overcurrent Protection. Heaters shall be protected against overcurrent in accordance with Section 210-20.

427-23. Nonheating Leads.

(a) Power supply nonheating leads (cold leads) for the electric heating elements shall be suitable for the temperature encountered and shall be supplied by the heating element manufacturer. Preassembled nonheating leads on approved heaters may be shortened if the markings specified in Section 427-24 are retained. Not less than 6 inches of nonheating leads shall be provided within the junction box.

(b) Nonheating power supply leads shall be protected where they emerge from electric pipeline or vessel heating units by metallic conduit or metallic tubing.

(c) Interconnecting nonheating leads connecting portions of the heating system shall be permitted to be covered by thermal insulation in the same manner as the heater.

427-24. Markings. Each factory-assembled heating unit shall be legibly marked within 3 inches of the end of each power supply nonheating lead with the permanent identification symbol, catalog number, and ratings in volts and watts, or volts and amperes.

427-25. Electrical Connections.

(a) Nonheating interconnections where required under thermal insulation, shall be made with properly installed insulated connectors approved for the purpose.

(b) Splice connections and terminations outside the thermal insulation shall be installed in a box or fitting in accordance with Sections 110-14 and 300-15.

427-26. Grounding. Exposed noncurrent-carrying metal parts of electric heating equipment which are likely to become energized shall be grounded as required in Article 250.

ARTICLE 430 — MOTORS, MOTOR CIRCUITS, AND CONTROLLERS

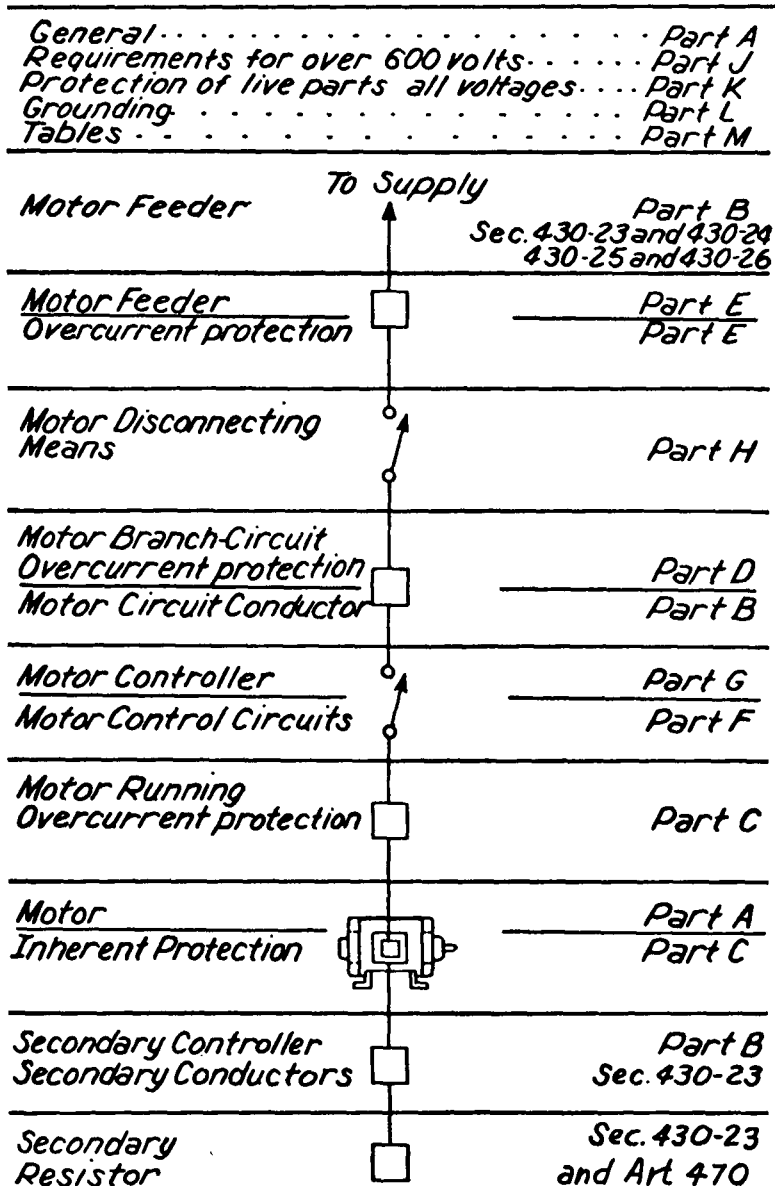
A. General

430-1. Motor Feeder and Branch Circuits. The following general requirements cover provisions for motors, motor circuits, and controllers that do not properly fall into the other parts of this Article.

See Article 440 for air-conditioning and refrigerating equipment.

See Diagram 430-1.

Diagram 430-1



430-2. Adjustable Speed Drive Systems. The incoming branch circuit or feeder to power conversion equipment included as a part of an adjustable speed drive system shall be based on the rated input to the power conversion equipment. If the power conversion equipment provides overload protection for the motor, additional protection is not required.

The disconnecting means shall be permitted to be in the incoming line to the conversion equipment and shall have a rating not less than 115 percent of the rated input current of the conversion unit.

430-3. Part-Winding Motors. A part-winding-start induction or synchronous motor is one arranged for starting by first energizing part of its primary (armature) winding and, subsequently, energizing the remainder of this winding in one or more steps. The purpose is to reduce the initial values of the starting current drawn or the starting torque developed by the motor. A standard part-winding-start induction motor is arranged so that one-half of its primary winding can be energized initially and, subsequently, the remaining half can be energized, both halves then carrying equal current. A hermetic refrigerant compressor motor shall not be considered a standard part-winding-start induction motor.

Where separate running overcurrent devices are used with a standard part-winding-start induction motor, each half of the motor winding shall be individually protected in accordance with Sections 430-32 and 430-37 with a trip current one-half that specified.

Each motor-winding connection shall have branch-circuit short-circuit and ground-fault protection rated at not more than one-half that specified by Section 430-52.

Exception: A single device having this half rating shall be permitted for both windings if it will allow the motor to start. Where a time-delay (dual-element) fuse is used as a single device for both windings, it shall be permitted to have a rating not exceeding 150 percent of motor full-load current.

430-4. In Sight From. Where this Article specifies that one equipment shall be "in sight from" another equipment, one of the equipments specified shall be visible and not more than 50 feet distant from the other.

430-5. Other Articles. Motors and controllers shall also comply with the applicable provisions of the following:

Air-Conditioning and Refrigerating Equipment	Article 440
Capacitors	Section 460-9
Cranes and Hoists	Article 610
Elevators, Dumbwaiters, Escalators, and Moving Walks	Article 620
Garages, Aircraft Hangars, Gasoline Dispensing and Service Stations, Bulk Storage Plants, Finishing Processes, and Flammable Anesthetics	Articles 511, 513, 514, 515, 516, and 517-E
Hazardous Locations	Articles 500 thru 503
Metalworking Machine Tools	Article 670
Motion-Picture Projectors	Sections 540-12, 540-17
Motion-Picture Studios	Article 530
Organs	Section 650-3
Resistors and Reactors	Article 470
Theaters	Section 520-48

430-6. Ampacity and Motor Rating Determination. Conductor ampacity and motor ratings shall be determined as specified in (a) and (b) below.

(a) **General Motor Applications.** Other than as specified for torque motors in (b) below, where the current rating of a motor is used to determine the ampacity of conductors or ampere ratings of switches, branch-circuit overcurrent devices, etc., the values given in Tables 430-147, 430-148, 430-149, and 430-150, including notes, shall be used instead of the actual current rating marked on the motor nameplate. Separate motor-running overcurrent protection shall be based on the motor nameplate current rating. Where a motor is marked in amperes, but not horsepower, the horsepower rating shall be assumed to be that corresponding to the value given in Tables 430-147, 430-148, 430-149, and 430-150, interpolated if necessary.

Exception No. 1: Multispeed motors shall be in accordance with Sections 430-22(a) and 430-52.

Exception No. 2: For equipment employing a shaded-pole or permanent-split-capacitor-type fan or blower motor that is marked with the motor type, the full-load current for such motor marked on the nameplate of the equipment in which the fan or blower motor is employed shall be used instead of the horsepower rating to determine the ampacity or rating of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground-fault protection, and the separate overload protection. This marking on the equipment nameplate shall not be less than the current marked on the fan or blower motor nameplate.

(b) **Torque Motors.** For torque motors the rated current shall be locked-rotor current, and this nameplate current shall be used to determine the ampacity of the branch-circuit conductors covered in Sections 430-22 and 430-24 and the ampere rating of the motor running overcurrent protection.

For motor controllers and disconnecting means, see Section 430-83, Exception No. 3 and Section 430-110.

(c) **A-C Adjustable Voltage Motors.** For motors used in alternating-current, adjustable voltage, variable torque drive systems, the ampacity of conductors, or ampere ratings of switches, branch-circuit overcurrent devices, etc., shall be based on the maximum operating current marked on the motor and/or control nameplate. If the maximum operating current does not appear on the nameplate, the ampacity determination shall be based on 150 percent of the values given in Tables 430-149 and 430-150.

430-7. Marking on Motors and Multimotor Equipment.

(a) **Usual Motor Applications.** A motor shall be marked with the following information:

- (1) Maker's name.
- (2) Rated volts and full-load amperes.
- (3) Rated frequency and number of phases, if an alternating-current motor.
- (4) Rated full-load speed.

(5) Rated temperature rise or the insulation system class and rated ambient temperature.

(6) Time rating.

(7) Rated horsepower if $\frac{1}{8}$ horsepower or more.

(8) Code letter if an alternating-current motor rated $\frac{1}{2}$ horsepower or more.

See (b) below.

(9) Secondary volts and full-load amperes if a wound-rotor induction motor.

(10) Field current and voltage for direct-current excited synchronous motors.

(11) Winding: straight shunt, stabilized shunt, compound, or series, if a direct-current motor.

A multispeed motor shall be marked with the amperes and horsepower for each speed. A motor provided with the thermal protector complying with Section 430-32(a)(2) or 430-32(c)(2) shall be marked "Thermally Protected." A motor complying with Section 430-32(c)(4) shall be marked "Impedance Protected." The time rating shall be 5, 15, 30, or 60 minutes, or continuous.

Exception No. 1: On polyphase wound-rotor motors the code letter shall be omitted.

Exception No. 2: Motors of arc welders are not required to be marked with the horsepower rating.

Exception No. 3: A shaded-pole or permanent-split capacitor motor shall not be required to have ampere or hp ratings marked for each speed.

Exception No. 4: Thermally protected motors rated 100 watts or less and complying with 430-32(c)(2) shall be permitted to use the abbreviated marking, "T.P."

Exception No. 5: Impedance protected motors rated 100 watts or less and complying with 430-32(c)(4) shall be permitted to use the abbreviated marking, "Z.P."

(b) Locked-Rotor Indicating Code Letters. Code letters marked on motor nameplates to show motor input with locked rotor shall be in accordance with Table 430-7(b).

The code letter indicating motor input with locked rotor shall be in an individual block on the nameplate, properly designated. This code letter shall be used for determining branch-circuit overcurrent protection by reference to Table 430-152, as provided in Section 430-52.

(1) Multispeed motors shall be marked with the code letter designating the locked-rotor kVA per horsepower for the highest speed at which the motor can be started.

Exception: Constant-horsepower multispeed motors shall be marked with the code letter giving the highest locked-rotor kVA per horsepower.

(2) Single-speed motors starting on Y connection and running on delta connections shall be marked with a code letter corresponding to the locked-rotor kVA per horsepower for the Y connection.

Table 430-7(b). Locked-Rotor Indicating Code Letters

Code Letter	Kilovolt-Amperes per Horsepower with Locked Rotor		
A	0	—	3.14
B	3.15	—	3.54
C	3.55	—	3.99
D	4.0	—	4.49
E	4.5	—	4.99
F	5.0	—	5.59
G	5.6	—	6.29
H	6.3	—	7.09
J	7.1	—	7.99
K	8.0	—	8.99
L	9.0	—	9.99
M	10.0	—	11.19
N	11.2	—	12.49
P	12.5	—	13.99
R	14.0	—	15.99
S	16.0	—	17.99
T	18.0	—	19.99
U	20.0	—	22.39
V	22.4	—	and up

(3) Dual-voltage motors that have a different locked-rotor kVA per horsepower on the two voltages shall be marked with the code letter for the voltage giving the highest locked-rotor kVA per horsepower.

(4) Motors with 60- and 50-Hertz ratings shall be marked with a code letter designating the locked rotor kVA per horsepower on 60 hertz.

(5) Part-winding-start motors shall be marked with a code letter designating the locked-rotor kVA per horsepower that is based upon the locked-rotor current for the full winding of the motor.

(c) **Torque Motors.** Torque motors are rated for operation at stand-still and shall be marked in accordance with (a) above.

Exception: Locked rotor torque shall replace horsepower.

(d) **Multimotor and Combination-Load Equipment.** Multimotor and combination-load equipment shall be provided with a visible nameplate marked with the maker's name, the rating in volts, frequency, number of phases, minimum supply circuit conductor ampacity, and the maximum ampere rating of the circuit overcurrent device. The conductor ampacity shall be computed in accordance with Section 430-25 and counting all of the motors and other loads that will be operated at the same time. The overcurrent device rating shall not exceed the value computed in accordance with Section 430-53. Multimotor equipment for use on two or more circuits shall be marked with the above information for each circuit.

Where the equipment is not factory-wired and the individual nameplates of motors and other loads are visible after assembly of the equipment, the individual nameplates shall be permitted to serve as the required marking.

430-8. Marking on Controllers. A controller shall be marked with the maker's name or identification, the voltage, the current or horsepower rating, and such other necessary data to properly indicate the motors for which it is suitable. A controller that includes motor-running overcurrent protection suitable for group motor application shall be marked with the motor-running overcurrent protection and the maximum branch-circuit overcurrent protection for such applications.

Combination controllers employing adjustable instantaneous trip circuit breakers shall be clearly marked to indicate the ampere settings of the adjustable trip element.

Where a controller is built in as an integral part of a motor or of a motor-generator set, individual marking of the controller shall not be required if the necessary data are on the nameplate. For controllers that are an integral part of equipment approved as a unit, the above marking shall be permitted on the equipment nameplate.

430-9. Marking at Terminals. Terminals of motors and controllers shall be suitably marked or colored where necessary to indicate the proper connections.

430-10. Wiring Space in Enclosures. Enclosures for motor controllers and disconnecting means shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to the other apparatus unless designs are employed which provide adequate space for this purpose.

See Section 373-8 for switch and overcurrent-device enclosures.

430-11. Protection Against Liquids. Suitable guards or enclosures shall be provided to protect exposed current-carrying parts of motors and the insulation of motor leads where installed directly under equipment, or in other locations where dripping or spraying oil, water, or other injurious liquid may occur, unless the motor is designed for the existing conditions.

430-12. Motor Terminal Housings.

(a) **Material.** Where motors are provided with terminal housings, the housings shall be of metal and of substantial construction.

Exception: In other than hazardous locations, substantial nonmetallic, nonburning housings shall be permitted on motors larger than 34 inches in diameter provided internal grounding means between the machine frame and the conduit connection is incorporated within the housing.

See Method of Test for Flammability of Self-Supporting Plastics (ANSI K65.21—1969) for over 0.127 CM (0.050 inch) in thickness, for nonburning test.

(b) **Dimensions and Space — Wire-to-Wire Connections.** When these terminal housings enclose wire-to-wire connections, they shall have minimum dimensions and usable volumes in accordance with the following:

Table 430-12(b). Terminal Housings — Wire-to-Wire Connections
Motors 11 Inches in Diameter or Less

HP	Cover Opening, Minimum Dimension, Inches	Usable Volume, Minimum, Cubic Inches
1 and smaller*	1 $\frac{5}{8}$	7 $\frac{1}{2}$
1 $\frac{1}{2}$, 2 and 3†	1 $\frac{3}{4}$	12
5 and 7 $\frac{1}{2}$	2	16
10 and 15	2 $\frac{1}{2}$	26

* For motors rated one horsepower and smaller and with the terminal housing partially or wholly integral with the frame or end shield, the volume of the terminal housing shall be not less than 0.8 cubic inch per wire-to-wire connection. The minimum cover opening dimension is not specified.

† For motors rated 1 $\frac{1}{2}$, 2 and 3 horsepower and with the terminal housing partially or wholly integral with the frame or end shield, the volume of the terminal housing shall be not less than 1.0 cubic inch per wire-to-wire connection. The minimum cover opening dimension is not specified.

Motors over 11 Inches in Diameter
Alternating-Current Motors

Max. Full-load Current for Three- phase Motors with Max. of Twelve Leads	Terminal Box Minimum Dimension Inches	Usable Volume Minimum Cubic Inches	Typical Maximum Horsepower Three Phase	
			230 Volt	460 Volt
45	2.5	26	15	30
70	3.0	44	25	50
110	3.6	72	40	75
160	4.5	130	60	125
250	5.6	250	100	200
400	7	500	150	300
600	8.2	900	250	500

Direct-Current Motors

Maximum Full-load Current for Motors with Maximum of Six Leads	Terminal Box Minimum Dimensions Inches	Usable Volume, Minimum Cubic Inches
68	2.5	26
105	3.0	44
165	3.6	72
240	4.5	130
375	5.6	250
600	7	500
900	8.2	900

Auxiliary leads for such items as brakes, thermostats, space heater, exciting fields, etc., may be neglected if their current-carrying area does not exceed 25 percent of the current-carrying area of the machine power leads.

(c) **Dimensions and Space—Fixed Terminal Connections.** Where these terminal housings enclose rigidly mounted motor terminals, the terminal housing shall be of sufficient size to provide minimum terminal spacings and usable volumes in accordance with Tables 430-12(c)(1) and (c)(2).

Table 430-12(c)(1). Terminal Spacings—Fixed Terminals

Volts	Minimum Spacing, Inches	
	Between Line Terminals	Between Line Terminals and Other Uninsulated Metal Parts
250 or less	$\frac{1}{4}$	$\frac{1}{4}$
251 through 600	$\frac{3}{8}$	$\frac{3}{8}$

Table 430-12(c)(2). Usable Volumes—Fixed Terminals

Power-Supply Conductor Size, AWG	Minimum Usable Volume per Power-Supply Conductor, Cubic Inches
14	1.0
12 and 10	$1\frac{1}{4}$
8 and 6	$2\frac{1}{4}$

(d) **Large Wire or Factory Connections.** For motors with larger ratings, greater number of leads, or larger wire sizes, or where motors are installed as a part of factory-wired equipment, without additional connection being required at the motor terminal housing during equipment installation, the terminal housing shall be of ample size to make connections, but the foregoing provisions for the volumes of terminal housings shall not be considered applicable.

430-13. Bushing. Where wires pass through an opening in an enclosure, conduit box, or barrier, a bushing shall be used to protect the conductors from the edges of openings having sharp edges. The bushing shall have smooth well-rounded surfaces where it may be in contact with the conductors. If used where oils, greases, or other contaminants may be present, the bushing shall be made of material not deleteriously affected.

For conductors exposed to deteriorating agents, see Section 310-8.

430-14. Location of Motors.

(a) **Ventilation and Maintenance.** Motors shall be located so that adequate ventilation is provided and so that maintenance, such as lubrication of bearings and replacing of brushes, can be readily accomplished.

(b) **Open Motors.** Open motors having commutators or collector rings shall be located or protected so that sparks cannot reach adjacent

combustible material, but this shall not prohibit the installation of these motors on wooden floors or supports.

430-16. Exposure to 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 that 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.

430-17. Highest Rated (Largest) Motor. In determining compliance with Sections 430-24, 430-53(b), 430-53(c), and 430-62(a), the highest rated (largest) motor shall be considered to be that motor having the highest rated full-load current. The full-load current used to determine the highest rated motor shall be the equivalent value corresponding to the motor horsepower rating selected from Tables 430-147, 430-148, 430-149, and 430-150.

B. Motor Circuit Conductors

430-21. General. Part B specifies sizes of conductors capable of carrying the motor current without overheating under the conditions specified.

Exception: The provisions of Section 430-124 shall apply over 600 volts, nominal.

The provisions of Articles 250, 300, and 310 shall not apply to conductors that form an integral part of approved equipment, or to integral conductors of motors, motor controllers, and the like.

See Sections 300-1(b) and 310-1.

430-22. Single Motor.

(a) General. Branch-circuit conductors supplying a single motor shall have an ampacity not less than 125 percent of the motor full-load current rating.

In case of a multispeed motor, the selection of branch-circuit conductors on the line side of the controller shall be based on the highest of the full-load current ratings shown on the motor nameplate; selection of branch-circuit conductors between the controller and the motor, which are energized for that particular speed, shall be based on the current rating for that speed.

Exception: Conductors for a motor used for short-time, intermittent, periodic, or varying duty shall have an ampacity not less than the percentage of the motor nameplate current rating shown in Table 430-22(a) Exception unless the authority having jurisdiction grants special permission for conductors of smaller size.

(b) Separate Terminal Enclosure. The conductors between a stationary motor rated one horsepower or less and the separate terminal enclosure permitted in Section 430-145(b) shall be permitted to be smaller than No. 14 but not smaller than No. 18, provided they have an ampacity as specified in (a) above.

430-23. Wound-Rotor Secondary.

(a) **Continuous Duty.** For continuous duty, the conductors connecting the secondary of a wound-rotor alternating-current motor to its controller shall have an ampacity not less than 125 percent of the full-load secondary current of the motor.

(b) **Other Than Continuous Duty.** For other than continuous duty, these conductors shall have an ampacity, in percent of full-load secondary current, not less than that specified in Table 430-22(a) Exception.

(c) **Resistor Separate from Controller.** Where the secondary resistor is separate from the controller, the ampacity of the conductors between controller and resistor shall not be less than that given in Table 430-23(c).

Table 430-22(a) Exception. Duty-Cycle Service

Classification of Service	Percentages of Nameplate Current Rating			
	5-Minute Rated Motor	15-Minute Rated Motor	30 & 60 Minute Rated Motor	Continuous Rated Motor
Short-Time Duty Operating valves, raising or lowering rolls, etc.	110	120	150	...
Intermittent Duty Freight and passenger elevators, tool heads, pumps, drawbridges, turntables, etc. For arc welders, see Section 630-21	85	85	90	140
Periodic Duty Rolls, ore and coal-handling machines, etc.	85	90	95	140
Varying Duty	110	120	150	200

Any motor application shall be considered as continuous duty unless the nature of the apparatus it drives is such that the motor will not operate continuously with load under any condition of use.

See Example No. 8, Chapter 9 and Diagram 430-1.

Table 430-23(c). Secondary Conductor

Resistor Duty Classification	Ampacity of Wire in Percent of Full-Load Secondary Current
Light starting duty	35
Heavy starting duty	45
Extra-heavy starting duty	55
Light intermittent duty	65
Medium intermittent duty	75
Heavy intermittent duty	85
Continuous duty	110

430-24. Conductors Supplying Several Motors. Conductors supplying two or more motors shall have an ampacity equal to the sum of the full-load current rating of all the motors plus 25 percent of the highest rated motor in the group.

Where one or more motors of the group are used on short-time, intermittent, periodic, or varying duty, the ampacity of the conductors shall be computed as follows:

(1) Determine the needed ampere rating for each motor used for other than continuous duty from Table 430-22(a) Exception.

(2) Determine the needed ampere rating for each continuous-duty motor based on 100 percent motor full-load current rating.

(3) Multiply the largest single motor ampere rating determined from (1) or (2) above by 1.25. Add all other motor ampere ratings from (1) and (2) above and select the conductor ampacity for this total ampere rating.

Exception: Where the circuitry is so interlocked as to prevent the starting and running of a second motor or group of motors, the conductor size shall be determined from the larger motor or group of motors that is to be operated at a given time.

See Example No. 8, Chapter 9.

430-25. Conductors Supplying Motors and Other Loads.

(a) **Combination Load.** Conductors supplying a motor load and in addition a lighting or appliance load shall have an ampacity sufficient for the lighting or appliance load computed in accordance with Article 220 and other applicable Sections plus the motor load determined in accordance with Section 430-24, or, for a single motor, in accordance with Section 430-22.

Exception: The ampacity of conductors supplying motor-operated fixed electric space heating equipment shall conform with Section 424-3(b).

(b) **Multimotor and Combination-Load Equipment.** The ampacity of the conductors supplying multimotor and combination-load equipment shall not be less than the minimum circuit ampacity marked on the equipment in accordance with Section 430-7(d).

430-26. Feeder Demand Factor. Where reduced heating of the conductors results from motors operating on duty-cycle, intermittently, or from all motors not operating at one time, the authority having jurisdiction may grant permission for feeder conductors to have an ampacity less than specified in Sections 430-24 and 430-25, provided the conductors have sufficient ampacity for the maximum load determined in accordance with the sizes and number of motors supplied and the character of their loads and duties.

430-27. Capacitors with Motors. Where capacitors are installed in motor circuits, conductors shall comply with Sections 460-7, 460-8, and 460-9.

430-28. Feeder Taps. Feeder tap conductors shall have an ampacity not less than that required by Part B, shall terminate in a branch-cir-

cuit protective device and, in addition, shall meet one of the following requirements:

(1) be enclosed by either an enclosed controller or by a raceway and be not more than 10 feet in length; or

(2) have an ampacity of at least one-third that of the feeder conductors, be protected from physical damage and be not more than 25 feet in length; or

(3) have the same ampacity as the feeder conductors.

C. Motor and Branch-Circuit Running Overcurrent and Overload Protection

430-31. General. Part C specifies overload devices intended to protect motors, motor-control apparatus, and motor branch-circuit conductors against excessive heating due to motor overloads and failure to start.

Overload in electrical apparatus is an operating overcurrent which, when it persists for a sufficient length of time, would cause damage or dangerous overheating of the apparatus. It does not include short circuits or ground faults.

These provisions shall not be interpreted as requiring overload protection where it might introduce additional or increased hazards, as in the case of fire pumps.

See Installation of Centrifugal Fire Pumps (NFPA No. 20-1972).

The provisions of Part C shall not apply to motor circuits rated over 600 volts nominal. See Part J.

430-32. Continuous-Duty Motors.

(a) More Than One Horsepower. Each continuous-duty motor rated more than one horsepower shall be protected against overload by one of the following means:

(1) A separate overload device that is responsive to motor current. This device shall be selected to trip or rated at no more than the following percent of the motor nameplate full-load current rating:

Motors with a marked service factor not less than 1.15 125%

Motors with a marked temperature rise not over 40°C 125%

All other motors 115%

For a multispeed motor, each winding connection shall be considered separately. This value may be modified as permitted by Section 430-34.

Where a separate motor-running overload device is so connected that it does not carry the total current designated on the motor nameplate, such as for wye-delta starting, the proper percentage of nameplate current applying to the selection or setting of the overload device shall be clearly designated on the equipment, or the manufacturer's selection table shall take this into account.

(2) A thermal protector integral with the motor, approved for use with the motor it protects on the basis that it will prevent dangerous overheating of the motor due to overload and failure to start. The ultimate trip current of a thermally protected motor shall not exceed the

following percentage of motor full-load current given in Tables 430-148, 430-149, and 430-150:

Motor full-load current not exceeding 9 amperes	170%
Motor full-load current 9.1 to and including 20 amperes . .	156%
Motor full-load current greater than 20 amperes	140%

If the motor current-interrupting device is separate from the motor and its control circuit is operated by a protective device integral with the motor, it shall be so arranged that the opening of the control circuit will result in interruption of current to the motor.

(3) A motor shall be considered as being properly protected if it is a part of an approved assembly that does not normally subject the motor to overloads and if there is a protective device integral with the motor that will protect the motor against damage due to failure to start.

(4) For motors larger than 1500 horsepower, a protective device having embedded temperature detectors that 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.

(b) One Horsepower or Less, Manually Started.

(1) Each continuous-duty motor rated at one horsepower or less that is not permanently installed, is manually started, and is within sight from the controller location shall be considered as protected against overload by the branch-circuit short-circuit and ground-fault protective device. This branch-circuit protective device shall not be larger than that specified in Part D of Article 430.

Exception: Any such motor shall be permitted at 125 volts or less on a branch circuit protected at not over 20 amperes.

(2) Any such motor that is not in sight from the controller location shall be protected as specified in Section 430-32(c). Any motor rated at one horsepower or less that is permanently installed shall be protected in accordance with Section 430-32(c).

(c) One Horsepower or Less, Automatically Started. Any motor of one horsepower or less that is started automatically shall be protected against overload by one of the following means:

(1) A separate overload device that is responsive to motor current. This device shall be selected to trip or rated at no more than the following percent of the motor nameplate full-load current rating:

Motors with a marked service factor not less than 1.15 . .	125%
Motors with a marked temperature rise not over 40°C . . .	125%
All other motors	115%

For a multispeed motor, each winding connection shall be considered separately. Modification of this value shall be permitted as provided in Section 430-34.

(2) A thermal protector integral with the motor, approved for use with the motor which it protects on the basis that it will prevent dangerous overheating of the motor due to overload and failure to start. Where the motor current interrupting device is separate from the motor and its control circuit is operated by a protective device integral

with the motor, it shall be so arranged that the opening of the control circuit will result in interruption of current to the motor.

(3) A motor shall be considered as being properly protected if it is part of an approved assembly that does not normally subject the motor to overloads and if there is a protective device integral with the motor that will protect the motor against damage due to failure to start, or if the assembly is also equipped with other safety controls (such as the safety combustion controls of a domestic oil burner) that protect the motor against damage due to failure to start. Where the assembly has safety controls that protect the motor, it shall be so indicated on the nameplate of the assembly where it will be visible after installation.

(4) In case the impedance of the motor windings is sufficient to prevent overheating due to failure to start, the motor shall be permitted to be protected as specified in Section 430-32(b) (1) for manually started motors if the motor is part of an approved assembly in which the motor will limit itself so that it will not be dangerously overheated.

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 that 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 overload by the motor-running overload device.

430-33. Intermittent and Similar Duty. A motor used for a condition of service that is inherently short-time, intermittent, periodic, or varying duty, as illustrated by Table 430-22(a) Exception, shall be considered as protected against overload by the branch-circuit short-circuit and ground-fault protective device, provided the protective device rating or setting does not exceed that specified in Table 430-152.

Any motor application shall be considered to be for continuous duty unless the nature of the apparatus it drives is such that the motor cannot operate continuously with load under any condition of use.

430-34. Selection of Overload Relay. Where the overload relay selected in accordance with Sections 430-32(a-1) and 430-32(c-1) is not sufficient to start the motor or to carry the load, the next higher size overload relay shall be permitted to be used provided the trip current of the overload relay does not exceed the following percent of motor full-load current rating:

Motors with marked service factor not less than 1.15 . . .	140%
Motors with a marked temperature rise not over 40°C . . .	140%
All other motors	130%

If not shunted during the starting period of the motor as provided in Section 430-35, the overload device shall have sufficient time delay to permit the motor to start and accelerate its load.

430-35. Shunting During Starting Period.

(a) **Manually Started.** For a manually started motor (including starting with a magnetic starter having pushbutton control), the running overload protection may be shunted or cut out of circuit during the

starting period of the motor if the device by which the overload protection is shunted or cut out cannot be left in the starting position and if fuses or inverse time circuit breakers rated or set at not over 400 percent of the full-load current of the motor are so located in the circuit as to be operative during the starting period of the motor.

(b) Automatically Started. The motor-running overload protection shall not be shunted or cut out during the starting period if the motor is automatically started.

430-36. Fuses — In Which Conductor. Where fuses are used for motor-running protection, a fuse shall be inserted in each ungrounded conductor.

A fuse shall also be inserted in the grounded conductor if the supply system is 3-wire, 3-phase AC with one conductor grounded.

430-37. Devices Other Than Fuses — In Which Conductor. Where devices other than fuses are used for motor-running overload protection, Table 430-37 shall govern the minimum allowable number and location of overload units such as trip coils, relays, or thermal cutouts.

Table 430-37 — Running Overload Units

Kind of Motor	Supply System	Number and location of overload units, such as trip coils, relays, or thermal cutouts
1-phase AC or DC	2-wire, 1-phase AC or DC ungrounded	1 in either conductor
1-phase AC or DC	2-wire, 1-phase AC or DC, one conductor grounded	1 in ungrounded conductor
1-phase AC or DC	3-wire, 1-phase AC or DC, grounded-neutral	1 in either ungrounded conductor
2-phase AC	3-wire, 2-phase AC, ungrounded	2, one in each phase
2-phase AC	3-wire, 2-phase AC, one conductor grounded	2 in ungrounded conductors
2-phase AC	4-wire, 2-phase AC, grounded or ungrounded	2, one per phase in ungrounded conductors
2-phase AC	5-wire, 2-phase AC, grounded neutral or ungrounded	2, one per phase in any ungrounded phase wire
3-phase AC	Any 3-phase	*3, one in each phase

** Exception: Where protected by other approved means.*

430-38. Number of Conductors Opened by Overload Device. Motor-running overload devices other than fuses, thermal cutouts, or thermal protectors shall simultaneously open a sufficient number of ungrounded conductors to interrupt current flow to the motor.

430-39. Motor Controller As Running Overload Protection. A motor controller shall also be permitted to serve as a running overload device if the number of overload units complies with Table 430-37 and if these units are operative in both the starting and running position in the case of a direct-current motor, and in the running position in the case of an alternating-current motor.

430-40. Thermal Cutouts and Overload Relays. Thermal cutouts, overload relays, and other devices for motor-running overload protection that are not capable of opening short circuits shall be protected by fuses or circuit breakers with ratings or settings in accordance with Section 430-52 or by a motor short-circuit protector in accordance with Section 430-52.

Exception No. 1: Where approved for group installation and marked to indicate the maximum size of fuse or inverse time circuit breaker by which they must be protected.

Exception No. 2: The fuse or circuit breaker ampere rating shall be permitted to be marked on the nameplate of approved equipment in which the thermal cutout or overload relay is used.

For instantaneous trip circuit breakers or motor short-circuit protectors, see Section 430-52.

430-42. Motors on General-Purpose Branch Circuits. Overload protection for motors used on general-purpose branch circuits as permitted in Article 210 shall be provided as specified in (a), (b), (c), or (d) below.

(a) Not Over One HP. One or more motors without individual running overload protection shall be permitted to be connected to general-purpose branch circuits only where the installation complies with all the limiting conditions specified in Section 430-53(a).

(b) Over One HP. Motors of larger ratings than specified in Section 430-53(a) shall be permitted to be connected to general-purpose branch circuits only where each motor is protected by running overload protection selected to protect the motor as specified in Section 430-32. Both the controller and the motor-running overload device shall be approved for group installation with the short-circuit and ground-fault protective device selected in accordance with Section 430-53.

(c) Cord- and Plug-Connected. Where a motor is connected to a branch circuit by means of an attachment plug and receptacle and individual running overload protection is omitted as provided in (a) above, the rating of the attachment plug and receptacle shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts. Where individual overload protection is required as provided in (b) above for a motor or motor-operated appliance that is attached to the branch circuit through an attachment plug and receptacle, the running overload device shall be an integral part of the motor or of the appliance. The rating of the attachment plug and receptacle shall determine the rating of the circuit to which the motor may be connected, as provided in Article 210.

(d) **Time Delay.** The branch-circuit short-circuit and ground-fault protective device protecting a circuit to which a motor or motor-operated appliance is connected shall have sufficient time delay to permit the motor to start and accelerate its load.

430-43. Automatic Restarting. A motor-running overload device that can restart a motor automatically after overload tripping shall not be installed unless approved for use with the motor it protects. A motor that can restart automatically after shutdown shall not be installed if its automatic restarting can result in injury to persons.

D. Motor Branch-Circuit Short-Circuit and Ground-Fault Protection

430-51. General. Part D specifies 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 add to or amend the provisions of Article 240.

The provisions of Part D do not apply to motor circuits rated over 600 volts, nominal. See Part J.

430-52. Rating or Setting for Individual Motor Circuit. The motor branch-circuit short-circuit and ground-fault protective device shall be capable of carrying the starting current of the motor. The required protection shall be considered as being obtained where the protective device has a rating or setting not exceeding the values given in Table 430-152.

An instantaneous trip circuit breaker shall be used only if adjustable, if part of a combination controller having motor-running overload and also short-circuit and ground-fault protection in each conductor, and if the combination is especially approved for the purpose. A motor short-circuit protector shall be permitted in lieu of devices listed in Table 430-152 if the motor short-circuit protector is part of a combination controller having both motor-running overload protection and short-circuit and ground-fault protection in each conductor if it will operate at not more than 1300 percent of full-load motor current and if the combination is especially approved for the purpose.

Where the values for branch-circuit protective devices determined by Table 430-152 do not correspond to the standard sizes or ratings of fuses, nonadjustable circuit breakers, or thermal protective devices, or possible settings of adjustable circuit breakers adequate to carry the load, the next higher size, rating, or setting shall be permitted.

See Section 240-6 for standard ratings of fuses and circuit breakers.

Exception: Where the rating or setting specified in Table 430-152 is not sufficient for the starting current of the motor:

a. The rating of a nontime-delay fuse not exceeding 600 amperes shall be permitted to be increased but shall in no case exceed 400 percent of the full-load current.

b. The rating of a time-delay (dual-element) fuse shall be permitted to be increased but shall in no case exceed 225 percent of the full-load current.

c. The setting of an instantaneous trip circuit breaker shall be permitted to be increased but shall in no case exceed 1300 percent of the motor full-load current.

d. Torque motor branch circuits shall be protected at the motor nameplate current rating in accordance with Section 240-3, Exception No. 1.

e. The rating of an inverse time circuit breaker shall be permitted to be increased but shall in no case exceed (1) 400 percent for full-load currents of 100 amperes or less, or (2) 300 percent for full-load currents greater than 100 amperes.

f. The rating of a fuse of 601-6000 ampere classification shall be permitted to be increased but shall in no case exceed 300 percent of the full-load current.

For a multispeed motor, a single short-circuit and ground-fault protective device shall be permitted for two or more windings of the motor, provided the rating of the protective device does not exceed the above applicable percentage of the nameplate rating of the smallest winding protected.

Where maximum branch-circuit protective device ratings are shown in the manufacturer's overload relay table for use with a motor controller or are otherwise marked on the equipment, they shall not be exceeded even if higher values are allowed as shown above.

See Example No. 8, Chapter 9 and Diagram 430-1.

430-53. Several Motors or Loads on One Branch Circuit. Two or more motors or one or more motors and other loads shall be permitted to be connected to the same branch circuit under the conditions specified in (a), (b), or (c) below.

(a) Not Over One HP. Several motors each not exceeding one horsepower in rating shall be permitted on a branch circuit protected at not over 20 amperes at 125 volts or less, or 15 amperes at more than 125 volts but no more than 600 volts, if all of the following conditions are met:

(1) The full-load rating of each motor does not exceed 6 amperes.

(2) The rating of the branch-circuit protective device marked on any of the controllers is not exceeded.

(3) Individual running overload protection conforms to Section 430-32.

(b) If Smallest Motor Protected. If the branch-circuit protective device is selected not to exceed that allowed by Section 430-52 for the motor of the smallest rating, two or more motors or one or more motors and other load(s), with each motor having individual running overload protection, shall be permitted to be connected to a branch circuit where it can be determined that the branch-circuit protective device will not open under the most severe normal conditions of service that might be encountered.

(c) Other Group Installation. Two or more motors of any rating or one or more motors and other load(s), with each motor having individual running overload protection, shall be permitted to be connected to one branch circuit if all of the following conditions are complied with:

(1) Each motor-running overload device is approved for group installation with a specified maximum rating of fuse and/or inverse time circuit breaker.

(2) Each motor controller is approved for group installation with a specified maximum rating of fuse and/or circuit breaker.

(3) Each circuit breaker is of the inverse time type and approved for group installation.

(4) The branch circuit shall be protected by fuses or inverse time circuit breakers having a rating not exceeding that specified in Section 430-52 for the largest motor connected to the branch circuit plus an amount equal to the sum of the full-load current ratings of all other motors and the ratings of other loads connected to the circuit. Where this calculation results in a rating less than the ampacity of the supply conductors, it shall be permitted to increase the maximum rating of the fuses or circuit breaker to a value not exceeding that permitted by Section 240-3 Exception No. 1.

(5) The branch-circuit fuses or inverse time circuit breakers are not larger than allowed by Section 430-40 for the thermal cutout or overload relay protecting the smallest motor of the group.

(d) **Single Motor Taps.** For group installations described above, the conductors of any tap supplying a single motor shall not be required to have an individual branch-circuit protective device, provided they comply with either of the following: (1) no conductor to the motor shall have an ampacity less than that of the branch-circuit conductors; or (2) no conductor to the motor shall have an ampacity less than $1/3$ that of the branch-circuit conductors, with a minimum in accordance with Section 430-22; the conductors to the motor-running overload device being not more than 25 feet long and being protected from physical damage.

430-54. Multimotor and Combination-Load Equipment. The rating of the branch-circuit protective device for multimotor and combination-load equipment shall not exceed the rating marked on the equipment in accordance with Section 430-7(d).

430-55. Combined Overcurrent Protection. Motor branch-circuit short-circuit and ground-fault protection and motor-running overload protection shall be permitted to be combined in a single protective device where the rating or setting of the device provides the running overload protection specified in Section 430-32.

430-56. Branch-Circuit Protective Devices — In Which Conductor. Branch-circuit protective devices shall comply with the provisions of Section 240-20.

430-57. Size of Fuseholder. Where fuses are used for motor branch-circuit short-circuit and ground-fault protection, the fuseholders shall not be of a smaller size than required to accommodate the fuses specified by Table 430-152.

Exception: Where fuses having time delay appropriate for the starting characteristics of the motor are used, fuseholders of smaller size than specified in Table 430-152 shall be permitted.

430-58. Rating of Circuit Breaker. A circuit breaker for motor branch-circuit short-circuit and ground-fault protection shall have a current rating in accordance with Sections 430-52 and 430-110.

E. Motor Feeder Short-Circuit and Ground-Fault Protection

430-61. General. Part E specifies protective devices intended to protect feeder conductors supplying motors against overcurrents due to short circuits or grounds.

430-62. Rating or Setting — Motor Load.

(a) **Specific Load.** A feeder supplying a specific fixed motor load(s) and consisting of conductor sizes based on Section 430-24 shall be provided with a protective device having a rating or setting not greater than the largest rating or setting of the branch-circuit short-circuit and ground-fault protective device for any motor of the group (based on Table 430-152), plus the sum of the full-load currents of the other motors of the group.

Where two or more motors of equal horsepower rating are the largest in the group, one of these motors shall be considered as the largest for the above calculations.

See Example No. 8, Chapter 9.

(b) **Future Additions.** For large-capacity installations, where heavy-capacity feeders are installed to provide for future additions or changes, the rating or setting of the feeder protective devices shall be permitted to be based on the rated ampacity of the feeder conductors.

430-63. Rating or Setting — Power and Light Loads. Where a feeder supplies a motor load, and in addition a lighting or a lighting and appliance load, the feeder protective device shall be permitted to have a rating or setting sufficient to carry the lighting or the lighting and appliance load as determined in accordance with Articles 210 and 220, plus, for a single motor, the rating permitted by Section 430-52, and for two or more motors, the rating permitted by Section 430-62.

F. Motor Control Circuits

430-71. General. Part F contains modifications of the general requirements and applies to the particular conditions of motor control circuits.

Definition of Control Circuit: The circuit of a control apparatus or system that carries the electric signals directing the performance of the controller, but does not carry the main power current.

Control circuits tapped from the load side of the motor branch-circuit short-circuit protective devices shall not be considered to be branch circuits and shall be permitted to be protected by either supplementary or branch-circuit overcurrent protective devices.

430-72. Overcurrent Protection.

(a) **In Equipment Enclosure.** Conductors of control circuits which do not extend beyond the control equipment enclosure shall be considered to be protected by the motor branch-circuit short-circuit and ground-fault protective device(s).

(b) **Extending Beyond Equipment Enclosure.** Conductors of control circuits extending beyond the control equipment enclosure shall be protected against overcurrent in accordance with their ampacities.

Exception No. 1: Where a control circuit transformer is provided, overcurrent protection shall be in accordance with Section 430-72(c).

Exception No. 2: The conductors shall be considered to be protected by the motor branch-circuit short-circuit and ground-fault protective device(s) under either of the following conditions:

(a) Where the rating or setting of the protective device(s) is not more than 300 percent of the ampacity of the control circuit conductors.

(b) Where the opening of the control circuit would create a hazard, as for example, the control circuit of a fire pump motor, and the like.

(c) Control Circuit Transformer. Where a control circuit transformer is provided and its secondary circuit extends beyond the control equipment enclosure, an overcurrent protective device(s) shall be provided in the secondary circuit. This device(s) shall be rated or set at not more than 200 percent of the rated secondary current of the transformer and not more than 200 percent of the ampacity of the control circuit conductors extending beyond the control equipment enclosure.

Exception No. 1: Where the transformer supplies a Class 2 circuit, overcurrent protection shall conform with Part C of Article 725.

Exception No. 2: Where protection is provided by other approved means.

Exception No. 3: Overcurrent protection shall be omitted where the opening of the control circuit would create a hazard, as for example, the control circuit of a fire pump motor, and the like.

430-73. Mechanical Protection of Conductor. Where damage to a control circuit would constitute a hazard, all conductors of such a remote-control circuit that are outside the control device itself shall be installed in a raceway or be otherwise suitably protected from physical damage.

Where one side of the control circuit is grounded, the control circuit shall be so arranged that an accidental ground in the remote-control devices will not start the motor.

430-74. Disconnection.

(a) General. Control circuits shall be so arranged that they will be disconnected from all sources of supply when the disconnecting means is in the open position. The disconnecting means shall be permitted to consist of two or more separate devices, one of which disconnects the motor and the controller from the source(s) of power supply for the motor, and the other(s), the control circuit(s) from its power supply. Where separate devices are used, they shall be located immediately adjacent one to each other.

(b) Control Transformer in Controller. Where a transformer or other device is used to obtain a reduced voltage for the control circuit and is located in the controller, such transformer or other device shall be connected to the load side of the disconnecting means for the control circuit.

G. Motor Controllers

430-81. General. Part G is intended to require suitable controllers for all motors.

(a) Definition. For definition of "Controller," see Article 100. For

the purpose of this Article, the term "Controller" includes any switch or device normally used to start and stop a motor.

(b) Stationary Motor of $\frac{1}{8}$ Horsepower or Less. For a stationary motor rated at $\frac{1}{8}$ horsepower or less that is normally left running and is so constructed that it cannot be damaged by overload or failure to start, such as clock motors and the like, the branch-circuit protective device shall be permitted to serve as the controller.

(c) Portable Motor of $\frac{1}{3}$ Horsepower or Less. For a portable motor rated at $\frac{1}{3}$ horsepower or less, the controller shall be permitted to be an attachment plug and receptacle.

430-82. Controller Design.

(a) Starting and Stopping. Each controller shall be capable of starting and stopping the motor it controls, and shall be capable of interrupting the stalled-rotor current of the motor.

(b) Autotransformer. An autotransformer starter shall provide an off position, a running position, and at least one starting position. It shall be so designed that it cannot rest in the starting position or in any position that will render the overload device in the circuit inoperative.

(c) Rheostats. Rheostats shall be in compliance with the following:

(1) Motor-starting rheostats shall be so designed that the contact arm cannot be left on intermediate segments. The point or plate on which the arm rests when in the starting position shall have no electrical connection with the resistor.

(2) Motor-starting rheostats for direct-current motors operated from a constant voltage supply shall be equipped with automatic devices that will interrupt the supply before the speed of the motor has fallen to less than $\frac{1}{3}$ its normal value.

430-83. Rating. The controller shall have a horsepower rating not lower than the horsepower rating of the motor.

Exception No. 1: For a stationary motor rated at 2 horsepower or less, and 300 volts or less, the controller shall be permitted to be a general-use switch having an ampere rating not less than twice the full-load current rating of the motor.

On AC circuits, general-use snap switches suitable only for use on AC (not general-use AC-DC snap switches) shall be permitted to control a motor rated at 2 horsepower or less and 300 volts or less having a full-load current rating not more than 80 percent of the ampere rating of the switch.

Exception No. 2: A branch-circuit inverse time circuit breaker rated in amperes only shall be permitted as a controller. Where this circuit breaker is also used for overload protection, it shall conform to the appropriate provisions of this Article governing overload protection.

Exception No. 3: The motor controller for a torque motor shall have a continuous-duty full-load current rating not less than the nameplate current rating of the motor. For a motor controller rated in horsepower but not marked with the foregoing current rating, the equivalent current rating shall be determined from the horsepower rating by using Table 430-147, 430-148, 430-149, or 430-150.

430-84. Need Not Open All Conductors. The controller shall not be required to open all conductors to the motor.

Exception: Where the controller serves also as a disconnecting means, it shall open all ungrounded conductors to the motor as provided in Section 430-111.

430-85. In Grounded Conductors. One pole of the controller shall be permitted to be placed in a permanently grounded conductor, provided the controller is so designed that the pole in the grounded conductor cannot be opened without simultaneously opening all conductors of the circuit.

430-86. Motor Not in Sight from Controller. Where a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

(1) The controller disconnecting means shall be capable of being locked in the open position.

(2) A manually operable switch that will disconnect the motor from its source of supply shall be placed within sight from the motor location.

430-87. Number of Motors Served by Each Controller. Each motor shall be provided with an individual controller.

Exception: For motors of 600 volts or less, a single controller rated at not less than the sum of the horsepower ratings of all of the motors of the group shall be permitted to serve the group of motors under any one of the following conditions:

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

b. Where a group of motors is under the protection of one over-current device as permitted in Section 430-53(a).

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

430-88. Adjustable-Speed Motors. Adjustable-speed motors that are controlled by means of field regulation shall be so equipped and connected that they cannot be started under weakened field.

Exception: Where the motor is designed for such starting.

430-89. Speed Limitation. Machines of the following types shall be provided with speed limiting devices:

(1) Separately excited direct-current motors.

(2) Series motors.

(3) Motor-generators and converters that can be driven at excessive speed from the direct-current end, as by a reversal of current or decrease in load.

Exception No. 1: When the inherent characteristics of the machines, the system, or the load and the mechanical connection thereto are such as to safely limit the speed.

Exception No. 2: When the machine is always under the manual control of a qualified operator.

430-90. Combination Fuseholder and Switch As Controller. The rating of a combination fuseholder and switch used as a motor controller shall be such that the fuseholder will accommodate the size of fuse specified in Part C of this Article for motor-running overload protection.

Exception: Where fuses having time delay appropriate for the starting characteristics of the motor are used, fuseholders of smaller size than specified in Part C of this Article shall be permitted.

H. Disconnecting Means

430-101. General. Part H is intended to require disconnecting means capable of disconnecting motors and controllers from the circuit.

See Diagram 430-1.

See Section 110-22 for identification of disconnecting means.

430-102. In Sight From Controller Location. A disconnecting means shall be located in sight from the controller location.

Exception: For motor circuits over 600 volts, nominal, the controller disconnecting means shall be permitted to be out of sight of the controller, provided the controller is marked with a warning label giving the location and identification of the disconnecting means to be locked in the open position.

430-103. To Disconnect Both Motor and Controller. The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently. The disconnecting means shall be permitted in the same enclosure with the controller.

See Section 430-113 for equipment receiving energy from more than one source.

430-104. To Be Indicating. The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.

430-105. Grounded Conductors. One pole of the disconnecting means shall be permitted to disconnect a permanently grounded conductor, provided the disconnecting means is so designed that the pole in the grounded conductor cannot be opened without simultaneously disconnecting all conductors of the circuit.

430-106. Service Switch As Disconnecting Means. Where an installation consists of a single motor, the service switch may serve as the disconnecting means if it complies with this Article and is within sight from the controller location.

430-107. Readily Accessible. One of the disconnecting means shall be readily accessible.

430-108. Every Switch. Every switch in the motor branch circuit within sight from the controller location shall comply with the requirements of Part H of this Article.

430-109. Type. The disconnecting means shall be a motor-circuit switch rated in horsepower or a circuit breaker.

Exception No. 1: For stationary motors of 1/8 horsepower or less, the branch-circuit overcurrent device shall be permitted to serve as the disconnecting means.

Exception No. 2: For stationary motors rated at 2 horsepower or less and 300 volts or less, the disconnecting means shall be permitted to be a general-use switch having an ampere rating not less than twice the full-load current rating of the motor.

On AC circuits, general-use snap switches suitable only for use on AC (not general-use AC-DC snap switches) shall be permitted to disconnect a motor having a full-load current rating not exceeding 80 percent of the ampere rating of the switch.

Exception No. 3: For motors of over 2 horsepower to and including 100 horsepower, the separate disconnecting means required for a motor with an autotransformer-type controller shall be permitted to be a general-use switch where all of the following provisions are met:

a. The motor drives a generator that is provided with overload protection.

b. The controller (1) is capable of interrupting the locked-rotor current of the motor, (2) is provided with a no-voltage release, and (3) is provided with running overload protection not exceeding 125 percent of the motor full-load current rating.

c. Separate fuses or an inverse time circuit breaker rated or set at not more than 150 percent of the motor full-load current are provided in the motor branch circuit.

Exception No. 4: For stationary motors rated at more than 100 horsepower, the disconnecting means shall be permitted to be a motor-circuit switch also rated in amperes, a general-use switch, or an isolating switch.

Isolating switches shall be plainly marked "Do not open under load."

Exception No. 5: For portable motors, an attachment plug and receptacle shall be permitted to serve as the disconnecting means.

430-110. Ampere Rating and Interrupting Capacity.

(a) General. The disconnecting means for motor circuits rated 600 volts, nominal or less shall have an ampere rating of at least 115 percent of the full-load current rating of the motor.

(b) For Torque Motors. The disconnecting means for a torque motor shall be selected on the basis of the motor nameplate current as follows:

(1) The ampacity shall be at least 115 percent of the motor nameplate current.

(2) To determine the equivalent horsepower in complying with the requirements of Section 430-109, select the horsepower rating from Table 430-147, 430-148, 430-149, or 430-150 corresponding to the motor current. Where the motor nameplate current does not correspond to a current shown in the Table, the horsepower rating corresponding to the next higher value shall be selected.

(c) For Combination Loads. Where two or more motors are used together or where one or more motors are used in combination with other loads, such as resistance heaters, and where the combined load may be simultaneous on a single disconnecting means, the ampere and horsepower ratings of the combined load shall be determined as follows:

(1) The rating of the disconnecting means shall be determined from the summation of all currents, including resistance loads, at the full-load condition and also at the locked-rotor condition. The combined full-load current and the combined locked-rotor current so obtained shall be considered as a single motor for the purpose of this requirement as follows:

The full-load current equivalent to the horsepower rating of each motor shall be selected from Table 430-148, 430-149, or 430-150. These full-load currents shall be added to the rating in amperes of other loads to obtain an equivalent full-load current for the combined load.

The locked-rotor current equivalent to the horsepower rating of each motor shall be selected from Table 430-151. The locked-rotor currents shall be added to the rating in amperes of other loads to obtain an equivalent locked-rotor current for the combined load. Where two or more motors and/or other loads cannot be started simultaneously, appropriate combinations of locked-rotor and full-load current shall be permitted to be used to determine the equivalent locked-rotor current for the simultaneous combined loads.

Exception: Where part of the concurrent load is resistance load, and where the disconnecting means is a switch rated in horsepower and amperes, the horsepower rating of the switch shall not be less than the combined load of the motor(s), and the ampere rating shall not be less than the locked-rotor current of the motor(s) plus the resistance load.

(2) The ampere rating of the disconnecting means shall not be less than 115 percent of the summation of all currents at the full-load condition determined in accordance with (c) (1) above.

(3) For small motors not covered by Table 430-147, 430-148, 430-149, or 430-150, the locked-rotor current shall be assumed to be 6 times the full-load current.

430-111. Switch or Circuit Breaker As Both Controller and Disconnecting Means. A switch or circuit breaker complying with Section 430-83 shall be permitted to serve as both controller and disconnecting means if it opens all ungrounded conductors to the motor, if it is protected by an overcurrent device (which may be the branch-circuit fuses) that opens all ungrounded conductors to the switch or circuit breaker, and if it is of one of the following types:

(1) An air-break switch, operable directly by applying the hand to a lever or handle.

(2) An inverse time circuit breaker operable directly by applying the hand to a lever or handle.

(3) An oil switch used on a circuit whose rating does not exceed 600 volts or 100 amperes, or by special permission on a circuit exceeding this capacity where under expert supervision.

The oil switch or circuit breaker specified above shall be permitted to be both power and manually operable.

The overcurrent device protecting the controller shall be permitted to be part of the controller assembly or shall be permitted to be separate.

An autotransformer-type controller shall be provided with a separate disconnecting means.

430-112. Motors Served by Single Disconnecting Means. Each motor shall be provided with an individual disconnecting means.

Exception: A single disconnecting means shall be permitted to serve a group of motors under any one of the following conditions:

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

b. Where a group of motors is under the protection of one set of branch-circuit protective devices as permitted by Section 430-53(a).

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

The single disconnecting means shall have a rating not less than is required by Section 430-110 for a single motor, the rating of which equals the sum of the horsepowers or currents of all the motors of the group.

430-113. Energy From More Than One Source. Equipment receiving electrical energy from more than one source shall be provided with disconnecting means from each source of electrical energy immediately adjacent to the equipment served. Each source shall be permitted to have a separate disconnecting means.

J. Over 600 Volts, Nominal

430-121. General. Part J recognizes the additional hazard due to the use of high voltage. It adds to or amends the other provisions of this Article. Other requirements for circuits and equipment operating at over 600 volts, nominal are in Article 710.

430-122. Marking on Controllers. In addition to the marking required by Section 430-8, a controller shall be marked with the control voltage.

430-123. Conductor Enclosures Adjacent to Motors. Flexible metal conduit not exceeding 6 feet in length shall be permitted to be employed for raceway connection to a motor terminal enclosure.

430-124. Size of Conductors. Conductors supplying motors shall have an ampacity not less than the current at which the motor overload protective device is selected to trip.

430-125. Motor Circuit Overcurrent Protection.

(a) General. The high-voltage circuit for each motor shall include coordinated protection to automatically interrupt motor running overcurrent (overload) and fault currents in the motor, the motor circuit conductors, and the motor control apparatus.

Exception: Where a motor is vital to operation of the plant and the motor should operate to failure if necessary to prevent a greater hazard to persons, the sensing device(s) is permitted to be connected to a supervised annunciator or alarm instead of interrupting the motor circuit.

(b) Overload Protection.

(1) Each motor shall be protected against dangerous heating due to motor overloads and failure to start by a thermal protector integral with the motor or external current sensing devices, or both.

(2) The secondary circuits of wound-rotor alternating-current motors including conductors, controllers, and resistors rated for the application, shall be considered as protected against overcurrent by the motor overload protection means.

(3) Operation of the overload interrupting device shall simultaneously disconnect all ungrounded conductors.

(4) Overload sensing devices shall not automatically reset after trip unless resetting of the overload sensing device does not cause automatic restarting of the motor or there is no hazard to persons created by automatic restarting of the motor and its connected machinery.

(c) Fault Current Protection.

(1) Fault current protection shall be provided in each motor circuit by one of the following means:

a. A circuit breaker of suitable type and rating so arranged that it can be serviced without hazard. The circuit breaker shall simultaneously disconnect all ungrounded conductors. The circuit breaker shall be permitted to sense the fault current by means of integral or external sensing elements.

b. Fuses of a suitable type and rating placed in each ungrounded conductor. Fuses shall be used with suitable disconnecting means or they shall be of a type that can also serve as the disconnecting means. They shall be so arranged that they cannot be serviced while they are energized.

(2) Fault current interrupting devices shall not reclose the circuit automatically.

Exception: Where circuits are exposed to transient faults and where automatic reclosing of the circuit does not create a hazard to persons.

(3) Overload protection and fault current protection shall be permitted to be provided by the same device.

430-126. Rating of Motor Control Apparatus. Motor controllers and motor branch-circuit disconnecting means shall have a continuous ampere rating not less than the current at which the overload protective device is selected to trip.

430-127. Disconnecting Means. The controller disconnecting means shall be capable of being locked in the open position.

K. Protection of Live Parts — All Voltages

430-131. General. Part K specifies that live parts shall be protected in a manner judged adequate to the hazard involved.

430-132. Where Required. Exposed live parts of motors and controllers operating at 50 volts or more between terminals shall be guarded against accidental contact by enclosure or by location as follows:

(1) By installation in a room or enclosure that is accessible only to qualified persons.

(2) By installation on a suitable balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons.

(3) By elevation 8 feet or more above the floor.

Exception: Stationary motors having commutators, collectors, and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground.

430-133. Guards for Attendants. Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact only by location as specified in Section 430-132, and where adjustment or other attendance may be necessary during the operation of the apparatus, suitable insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

For working space, see Sections 110-16 and 110-34.

L. Grounding

430-141. General. Part L specifies the grounding of motor and controller frames to prevent a potential above ground in the event of accidental contact between live parts and frames. Insulation, isolation, or guarding are suitable alternatives to grounding of motors under certain conditions.

430-142. Stationary Motors. The frames of stationary motors shall be grounded under any of the following conditions:

- (1) Where supplied by metal-enclosed wiring.
- (2) Where in a wet location and not isolated or guarded.
- (3) If in a hazardous location as covered in Articles 500 through 517.
- (4) If the motor operates with any terminal at over 150 volts to ground.

Where the frame of the motor is not grounded, it shall be permanently and effectively insulated from the ground.

430-143. Portable Motors. The frames of portable motors that operate at over 150 volts to ground shall be guarded or grounded.

See Section 250-45(d) for grounding of portable appliances in other than residential occupancies.

See Section 250-59(b) for color of grounding conductor.

430-144. Controllers. Controller enclosures shall be grounded regardless of voltage.

Exception No. 1: Enclosures attached to ungrounded portable equipment.

Exception No. 2: Lined covers of snap switches.

430-145. Method of Grounding. Where required, grounding shall be done in the manner specified in Article 250.

(a) **Grounding Through Terminal Housings.** Where the wiring to fixed motors is Type AC metal-clad cable or in metal raceways, junction boxes to house motor terminals shall be provided, and the armor of the cable or the metal raceways shall be connected to them in the manner specified in Article 250.

(b) **Separation of Junction Box from Motor.** The junction box required by (a) above shall be permitted to be separated from the motor not more than 6 feet, provided the leads to the motor are Type AC metal-clad cable or armored cord or are stranded leads enclosed in flexible or rigid metal conduit or electrical metallic tubing not smaller than $\frac{3}{8}$ -inch electrical trade size, the armor or raceway being connected both to the motor and to the box. Where stranded leads are used, protected as specified above, they shall not be larger than No. 10, and shall comply with other requirements of this Code for conductors to be used in raceways.

(c) **Grounding of Controller Mounted Devices.** Instrument transformer secondaries and exposed noncurrent-carrying metal or other conductive parts or cases of instrument transformers, meters, instruments, and relays shall be grounded as specified in Sections 250-121 through 250-125.

Table 430-147. Full-Load Current in Amperes, Direct-Current Motors

The following values of full-load currents* are for motors running at base speed.

HP	Armature Voltage Rating*					
	90V	120V	180V	240V	500V	550V
$\frac{1}{4}$	4.0	3.1	2.0	1.6		
$\frac{1}{3}$	5.2	4.1	2.6	2.0		
$\frac{1}{2}$	6.8	5.4	3.4	2.7		
$\frac{3}{4}$	9.6	7.6	4.8	3.8		
1	12.2	9.5	6.1	4.7		
$1\frac{1}{2}$		13.2	8.3	6.6		
2		17	10.8	8.5		
3		25	16	12.2		
5		40	27	20		
$7\frac{1}{2}$		58		29	13.6	12.2
10		76		38	18	16
15				55	27	24
20				72	34	31
25				89	43	38
30				106	51	46
40				140	67	61
50				173	83	75
60				206	99	90
75				255	123	111
100				341	164	148
125				425	205	185
150				506	246	222
200				675	330	294

* These are average direct-current quantities.

Table 430-148. Full-Load Currents in Amperes**Single-Phase Alternating-Current Motors**

The following values of full-load currents are for motors running at usual speeds and motors with normal torque characteristics. Motors built for especially low speeds or high torques may have higher full-load currents, and multispeed motors will have full-load current varying with speed, in which case the nameplate current ratings shall be used.

To obtain full-load currents of 208- and 200-volt motors, increase corresponding 230-volt motor full-load currents by 10 and 15 percent, respectively.

The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120 and 220 to 240.

HP	115V	230V
$\frac{1}{8}$	4.4	2.2
$\frac{1}{4}$	5.8	2.9
$\frac{1}{3}$	7.2	3.6
$\frac{1}{2}$	9.8	4.9
$\frac{3}{4}$	13.8	6.9
1	16	8
$1\frac{1}{2}$	20	10
2	24	12
3	34	17
5	56	28
$7\frac{1}{2}$	80	40
10	100	50

Table 430-149. Full-Load Current**Two-Phase Alternating-Current Motors (4-Wire)**

The following values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, and multispeed motors will have full-load current varying with speed, in which case the nameplate current rating shall be used. Current in the common conductor of a 2-phase, 3-wire system will be 1.41 times the value given.

The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

HP	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type †Unity Power Factor Amperes			
	115V	230V	460V	575V	2300V	220V	440V	550V	2300V
½	4	2	1	.8					
¾	4.8	2.4	1.2	1.0					
1	6.4	3.2	1.6	1.3					
1½	9	4.5	2.3	1.8					
2	11.8	5.9	3	2.4					
3		8.3	4.2	3.3					
5		13.2	6.6	5.3					
7½		19	9	8					
10		24	12	10					
15		36	18	14					
20		47	23	19					
25		59	29	24		47	24	19	
30		69	35	28		56	29	23	
40		90	45	36		75	37	31	
50		113	56	45		94	47	38	
60		133	67	53	14	111	56	44	11
75		166	83	66	18	140	70	57	13
100		218	109	87	23	182	93	74	17
125		270	135	108	28	228	114	93	22
150		312	156	125	32		137	110	26
200		416	208	167	43		182	145	35

† For 90 and 80 percent power factor, the above figures shall be multiplied by 1.1 and 1.25 respectively.

Table 430-150. Full-Load Current*
Three-Phase Alternating-Current Motors

HP	Induction Type Squirrel-Cage and Wound Rotor Amperes					Synchronous Type †Unity Power Factor Amperes			
	115V	230V	460V	575V	2300V	220V	440V	550V	2300V
½	4	2	1	.8					
¾	5.6	2.8	1.4	1.1					
1	7.2	3.6	1.8	1.4					
1½	10.4	5.2	2.6	2.1					
2	13.6	6.8	3.4	2.7					
3		9.6	4.8	3.9					
5		15.2	7.6	6.1					
7½		22	11	9					
10		28	14	11					
15		42	21	17					
20		54	27	22					
25		68	34	27		54	27	22	
30		80	40	32		65	33	26	
40		104	52	41		86	43	35	
50		130	65	52		108	54	44	
60		154	77	62	16	128	64	51	12
75		192	96	77	20	161	81	65	15
100		248	124	99	26	211	106	85	20
125		312	156	125	31	264	132	106	25
150		360	180	144	37		158	127	30
200		480	240	192	49		210	168	40

For full-load currents of 208- and 200-volt motors, increase the corresponding 230-volt motor full-load current by 10 and 15 percent, respectively.

* These values of full-load current are for motors running at speeds usual for belted motors and motors with normal torque characteristics. Motors built for especially low speeds or high torques may require more running current, and multispeed motors will have full-load current varying with speed, in which case the nameplate current rating shall be used.

† For 90 and 80 percent power factor the above figures shall be multiplied by 1.1 and 1.25 respectively.

The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

Table 430-151. Locked-Rotor Current Conversion Table

As Determined from Horsepower and Voltage Rating
For Use Only With Sections 430-110, 440-12, and 440-41.

Conversion Table

Max HP Rating	Motor Locked-Rotor Current Amperes						
	Single Phase		Two or Three Phase				
	115V	230V	115V	200V	230V	460V	575V
1/2	58.8	29.4	24	14	12	6	4.8
3/4	82.8	41.4	33.6	19	16.8	8.4	6.6
1	96	48	42	24	21	10.8	8.4
1 1/2	120	60	60	34	30	15	12
2	144	72	78	45	39	19.8	15.6
3	204	102	—	62	54	27	24
5	336	168	—	103	90	45	36
7 1/2	480	240	—	152	132	66	54
10	600	300	—	186	162	84	66
15	—	—	—	276	240	120	96
20	—	—	—	359	312	156	126
25	—	—	—	442	384	192	156
30	—	—	—	538	468	234	186
40	—	—	—	718	624	312	246
50	—	—	—	862	750	378	300
60	—	—	—	1035	900	450	360
75	—	—	—	1276	1110	558	444
100	—	—	—	1697	1476	738	588
125	—	—	—	2139	1860	930	744
150	—	—	—	2484	2160	1080	864
200	—	—	—	3312	2880	1440	1152

**Table 430-152. Maximum Rating or Setting of
Motor Branch-Circuit Protective Devices**

Type of Motor	Percent of Full-Load Current			
	Nontime Delay Fuse	Dual- Element (Time- Delay) Fuse	Instant- aneous Trip Breaker	*Inverse Time Breaker
Single-phase, all types				
No code letter	300	175	700	250
All AC single-phase and polyphase squirrel-cage and synchronous motors† with full-voltage, resis- tor or reactor starting:				
No code letter	300	175	700	250
Code letter F to V	300	175	700	250
Code letter B to E	250	175	700	200
Code letter A	150	150	700	150
All AC squirrel-cage and synchronous motors† with autotransformer starting:				
Not more than 30 amps				
No code letter	250	175	700	200
More than 30 amps				
No code letter	200	175	700	200
Code letter F to V	250	175	700	200
Code letter B to E	200	175	700	200
Code letter A	150	150	700	150
High-reactance squirrel- cage				
Not more than 30 amps				
No code letter	250	175	700	250
More than 30 amps				
No code letter	200	175	700	200
Wound-rotor — No				
code letter	150	150	700	150
Direct-current (constant voltage)				
Not more than 50 hp				
No code letter	150	150	250	150
More than 50 hp				
No code letter	150	150	175	150

For explanation of Code Letter Marking, see Table 430-7(b).

For certain exceptions to the values specified, see Sections 430-52 through 430-54.

* The values given in the last column also cover the ratings of nonadjustable inverse time types of circuit breakers that may be modified as in Section 430-52.

† Synchronous motors of the low-torque, low-speed type (usually 450 rpm or lower), such as are used to drive reciprocating compressors, pumps, etc. that start unloaded, do not require a fuse rating or circuit-breaker setting in excess of 200 percent of full-load current.

ARTICLE 440 — AIR-CONDITIONING AND REFRIGERATING EQUIPMENT

A. General

440-1. Scope.

The provisions of this Article apply to electric motor-driven air-conditioning and refrigerating equipment, and to the branch circuits and controllers for such equipment. It provides for the special considerations necessary for circuits supplying hermetic refrigerant motor-compressors and for any air-conditioning and/or refrigerating equipment which is supplied from an individual branch circuit which supplies a hermetic refrigerant motor-compressor.

Hermetic Refrigerant Motor-Compressor: A combination consisting of a compressor and motor, both of which are enclosed in the same housing, with no external shaft or shaft seals, the motor operating in the refrigerant.

440-2. Other Articles.

(a) These provisions are in addition to, or amendatory of, the provisions of Article 430 and other Articles in this Code, which apply except as modified in this Article.

(b) The rules of Articles 422, 424, or 430, as applicable, shall apply to air-conditioning and refrigerating equipment which does not incorporate a hermetic refrigerant motor-compressor. Examples of such equipment are devices which employ refrigeration compressors driven by conventional motors, furnaces with air-conditioning evaporator coils installed, fan-coil units, remote forced air-cooled condensers, remote commercial refrigerators, etc.

(c) Devices such as room air conditioners, household refrigerators and freezers, drinking-water coolers, and beverage dispensers shall be considered appliances and the provisions of Article 422 shall also apply.

(d) Hermetic refrigerant motor-compressors, circuits, controllers, and equipment shall also comply with the applicable provisions of the following:

Capacitors	Section 460-9
Garages, Aircraft Hangars, Gasoline Dispensing and Service Stations, Bulk Storage Plants, Finishing Processes and Flammable Anesthetics	Articles 511, 513, 514, 515, 516, and 517-E
Hazardous Locations	Articles 500 thru 503
Motion-Picture Studios	Article 530
Resistors and Reactors	Article 470

440-3. Marking on Hermetic Refrigerant Motor-Compressors and Equipment.

(a) A hermetic refrigerant motor-compressor shall be provided with a nameplate which shall give the manufacturer's name, trademark or symbol; identifying designation; the phase; voltage; and frequency. The rated load current in amperes of the motor-compressor, shall be marked by the equipment manufacturer on either or both the

motor-compressor nameplate and the nameplate of the equipment in which the motor-compressor is used. The locked-rotor current of each single-phase motor-compressor having a rated-load current of more than 9 amperes at 115 volts or more than 4.5 amperes at 230 volts and each polyphase motor-compressor shall be marked on the motor-compressor nameplate. Where a thermal protector complying with Sections 440-52(a)(2) and (b)(2) is used, the motor-compressor nameplate or the equipment nameplate shall be marked with the words "Thermally Protected." Where a protective system, complying with Sections 440-52(a)(4) and 440-52(b)(4), is used and is furnished with the equipment, the equipment nameplate shall be marked with the words, "Thermally Protected System." Where a protective system complying with Sections 440-52(a)(4) and 440-52(b)(4) is specified, the equipment nameplate shall be appropriately marked.

Definition: The rated-load current for a hermetic refrigerant motor-compressor is the current resulting when the motor-compressor is operated at the rated load, rated voltage and rated frequency of the equipment it serves.

(b) Multimotor and combination-load equipment shall be provided with a visible nameplate marked with the maker's name, the rating in volts, frequency and number of phases, minimum supply circuit conductor ampacity, and the maximum rating of the branch-circuit short-circuit and ground-fault protective device. The ampacity shall be calculated by using Part D and counting all the motors and other loads which will be operated at the same time. The branch-circuit short-circuit and ground-fault protective device rating shall not exceed the value calculated by using Part C. Multimotor or combination-load equipment for use on two or more circuits shall be marked with the above information for each circuit.

Exception No. 1: Multimotor and combination-load equipment which is suitable under the provisions of this Article for connection to a single 15- or 20-ampere, 120-volt, or a 15-ampere, 208- or 240-volt single-phase branch circuit shall be permitted to be marked as a single load.

Exception No. 2: Room air conditioners as provided in Part G of Article 440.

(c) Hermetic refrigerant motor-compressors or equipment containing such compressor(s) in which the protection system, approved for use with the motor-compressor which it protects, permits continuous current in excess of the specified percentage of nameplate rated-load current given in Section 440-52(b)(2) or (b)(4) shall also be marked with a branch-circuit selection current that complies with Section 440-52(b)(2) or (b)(4). This marking shall be provided by the equipment manufacturer and shall be on the nameplate(s) where the rated-load current(s) appear.

Definition: Branch-circuit selection current is the value in amperes to be used instead of the rated-load current in determining the ratings of motor branch-circuit conductors, disconnecting means, controllers and branch-circuit short-circuit and ground-fault protective devices wherever the running overload protective device permits a sustained current greater than the specified percentage of the rated-load current. The value of branch-circuit selection current will always be greater than the marked rated-load current.

440-4. Marking on Controllers. A controller shall be marked with the

maker's name, trademark, or symbol; identifying designation; the voltage; phase; full-load and locked-rotor current (or horsepower) rating; and such other data as may be needed to properly indicate the motor-compressor for which it is suitable.

440-5. Ampacity and Rating. Ampacity of conductors and rating of equipment shall be determined as follows:

(a) For a hermetic refrigerant motor-compressor, the rated-load current marked on the nameplate of the equipment in which the motor-compressor is employed shall be used in determining the rating or ampacity of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground-fault protection, and the separate motor overload protection. Where no rated-load current is shown on the equipment nameplate, the rated-load current shown on the compressor nameplate shall be used. For disconnecting means and controllers, see also Sections 440-12 and 440-41.

Exception No. 1: When so marked, the branch-circuit selection current shall be used instead of the rated-load current to determine the rating or ampacity of the disconnecting means, the branch-circuit conductors, the controller, and the branch-circuit short-circuit and ground-fault protection.

Exception No. 2: As permitted in Section 440-22(b) for branch-circuit short-circuit and ground-fault protection of cord- and plug-connected equipment.

(b) For multimotor equipment employing a shaded-pole or permanent split-capacitor-type fan or blower motor, the full-load current for such motor marked on the nameplate of the equipment in which the fan or blower motor is employed shall be used instead of the horsepower rating to determine the ampacity or rating of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground-fault protection, and the separate overload protection. This marking on the equipment nameplate shall not be less than the current marked on the fan or blower motor nameplate.

440-6. Highest Rated (Largest) Motor. In determining compliance with this Article and with Sections 430-24, 430-53(b), 430-53(c), and 430-62(a), the highest rated (largest) motor shall be considered to be that motor which has the highest rated-load current. Where two or more motors have the same rated-load current, only one of them shall be considered as the highest rated (largest) motor. For other than hermetic refrigerant motor-compressors, and fan or blower motors as covered in Section 440-5(b), the full-load current used to determine the highest rated motor shall be the equivalent value corresponding to the motor horsepower rating selected from Table 430-148, 430-149, or 430-150.

Exception: When so marked, the branch-circuit selection current shall be used instead of the rated-load current in determining the highest rated (largest) motor-compressor.

440-7. Single Machine. An air-conditioning or refrigerating system shall be considered to be a single machine under the provisions of Section 430-87 Exception and Section 430-112 Exception. The motors shall be permitted to be located remotely from each other.

B. Disconnecting Means

440-11. General. The provisions of Part B are intended to require disconnecting means capable of disconnecting air-conditioning and refrigerating equipment including motor-compressors, and controllers, from the circuit feeder. See Diagram 430-1(a).

440-12. Rating and Interrupting Capacity.

(a) A disconnecting means serving a hermetic refrigerant motor-compressor shall be selected on the basis of the nameplate rated-load current or branch-circuit selection current, whichever is greater, and locked-rotor current, respectively, of the motor-compressor as follows:

(1) The ampere rating shall be at least 115 percent of the nameplate rated-load current or branch-circuit selection current, whichever is greater.

(2) To determine the equivalent horsepower in complying with the requirements of Section 430-109, the horsepower rating shall be selected from Tables 430-148, 430-149, or 430-150 corresponding to the rated-load current or branch-circuit selection current, whichever is greater, and also the horsepower rating from Table 430-151 corresponding to the locked-rotor current. In case the nameplate rated-load current or branch-circuit selection current and locked-rotor current do not correspond to the currents shown in Tables 430-148, 430-149, 430-150, or 430-151, the horsepower rating corresponding to the next higher value shall be selected. In case different horsepower ratings are obtained when applying these Tables, a horsepower rating at least equal to the larger of the values obtained shall be selected.

(b) Where one or more hermetic refrigerant motor-compressors are used together or are used in combination with other motors and/or loads such as resistance heaters and where the combined load may be simultaneous on a single disconnecting means, the rating for the combined load shall be determined as follows:

(1) The horsepower rating of the disconnecting means shall be determined from the summation of all currents, including resistance loads, at the rated-load condition and also at the locked-rotor condition. The combined rated-load current and the combined locked-rotor current so obtained shall be considered as a single motor for the purpose of this requirement as follows:

a. The full-load current equivalent to the horsepower rating of each motor, other than a hermetic refrigerant motor-compressor, and fan or blower motors as covered in Section 440-5(b) shall be selected from Tables 430-148, 430-149, or 430-150. These full-load currents shall be added to the motor-compressor rated-load current(s) or branch-circuit selection current(s), whichever is greater, and to the rating in amperes of other loads to obtain an equivalent full-load current for the combined load.

b. The locked-rotor current equivalent to the horsepower rating of each motor, other than a hermetic refrigerant motor-compressor, shall be selected from Table 430-151, and for fan and blower motors of the shaded-pole or permanent split-capacitor type marked with the locked-rotor current, the marked value shall be used. The locked-rotor currents shall be added to the motor-compressor locked-rotor cur-

rent(s) and to the rating in amperes of other loads to obtain an equivalent locked-rotor current for the combined load. Where two or more motors and/or other loads cannot be started simultaneously, appropriate combinations of locked-rotor and rated-load current or branch-circuit selection current, whichever is greater, shall be an acceptable means of determining the equivalent locked-rotor current for the simultaneous combined load.

Exception: Where part of the concurrent load is a resistance load and the disconnecting means is a switch rated in horsepower and amperes, the horsepower rating of the switch shall be not less than the combined load of the motor-compressor(s) and other motor(s) at the locked-rotor condition and the ampere rating shall be not less than this locked-rotor load plus the resistance load.

(2) The ampere rating of the disconnecting means shall be at least 115 percent of the summation of all currents at the rated-load condition determined in accordance with Section 440-12(b) (1).

(c) For small motor-compressors not having the locked-rotor current marked on the nameplate, or for small motors not covered by Tables 430-147, 430-148, 430-149, or 430-150, the locked-rotor current shall be assumed to be 6 times the rated-load current. See Section 440-3(a).

(d) Where the rated-load or locked-rotor current as determined above would indicate a disconnecting means rated in excess of 100 hp, the provisions of Section 430-109, Exception No. 4, shall apply.

440-13. Cord-Connected Equipment. For cord-connected equipment such as room air conditioners, household refrigerators and freezers, drinking water coolers and beverage dispensers, a separable connector or an attachment plug and receptacle shall be permitted to serve as the disconnecting means. See also Section 440-63.

440-14. Location. A disconnecting means shall be located within sight from and readily accessible from the air-conditioning or refrigerating equipment.

See Parts G and H of Article 430 for additional requirements.

C. Branch-Circuit Short-Circuit and Ground-Fault Protection

440-21. General. The provisions of Part C specify overcurrent devices intended to protect the branch-circuit conductors, control apparatus and motors in circuits supplying hermetic refrigerant motor-compressors against overcurrent due to short circuits and grounds. They are in addition to or amendatory of the provisions of Article 240.

440-22. Application and Selection.

(a) **Rating or Setting for Individual Motor-Compressor.** The motor-compressor branch-circuit short-circuit and ground-fault protective device shall be capable of carrying the starting current of the motor. The required protection shall be considered as being obtained when this device has a rating or setting not exceeding 175 percent of the motor-compressor rated-load current or branch-circuit selection current, whichever is greater (15 amperes size minimum); provided that where the protection specified is not sufficient for the starting current of the motor, it shall be permitted to be increased, but shall not exceed

225 percent of the motor rated-load current or branch-circuit selection current, whichever is greater.

(b) Rating or Setting for Equipment. The equipment branch-circuit short-circuit and ground-fault protective device shall be capable of carrying the starting current of the equipment. Where the hermetic refrigerant motor-compressor is the only load on the circuit, the protection shall conform with Section 440-22(a). Where the equipment incorporates more than one hermetic refrigerant motor-compressor or a hermetic refrigerant motor-compressor and other motors or other loads, the equipment protection shall conform with Section 430-53 and the following:

(1) Where a hermetic refrigerant motor-compressor is the largest load connected to the circuit, the rating or setting of the protective device shall not exceed the value specified in Section 440-22(a) for the largest motor-compressor plus the sum of the rated-load current or branch-circuit selection current, whichever is greater, of the other motor-compressor(s) and the ratings of the other loads supplied.

(2) Where a hermetic refrigerant motor-compressor is not the largest load connected to the circuit, the rating or setting of the protective device shall not exceed a value equal to the sum of the rated-load current or branch-circuit selection current, whichever is greater, rating(s) for the motor-compressor(s) plus the value specified in Section 430-53(c)(4) where other motor loads are supplied, or the value specified in Section 240-3 where only nonmotor loads are supplied in addition to the motor-compressor(s).

Exception No. 1: Equipment which will start and operate on a 15- or 20-ampere, 120-volt or 15-ampere, 208- or 240-volt, single-phase branch circuit shall be considered as protected by the 15- or 20-ampere overcurrent device protecting the branch circuit, but if the maximum circuit protective device rating marked on the equipment is less than these values, the circuit protective device shall not exceed the value marked on the equipment nameplate.

Exception No. 2: The nameplate marking of cord- and plug-connected equipment rated not greater than 250 volts, single-phase, such as household refrigerators and freezers, drinking-water coolers, and beverage dispensers shall be used in determining the branch-circuit requirements, and each unit shall be considered as a single motor unless the nameplate is marked otherwise.

(c) Where maximum protective device ratings shown on a manufacturer's heater table for use with a motor controller are less than the rating or setting selected in accordance with Sections 440-22(a) and (b), the protective device rating shall not exceed the manufacturer's values marked on the equipment.

D. Branch-Circuit Conductors

440-31. General. The provisions of Part D and Articles 300 and 310 specify sizes of conductors required to carry the motor current without

overheating under the conditions specified, except as modified in Section 440-5(a), Exception No. 1.

The provisions of these Articles shall not apply to integral conductors of motors, motor controllers and the like, or to conductors which form an integral part of approved equipment.

See Sections 300-1(b) and 310-1 for similar requirements.

440-32. Single Motor-Compressor. Branch-circuit conductors supplying a single motor-compressor shall have an ampacity not less than 125 percent of either the motor-compressor rated-load current or the branch-circuit selection current, whichever is greater.

440-33. Motor-Compressor(s) With or Without Additional Motor Loads. Conductors supplying one or more motor-compressor(s) with or without additional motor load(s) shall have an ampacity not less than the sum of the rated-load or branch-circuit selection current ratings, whichever are larger, of all the motor-compressor(s) plus the full-load currents of the other motor(s), plus 25 percent of the highest motor or motor-compressor rating in the group.

Exception No. 1: When the circuitry is so interlocked as to prevent the starting and running of a second motor-compressor or group of motor-compressors, the conductor size shall be determined from the largest motor-compressor or group of motor-compressors that is to be operated at a given time.

Exception No. 2: Room Air Conditioners as provided in Part G of Article 440.

440-34. Combination Load. Conductors supplying a motor-compressor load in addition to a lighting or appliance load as computed from Article 220 and other applicable Articles, shall have an ampacity sufficient for the lighting or appliance load plus the required ampacity for the motor-compressor load determined in accordance with Section 440-33, or, for a single motor-compressor, in accordance with Section 440-32.

Exception: When the circuitry is so interlocked as to prevent simultaneous operation of the motor-compressor(s) and all other loads connected, the conductor size shall be determined from the largest size required for the motor-compressor(s) and other loads to be operated at a given time.

440-35. Multimotor and Combination-Load Equipment. The ampacity of the conductors supplying multimotor and combination-load equipment shall not be less than the minimum circuit ampacity marked on the equipment in accordance with Section 440-3(b).

E. Controllers for Motor-Compressors

440-41. Rating.

(a) A motor-compressor controller shall have both a continuous-duty full-load current rating, and a locked-rotor current rating, not less than the nameplate rated-load current or branch-circuit selection current, whichever is greater, and locked-rotor current, respectively (see Sections 440-5 and 440-6) of the compressor. In case the motor controller is rated in horsepower, but is without one or both of the

foregoing current ratings, equivalent currents shall be determined from the ratings as follows: Use Table 430-148, 430-149, or 430-150 to determine the equivalent full-load current rating. Use Table 430-151 to determine the equivalent locked-rotor current rating.

(b) A controller, serving more than one motor-compressor or a motor-compressor and other loads, shall have a continuous-duty full-load current rating, and a locked-rotor current rating not less than the combined load as determined in accordance with Section 440-12(b).

F. Motor-Compressor and Branch-Circuit Overload Protection

440-51. General. The provisions of Part F specify devices intended to protect the motor-compressor, the motor-control apparatus, and the branch-circuit conductors against excessive heating due to motor overload and failure to start. (See Section 240-3(a), Exception No. 3.)

Note: Overload in electrically driven apparatus is an operating overcurrent which, when it persists for a sufficient length of time, would cause damage or dangerous overheating. It does not include short circuits or ground faults.

440-52. Application and Selection.

(a) **Protection of Motor-Compressor.** Each motor-compressor shall be protected against overload and failure to start by one of the following means:

(1) A separate overload relay which is responsive to motor-compressor current. This device shall be selected to trip at not more than 140 percent of the motor-compressor rated-load current.

(2) A thermal protector integral with the motor-compressor, approved for use with the motor-compressor which it protects, on the basis that it will prevent dangerous overheating of the motor-compressor due to overload and failure to start. If the current-interrupting device is separate from the motor-compressor and its control circuit is operated by a protective device integral with the motor-compressor, it shall be so arranged that the opening of the control circuit will result in interruption of current to the motor-compressor.

(3) A fuse or inverse time circuit breaker responsive to motor current, which shall also be permitted to serve as the branch-circuit short-circuit and ground-fault protective device. This device shall be rated at not more than 125 percent of the motor-compressor rated-load current. It shall have sufficient time delay to permit the motor-compressor to start and accelerate its load. The equipment or the motor-compressor shall be marked with this maximum branch-circuit fuse or inverse time circuit breaker rating.

(4) A protective system, furnished or specified and approved for use with the motor-compressor which it protects on the basis that it will prevent dangerous overheating of the motor-compressor due to overload and failure to start. If the current interrupting device is separate from the motor-compressor and its control circuit is operated by a protective device which is not integral with the current-interrupting device, it shall be so arranged that the opening of the control circuit will result in interruption of current to the motor-compressor.

(b) **Protection of Motor-Compressor Control Apparatus and Branch-Circuit Conductors.** The motor-compressor controller(s), the discon-

necting means and branch-circuit conductors shall be protected against overcurrent due to motor overload and failure to start by one of the following means which may be the same device or system protecting the motor-compressor in accordance with Section 440-52(a):

Exception: For motor-compressors and equipment on 15- or 20-ampere single-phase branch circuits as provided in Sections 440-54 and 440-55.

(1) An overload relay selected in accordance with Section 440-52(a)(1).

(2) A thermal protector applied in accordance with Section 440-52(a)(2) and which will not permit a continuous current in excess of 156 percent of the marked rated-load current or branch-circuit selection current.

(3) A fuse or inverse time circuit breaker selected in accordance with Section 440-52(a)(3).

(4) A protective system in accordance with Section 440-52(a)(4) and which will not permit a continuous current in excess of 156 percent of the marked rated-load current or branch-circuit selection current.

440-53. Overload Relays. Overload relays and other devices for motor overload protection, which are not capable of opening short circuits, shall be protected by fuses or inverse time circuit breakers with ratings or settings in accordance with Part C unless approved for group installation or for part-winding motors and marked to indicate the maximum size of fuse or inverse time circuit breaker by which they shall be protected.

Exception: The fuse or inverse time circuit breaker-size marking shall be permitted on the nameplate of approved equipment in which the overload relay or other overload device is used.

440-54. Motor-Compressors and Equipment on 15- or 20-Ampere Branch Circuits — Not Cord- and Attachment Plug-Connected. Overload protection for motor-compressors and equipment used on 15- or 20-ampere 120 volt, or 15-ampere 208- or 240-volt, single-phase branch circuits as permitted in Article 210, shall be permitted as indicated in (a) and (b) below:

(a) The motor-compressor shall be provided with overload protection selected as specified in Section 440-52(a). Both the controller and motor overload protective device shall be approved for installation with the short-circuit and ground-fault protective device for the branch circuit to which the equipment is connected.

(b) The short-circuit and ground-fault protective device protecting the branch circuit shall have sufficient time delay to permit the motor-compressor and other motors to start and accelerate their loads.

440-55. Cord-and-Attachment Plug-Connected Motor-Compressors and Equipment on 15- or 20-Ampere Branch Circuits. Overload protection for motor-compressors and equipment that are cord-and-attachment plug-connected and used on 15- or 20-ampere 120-volt, or 15-ampere 208- or 240-volt, single-phase branch circuits as permitted in Article 210, shall be permitted as indicated in (a), (b), and (c) below.

(a) The motor-compressor shall be provided with overload protection as specified in Section 440-52(a). Both the controller and the motor overload protective device shall be approved for installation with the short-circuit and ground-fault protective device for the branch circuit to which the equipment is connected.

(b) The rating of the attachment plug and receptacle shall not exceed 20 amperes at 125 volts or 15 amperes at 250 volts.

(c) The short-circuit and ground-fault protective device protecting the branch circuit shall have sufficient time delay to permit the motor-compressor and other motors to start and accelerate their loads.

G. Provisions For Room Air Conditioners

440-60. General. The provisions of Part G shall apply to electrically energized room air conditioners that control temperature and humidity. For the purpose of Part G, a room air conditioner (with or without provisions for heating) shall be considered as an alternating current appliance of the air cooled window, console, or in-wall type, that is installed in the conditioned room and which incorporates a hermetic refrigerant motor-compressor(s). The provisions of Part G cover equipment rated not over 250 volts, single phase, and such equipment shall be permitted to be cord-and-attachment plug-connected.

A room air conditioner that is rated 3 phase or rated over 250 volts shall be directly connected to a wiring method recognized in Chapter 3, and provisions of Part G shall not apply.

440-61. Grounding. Room air conditioners shall be grounded in accordance with Sections 250-42, 250-43, and 250-45.

440-62. Branch Circuit Requirements.

(a) A room air conditioner shall be considered as a single motor unit in determining its branch circuit requirements when all the following conditions are met:

(1) It is cord-and-attachment plug-connected.

(2) Its rating is not more than 40 amperes and 250 volts, single phase.

(3) Total rated-load current is shown on the room air conditioner nameplate rather than individual motor currents, and

(4) The rating of the branch-circuit short-circuit and ground-fault protective device does not exceed the ampacity of the branch-circuit conductors or the rating of the receptacle, whichever is less.

(b) The total marked rating of a cord-and-attachment plug-connected room air conditioner shall not exceed 80 percent of the rating of a branch circuit where no other loads are supplied.

(c) The total marked rating of a cord-and-attachment plug-connected room air conditioner shall not exceed 50 percent of the rating of a branch circuit where lighting units or other appliances are also supplied.

440-63. Disconnecting Means. An attachment plug and receptacle shall be permitted to serve as the disconnecting means for a single phase room air conditioner rated 250 volts or less if: (1) the manual controls on the room air conditioner are readily accessible and located within 6 feet of the floor, or (2) an approved manually operable switch is installed in a readily accessible location within sight from the room air conditioner.

440-64. Supply Cords. Where a flexible cord is used to supply a room air conditioner, the length of such cord shall not exceed: (1) 10 feet for a nominal 120 volt rating, or (2) 6 feet for a nominal 208 or 240 volt rating.

ARTICLE 445 — GENERATORS

445-1. Scope. Generators and their associated wiring and equipment shall be considered to be separately derived systems and shall comply with the applicable provisions of Article 230, 250, 700, and 750.

445-2. Location. Generators shall be of a type suitable for the locations in which they are installed. They shall also meet the requirements for motors in Section 430-14. Generators installed in hazardous locations as described in Articles 500 through 503, or in other locations as described in Articles 510 through 517, and in Articles 520, 530, and 665 shall also comply with the applicable provisions of those Articles.

445-3. Marking. Each generator shall be provided with a nameplate giving the maker's name, the rated frequency, power factor, number of phases if of alternating current, the rating in kilowatts or kilovolt amperes, the normal volts and amperes corresponding to the rating, rated revolutions per minute, insulation system class and rated ambient temperature or rated temperature rise, and time rating.

445-4. Overcurrent Protection.

(a) **Constant-Voltage Generators.** Constant-voltage generators, except alternating-current generator exciters, shall be protected from overloads by inherent design, circuit breakers, fuses, or other acceptable current-limiting means, suitable for the conditions of use.

(b) **Two-Wire Generators.** Two-wire, direct-current generators shall be permitted to have overcurrent protection in one conductor only if the overcurrent device is actuated by the entire current generated other than the current in the shunt field. The overcurrent device shall not open the shunt field.

(c) **65 Volts or Less.** Generators operating at 65 volts or less and driven by individual motors shall be considered as protected by the overcurrent device protecting the motor if these devices will operate when the generators are delivering not more than 150 percent of their full-load rated current.

(d) **Balancer Sets.** Two-wire, direct-current generators used in conjunction with balancer sets to obtain neutrals for 3-wire systems shall be equipped with overcurrent devices that will disconnect the 3-wire system in case of excessive unbalancing of voltages or currents.

(e) **3-Wire, Direct-Current Generators.** Three-wire, direct-current generators, whether compound or shunt wound, shall be equipped with overcurrent devices, one in each armature lead, and so connected as to be actuated by the entire current from the armature. Such overcurrent devices shall consist either of a double-pole, double-coil circuit breaker, or of a 4-pole circuit breaker connected in the main and equalizer leads and tripped by two overcurrent devices, one in each armature lead. Such protective devices shall be so interlocked that no

one pole can be opened without simultaneously disconnecting both leads of the armature from the system.

445-5. Ampacity of Conductors. The conductors of the generator shall have an ampacity not less than 115 percent of the nameplate current rating of the generator. Neutral conductors shall be the same size as the conductors of the outside legs.

445-6. Protection of Live Parts. Live parts of generators of more than 150 volts to ground shall not be exposed to accidental contact where accessible to unqualified persons.

445-7. Guards for Attendants. Where necessary for the safety of attendants, the requirements of Section 430-133 shall apply.

445-8. Grounding. The frames of generators shall be grounded as specified in Section 250-26 when the system is required to be grounded by Section 250-5(c) and 250-6.

445-9. Bushings. Where wires pass through an opening in an enclosure, conduit box, or barrier, a bushing shall be used to protect the conductors from the edges of an opening having sharp edges. The bushing shall have smooth, well-rounded surfaces where it may be in contact with the conductors. If used where oils, grease, or other contaminants may be present, the bushing shall be made of a material not deleteriously affected.

ARTICLE 450 — TRANSFORMERS AND TRANSFORMER VAULTS

(Including Secondary Ties)

450-1. Scope. This Article covers the installation of all transformers.

Exception No. 1: Current transformers.

Exception No. 2: Dry-type transformers that constitute a component part of other apparatus and comply with the requirements for such apparatus.

Exception No. 3: Transformers which are an integral part of an X-ray, high-frequency, or electrostatic-coating apparatus.

Exception No. 4: Transformers used with Class 2 and Class 3 circuits that comply with Article 725.

Exception No. 5: Transformers for sign and outline lighting that comply with Article 600.

Exception No. 6: Transformers for electric-discharge lighting that comply with Article 410.

Exception No. 7: Transformers used for power-limited fire protective signaling circuits that comply with Part C of Article 760.

This Article also covers the installation of transformers in hazardous locations as modified by Articles 501 through 503.

A. General Provisions

450-2. Location. Transformers and transformer vaults shall be readily accessible to qualified personnel for inspection and maintenance.

Exception No. 1: Dry-type transformers 600 volts or less, located in the open on walls, columns, or structures, shall not be required to be readily accessible.

Exception No. 2: Dry-type transformers not exceeding 600 volts and 50 kVA shall be permitted in fire-resistant hollow spaces of buildings not permanently closed in by structure and provided they meet the ventilation requirements of Section 450-8.

The location of oil-insulated transformers and transformer vaults is covered in Sections 450-24, 450-25, and 450-41; dry-type transformers, in Section 450-21; and askarel-insulated transformers, in Section 450-23.

450-3. Overcurrent Protection. Overcurrent protection shall comply with (a) through (c) below. As used in this section, the word "transformer" shall mean a transformer or polyphase bank of two or three single-phase transformers operating as a unit.

(a) Transformers Over 600 Volts.

(1) Primary. Each transformer over 600 volts shall be protected by an individual overcurrent device on the primary side. Where fuses are used, they shall be rated at not more than 150 percent of the rated primary current of the transformer. Where circuit breakers are used, they shall be set at not more than 300 percent of the rated primary current of the transformer.

Exception No. 1: Where 150 percent of the rated primary current of the transformer does not correspond to a standard rating of a fuse, the next higher standard rating shall be permitted.

Exception No. 2: An individual overcurrent device shall not be required where the primary circuit overcurrent device provides the protection specified in this Section.

Exception No. 3: As provided in (a) (2) below.

(2) Primary and Secondary. A transformer over 600 volts having an overcurrent device on the secondary side rated or set to open at not more than the values noted in Table 450-3(a)(2), or a transformer equipped with a coordinated thermal overload protection by the manufacturer, shall not be required to have an individual overcurrent device in the primary connection provided the primary feeder overcurrent device is rated or set to open at not more than the values noted in Table 450-3(a)(2).

Table 450-3(a)(2)

Transformers Over 600 Volts.

Having Overcurrent Protection on the Primary and Secondary Sides.

Transformer Rated Impedance	Maximum Overcurrent Device				
	Primary		Secondary		
	Over 600 Volts		Over 600 Volts	600 Volts or Below	
	Circuit Breaker Setting	Fuse Rating	Circuit Breaker Setting	Fuse Rating	Circuit Breaker Setting or Fuse Rating
Not more than 6%	600%	300%	300%	150%	250%
More than 6% and not more than 10%	400%	200%	250%	125%	250%

(b) Transformers 600 Volts or Less.

(1) Primary. Each transformer 600 volts or less shall be protected by an individual overcurrent device on the primary side, rated or set at not more than 125 percent of the rated primary current of the transformer.

Exception No. 1: Where the rated primary current of a transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, the next higher standard rating described in Section 240-6 shall be permitted. Where the rated primary current is less than 9 amperes, an overcurrent device rated or set at not more than 167 percent of the primary current shall be permitted.

Where the rated primary current is less than 2 amperes, an overcurrent device rated or set at not more than 300% shall be permitted.

Exception No. 2: An individual overcurrent device shall not be required where the primary circuit overcurrent device provides the protection specified in this Section.

Exception No. 3: As provided in (b) (2) below.

(2) Primary and Secondary. A transformer 600 volts or less having an overcurrent device on the secondary side rated or set at not more than 125 percent of the rated secondary current of the transformer shall not be required to have an individual overcurrent device on the primary side if the primary feeder overcurrent device is rated or set at a current value not more than 250 percent of the rated primary current of the transformer.

A transformer 600 volts or less, equipped with coordinated thermal overload protection by the manufacturer and arranged to interrupt the primary current, shall not be required to have an individual overcurrent device on the primary side if the primary feeder overcurrent device is rated or set at a current value not more than 6 times the rated current of the transformer for transformers having more than 6 percent impedance and not more than 4 times the rated current of the transformer for transformers having more than 6 but not more than 10 percent impedance.

Exception: Where the rated secondary current of a transformer is 9 amperes or more and 125 percent of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, the next higher standard rating described in Section 240-6 shall be permitted.

Where the rated secondary current is less than 9 amperes, an overcurrent device rated or set at not more than 167 percent of the rated secondary current shall be permitted.

(c) Potential (Voltage) Transformers. Potential transformers installed indoors or enclosed shall be protected with primary fuses.

450-4. Grounding Autotransformers. Grounding autotransformers covered in this Section are zig-zag or T-connected transformers connected to 3-phase 3-wire ungrounded systems for the purpose of creating a 3-phase 4-wire distribution system or to provide a neutral reference for grounding purposes. Such transformers shall have a con-

tinuous per phase current rating and a continuous neutral current rating.

The phase current in a grounding autotransformer is one-third the neutral current.

(a) Three-Phase 4-Wire System. A grounding autotransformer used to create a 3-phase 4-wire distribution system for a 3-phase 3-wire ungrounded system shall conform to the following:

(1) Connections. The transformer shall be directly connected to the ungrounded phase conductors and shall not be switched or provided with overcurrent protection which is independent of the main switch and common-trip overcurrent protection for the 3-phase 4-wire system.

(2) Overcurrent Protection. An overcurrent sensing device shall be provided that will cause the main switch or common-trip overcurrent protection referred to in (a)(1) above to open if the load on the autotransformer reaches or exceeds 125 percent of its continuous current per phase or neutral rating. Delayed tripping for temporary overcurrents sensed at the autotransformer overcurrent device shall be permitted for the purpose of allowing proper operation of branch or feeder protective devices on the 4-wire system.

(3) Transformer Fault Sensing. A fault sensing system that will cause the opening of a main switch or common trip overcurrent device for the 3-phase 4-wire system shall be provided to guard against single-phasing or internal faults.

This can be accomplished by the use of two subtractive-connected donut-type current transformers installed to sense and signal when an unbalance occurs in the line current to the autotransformer of 50 percent or more of rated current.

(4) Rating. The autotransformer shall have a continuous neutral current rating sufficient to handle the maximum possible neutral unbalanced load current of the 4-wire system.

(b) Ground Reference for Fault Protection Devices. A grounding autotransformer used to make available a specified magnitude of ground fault current for operation of a ground responsive protective device on a 3-phase 3-wire ungrounded system shall conform to the following requirements:

(1) Rating. The autotransformer shall have a continuous neutral current rating sufficient for the specified ground fault current.

(2) Overcurrent Protection. An overcurrent protective device of adequate short-circuit rating that will open simultaneously all ungrounded conductors when it operates shall be applied in the grounding autotransformer branch circuit and rated or set at a current not exceeding 125 percent of the autotransformer continuous per phase current rating or 42 percent of the continuous current rating of any series connected devices in the autotransformer neutral connection. Delayed tripping for temporary overcurrents to permit the proper operation of ground responsive tripping devices on the main system shall be permitted, but shall not exceed values which would be more than the short-time current rating of the grounding autotransformer or any series connected devices in the neutral connection thereto.

(c) **Ground Reference for Damping Transitory Overvoltages.** A grounding autotransformer used to limit transitory overvoltages shall be of suitable rating and connected in accordance with (a) (1) above.

450-5. Secondary Ties. A secondary tie is a circuit operating at 600 volts or less between phases that 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.

As used in this Section, the word "transformer" means a transformer or a bank of transformers operating as a unit.

(a) **Tie Circuits.** Tie circuits shall be provided with overcurrent protection at each end as required in Article 240.

Exception: Under the conditions described in (a) (1) and (a) (2) below, the overcurrent protection shall be permitted to be in accordance with (a) (3) below.

(1) **Loads at Transformer Supply Points Only.** Where all loads are connected at the transformer supply points at each end of the tie and overcurrent protection is not provided in accordance with Article 240, the rated ampacity of the tie shall not be less than 67 percent of the rated secondary current of the largest transformer connected to the secondary tie system.

(2) **Loads Connected Between Transformer Supply Points.** Where load is connected to the tie at any point between transformer supply points and overcurrent protection is not provided in accordance with Article 240, the rated ampacity of the tie shall not be less than 100 percent of the rated secondary current of the largest transformer connected to the secondary tie system.

Exception: As otherwise provided in (a) (4) below.

(3) **Tie Circuit Protection.** Under the conditions described in (a) (1) and (a) (2) above, both ends of each tie conductor shall be equipped with a protective device that 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 construction and characteristics according to the operating voltage and the type of insulation on the tie conductors, or (2) automatic circuit breakers actuated by devices having comparable current-time characteristics.

(4) **Interconnection of Phase Conductors Between Transformer Supply Points.** Where the tie consists of more than one conductor per phase, the conductors of each phase shall be interconnected in order to establish a load supply point, and the protection specified in (a) (3) above shall be provided in each tie conductor at this point.

Exception: Loads shall be permitted to be connected to the individual conductors of a paralleled conductor tie without interconnecting the conductors of each phase and without the protection specified in (a) (3) above at load connection points provided the tie conductors of each phase have a combined capacity of not less than 133 percent 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; and the loads are equally divided on each phase and on the individual conductors of each phase as far as practicable.

(5) Tie Circuit Control. Where the operating voltage exceeds 150 volts to ground, secondary ties provided with limiters shall have a switch at each end, that when open, will de-energize the associated tie conductors and limiters. The current rating of the switch shall not be 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. Where secondary ties are used, an overcurrent device rated or set at not more than 250 percent of the rated secondary current of the transformers shall be provided in the secondary connections of each transformer. In addition, an automatic circuit breaker actuated by a reverse-current relay set to open the circuit at not more than the rated secondary current of the transformer shall be provided in the secondary connection of each transformer.

450-6. Parallel Operation. Transformers shall be permitted to be operated in parallel and switched as a unit provided that the overcurrent protection for each transformer meets the requirements of Section 450-3.

450-7. Guarding. Transformers shall be guarded as specified in (a) through (d) below.

(a) Mechanical Protection. Appropriate provisions shall be made to minimize the possibility of damage to transformers from external causes where the transformers are exposed to physical damage.

(b) Case or Enclosure. Dry-type transformers shall be provided with a noncombustible moisture-resistant case or enclosure that will provide reasonable protection against the accidental insertion of foreign objects.

(c) Exposed Live Parts. Transformers shall be so installed that live parts are guarded in accordance with Section 110-17.

(d) Voltage Warning. The operating voltage of exposed live parts of transformer installations shall be indicated by signs or visible markings on the equipment or structures.

450-8. Ventilation. The ventilation shall be adequate to dispose of the transformer full-load losses without creating an excessive ambient temperature.

See ANSI C57.12.00-1968 — General Requirements for Distribution, Power, and Regulating Transformers and Shunt Reactors.

450-9. Grounding. Exposed noncurrent-carrying metal parts of transformer installations, including fences, guards, etc., shall be grounded where required under the conditions and in the manner specified for electric equipment and other exposed metal parts in Article 250.

450-10. Marking. Each transformer shall be provided with a nameplate giving the name of the manufacturer; rated kilovolt-amperes; frequency; primary and secondary voltage; impedance of transformers 25 kVA and larger; and the amount and kind of insulating liquid

where used. In addition, the nameplate of each dry-type transformer shall include the temperature class for the insulation system.

B. Specific Provisions Applicable to Different Types of Transformers

450-21. Dry-Type Transformers Installed Indoors. Transformers installed indoors and 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 over 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.

Exception No. 1: Transformers constructed with Class 80°C rise or higher insulation and separated from combustible material by a fire-resistant heat-insulating barrier or by not less than 6 feet horizontally and 12 feet vertically.

Exception No. 2: Transformers constructed with Class 80°C rise or higher insulation and of completely enclosed and ventilated type construction.

Transformers rated over 35,000 volts shall be installed in a vault complying with Part C of this Article.

450-22. Dry-Type Transformers Installed Outdoors. Dry-type transformers installed outdoors shall have a weatherproof enclosure.

450-23. Askarel-Insulated Transformers Installed Indoors. Askarel-insulated transformers installed indoors and rated over 25 kVA shall be furnished with a pressure-relief vent. Where installed in a poorly ventilated place, they shall be furnished with a means for absorbing any gases generated by arcing inside the case, or the pressure relief vent shall be connected to a chimney or flue that will carry such gases outside the building. Askarel-insulated transformers rated over 35,000 volts shall be installed in a vault.

450-24. Oil-Insulated Transformers Installed Indoors. Oil-insulated transformers installed indoors shall be installed in a vault constructed as specified in Part C of this Article.

Exception No. 1: Where the total capacity does not exceed 112½ kVA, the vault specified in Part C of this Article shall be permitted to be constructed of reinforced concrete not less than 4 inches thick.

Exception No. 2: Where the voltage does not exceed 600, a vault shall not be required if suitable arrangements are made to prevent a transformer oil fire from igniting other materials; and the total 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.

Exception No. 3: Electric furnace transformers having a total rating not exceeding 75 kVA shall be permitted to be installed without a vault in a building or room of fire-resistant construction provided suitable arrangements are made to prevent a transformer oil fire from spreading to other combustible material.

Exception No. 4: Transformers shall be permitted to be installed in a detached building that does not comply with Part C of this Article if neither the building nor its contents present a fire hazard to any other building or property, and if the building is used only in supplying electric service and the interior is accessible only to qualified persons.

450-25. Oil-Insulated Transformers Installed Outdoors. Combustible material, combustible buildings and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on roofs, attached to, or adjacent to a building or combustible material.

Space separations, fire-resistant barriers, automatic water spray systems, and enclosures that 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 shall be permitted to consist of fire-resistant dikes, curbed areas or basins, or trenches filled with coarse crushed stone. Oil enclosures shall be provided with trapped drains where the exposure and the quantity of oil involved are such that removal of oil is important. Transformers installed on poles or structures or underground shall conform to the National Electrical Safety Code, ANSI C2-1973.

C. Transformer Vaults

450-41. Location. Vaults shall be located where they can be ventilated to the outside air without using flues or ducts wherever such an arrangement is practicable.

450-42. Walls, Roof and Floor. The walls and roofs of vaults shall be constructed of materials which have adequate structural strength for the conditions with a minimum fire resistance of 3 hours according to ASTM Standard E119-71; Fire Tests of Building Construction and Materials; (NFPA No. 251-1972, also Methods of Fire Tests of Building Construction and Materials, ANSI A2.1-1972). The floors of vaults in contact with the earth shall be of concrete not less than 4 inches thick, but when the vault is constructed with a vacant space or other stories below it, the floor shall have adequate structural strength for the load imposed thereon and a minimum fire resistance of 3 hours.

Six inch thick reinforced concrete is a typical 3-hour construction.

450-43. Doorways. Vault doorways shall be protected as follows:

(a) **Type of Door.** Each doorway leading into a vault from the building interior shall be provided with a tight fitting door having a minimum fire rating of 3 hours as defined in the Standard for the Installation of Fire Doors and Windows (NFPA No. 80-1973). The authority having jurisdiction shall be permitted to require such a door for an exterior wall opening where conditions warrant.

For further information, see Standard for the Installation of Fire Doors and Windows (NFPA No. 80-1970) for definition of Class A situations.

(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 can be readily and quickly opened from the inside.

450-45. Ventilation Openings. Where required by Section 450-8, openings for ventilation shall be provided in accordance with (a) through (f) below.

(a) **Location.** Ventilation openings shall be located as far away as possible from doors, windows, fire escapes, and combustible material.

(b) **Arrangement.** A vault ventilated by natural circulation of air shall be permitted to 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 shall be permitted in one or more openings in or near the roof.

(c) **Size.** For a vault ventilated by natural circulation of air to an outdoor area, the combined net area of all ventilating openings after deducting the area occupied by screens, gratings, or louvers shall not be less than 3 square inches per kVA of transformer capacity in service, and in no case shall the net area be less than one 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.** All ventilation openings to the indoors shall be provided with automatic closing dampers of not less than No. 10 MSG steel that operate in response to a vault fire.

(f) **Ducts.** Ventilating ducts shall be constructed of fire-resistant material.

450-46. Drainage. Where practicable, vaults containing more than 100-kVA transformer capacity shall be provided with a drain or other means that will carry off any accumulation of oil or water in the vault unless local conditions make this impracticable. The floor shall be pitched to the drain where provided.

450-47. Water Pipes and Accessories. Any pipe or duct system, foreign to the electrical installation shall not enter or pass through a transformer vault. Piping or other facilities provided for fire protection or for water cooled transformers shall not be considered foreign to the electrical installation.

Exception: By special permission, pipe or duct systems foreign to the electrical installation that do not contain appurtenances thereto that require maintenance shall be permitted to be installed in the transformer vault.

450-48. Storage in Vaults. Materials shall not be stored in transformer vaults.

ARTICLE 460 — CAPACITORS

460-1. Scope. This Article covers the installation of capacitors on electric circuits.

Surge capacitors or capacitors included as a component part of other apparatus and conforming with the requirements of such apparatus are excluded from these requirements.

This Article also covers the installation of capacitors in hazardous locations as modified by Articles 501 through 503.

460-2. Enclosing and Guarding.

(a) Capacitors containing more than 3 gallons of flammable liquid shall be enclosed in vaults or outdoor fenced enclosures complying with Article 710.

(b) Capacitors shall be enclosed, located, or guarded so that persons cannot come into accidental contact or bring conducting materials into accidental contact with exposed energized parts, terminals, or buses associated with them.

Exception: No additional guarding is required for enclosures accessible only to authorized and qualified persons.

A. Under 600 Volts, Nominal

460-6. Drainage of Stored Charge. Capacitors shall be provided with a means of draining the stored charge.

(a) **Time of Discharge.** The residual voltage of a capacitor shall be reduced to 50 volts or less within one minute after the capacitor is disconnected from the source of supply.

(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.

460-7. Power Factor Correction — Motor Circuit. The total kVAR rating of capacitors that are connected on the load side of a motor controller shall not exceed the value required to raise the no-load power factor of the motor to unity.

460-8. Conductors.

(a) **Ampacity.** The ampacity of capacitor circuit conductors shall not be less than 135 percent of the rated current of the capacitor. The ampacity of conductors that connect a capacitor to the terminals of a motor or to motor circuit conductors shall not be less than 1/3 the ampacity of the motor circuit conductors and in no case less than 135 percent of the rated current of the capacitor.

(b) **Overcurrent Protection.**

(1) An overcurrent device shall be provided in each ungrounded conductor for each capacitor bank.

Exception: A separate overcurrent device shall not be required for a capacitor connected on the load side of a motor-running overcurrent device.

(2) The rating or setting of the overcurrent device shall be as low as practicable.

(c) Disconnecting Means.

(1) A disconnecting means shall be provided in each ungrounded conductor for each capacitor bank.

Exception: Where a capacitor is connected on the load side of a motor running overcurrent device.

(2) The disconnecting means shall not be required to open all ungrounded conductors simultaneously.

(3) The disconnecting means shall be permitted to disconnect the capacitor from the line as a regular operating procedure.

(4) The rating of the disconnecting means shall not be less than 135 percent of the rated current of the capacitor.

460-9. Rating or Setting of Motor-Running Overcurrent Device. Where a motor installation includes a capacitor connected on the load side of the motor-running overcurrent device, the rating or setting of the motor overcurrent device shall be determined in accordance with Section 430-32.

Exception: Instead of using the full-load rated current of the motor as provided in Section 430-32, a lower value corresponding with the improved power factor of the motor circuit shall be used. Section 430-22 applies with respect to the rating of the motor circuit conductors.

460-10. Grounding. Capacitor cases shall be grounded in accordance with Article 250.

Exception: Where the capacitor units are supported on a structure which is designed to operate at other than ground potential.

460-12. Marking. Each capacitor shall be provided with a nameplate giving the name of the manufacturer, rated voltage, frequency, kVAR or amperes, number of phases, and, if filled with a combustible liquid, the amount of liquid in gallons. When filled with a nonflammable liquid, the nameplate shall so state. The nameplate shall also indicate if a capacitor has a discharge device inside the case.

B. Over 600 Volts, Nominal

460-24. Switching.

(a) **Load Current.** Group-operated switches shall be used for capacitor switching and shall be capable of (1) carrying continuously not less than 135 percent of the rated current of the capacitor installation; (2) interrupting the maximum continuous load current of each capacitor, capacitor bank, or capacitor installation that will be switched as a unit; (3) withstanding the maximum inrush current, including contributions from adjacent capacitor installations; (4) carrying currents due to faults on capacitor side of switch.

(b) Isolation.

(1) A means shall be installed to isolate from all sources of potential each capacitor, capacitor bank, or capacitor installation that will be removed from service as a unit.

(2) The isolating means shall provide a visible gap in the electrical circuit adequate for the operating voltage.

(3) Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load interrupting device or shall be provided with prominently displayed caution signs in accordance with Section 710-22 to prevent switching load current.

(c) **Additional Requirements for Series Capacitors.** The proper switching sequence shall be assured by use of one of the following: (1) mechanically sequenced isolating and bypass switches; (2) interlocks, or (3) switching procedure prominently displayed at the switching location.

460-25. Overcurrent Protection.

(a) A means shall be provided to detect and interrupt fault current likely to cause dangerous pressure within an individual capacitor.

(b) Single-phase or multiphase devices shall be permitted for this purpose.

(c) Capacitors may be protected individually or in groups.

(d) Protective devices for capacitors or capacitor equipment shall be rated or adjusted to operate within the limits of the Safe Zone for individual capacitors as defined by ANSI Standard for Shunt Power Capacitors, C-55.1-1968.

Exception: If the protective devices are rated or adjusted to operate within the limits of the ANSI Standard for Zone 1 or Zone 2, the capacitors shall be enclosed or isolated.

In no event shall the rating or adjustment of the protective devices exceed the maximum limit of the ANSI Standard, Zone 2.

460-26. Identification. Each capacitor shall be provided with a permanent nameplate giving the maker's name, rated voltage, frequency, kVAR or amperes, number of phases, and the amount of liquid in gallons identified as flammable, if such is the case.

460-27. Grounding. Capacitor neutrals and cases, if grounded, shall be grounded in accordance with Article 250.

Exception: Where the capacitor units are supported on a structure which is designed to operate at other than ground potential.

460-28. Means for Discharge.

(a) A means shall be provided to reduce the residual voltage of a capacitor to 50 volts or less within 5 minutes after the capacitor is disconnected from the source of supply.

(b) A discharge circuit shall be either permanently connected to the terminals of the capacitor or provided with automatic means of connecting it to the terminals of the capacitor bank after disconnection of the capacitor from the source of supply. The windings of motors, or transformers, or of other equipment directly connected to capacitors without a switch or overcurrent device interposed must meet the requirements of (a) above.

ARTICLE 470 — RESISTORS AND REACTORS

For Rheostats, See Section 430-82

A. 600 Volts, Nominal and Under

470-1. Scope. This Article covers the installation of separate resistors and reactors on electric circuits.

Exception: Resistors and reactors that are component parts of other apparatus.

This Article also covers the installation of resistors and reactors in hazardous locations as modified by Articles 501 through 503.

470-2. Location. Resistors and reactors shall not be placed where exposed to physical damage.

470-3. Space Separation. A thermal barrier shall be required if the space between the resistors and reactors and any combustible material is less than 12 inches.

470-4. Conductor Insulation. Insulated conductors used for connections between resistance elements and controllers shall be suitable for an operating temperature of not less than 90°C (194°F).

Exception: Other conductor insulations shall be permitted for motor starting service.

B. Over 600 Volts, Nominal

470-18. General.

(a) Resistors and reactors shall be protected against physical damage.

(b) Resistors and reactors shall be isolated by enclosure or elevation to protect personnel from accidental contact with energized parts.

(c) Resistors and reactors shall not be installed in close enough proximity to combustible materials to constitute a fire hazard and in no case closer than within one foot of combustible materials.

(d) Clearances from resistors and reactors to grounded surfaces shall be adequate for the voltage involved.

See Article 710.

(e) Metallic enclosures of reactors and adjacent metal parts shall be installed so that the temperature rise from induced circulating currents will not be hazardous to personnel or constitute a fire hazard.

470-19. Grounding. Resistor and reactor cases or enclosures shall be grounded in accordance with Article 250.

470-20. Oil-Filled Reactors. Installation of oil-filled reactors, in addition to the above requirements, shall comply with applicable requirements of Article 450.

ARTICLE 480 — STORAGE BATTERIES

480-1. Scope. The provisions of this Article shall apply to all stationary installations of storage batteries.

480-2. Definition of Nominal Battery Voltage: The voltage computed on the basis of 2.0 volts per cell for the lead-acid type, and 1.2 volts per cell for the alkali type.

480-3. Wiring and Equipment Supplied From Batteries. Wiring and equipment supplied from storage batteries shall be subject to the requirements of this Code applying to wiring and equipment operating at the same voltage.

Exception: As otherwise provided for communication systems in Article 800.

480-4. Grounding. The requirements of Article 250 shall apply.

480-5. Insulation of Batteries of Not Over 250 Volts. This Section shall apply to storage batteries having cells so connected as to operate at a nominal battery voltage of not over 250 volts.

(a) **Lead-Acid Batteries.** Cells and multicompartament batteries with covers sealed to containers of nonconductive heat-resistant material shall not require additional insulating support.

(b) **Alkali-Type Batteries.** Cells with covers sealed to jars of nonconductive heat-resistant material shall require no additional insulation support. Cells in jars of conductive material shall be installed in trays of nonconductive material with not more than 20 cells (24 volts) in the series circuit in any one tray.

(c) **Sealed Rubber Jars.** Cells in sealed rubber or composition containers shall require no additional insulating support where the total nominal voltage of all cells in series does not exceed 150. Where the total voltage exceeds 150, 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.

(d) **Sealed Glass or Plastic Jars.** Cells in sealed glass jars or in sealed jars of approved heat-resistant plastic, with or without wood trays, shall not require additional insulation.

480-6. Insulation of Batteries of Over 250 Volts. The provisions of Section 480-5 shall apply to storage batteries having the cells so connected as to operate at a nominal voltage exceeding 250 volts, and, in addition, the provisions of this Section shall also apply to such batteries. Cells shall be installed in groups having a total nominal voltage of not over 250 volts on any one rack. Insulation, which can be air, shall be provided between racks. Maximum protection can be secured by sectionalizing high-voltage batteries into groups.

480-7. Racks and Trays. Racks and trays shall conform to the following:

(a) **Racks.** Racks, as required in this Article, are rigid frames designed to support cells or trays. They shall be substantial and made of:

(1) Metal, so treated as to be resistant to deteriorating action by the electrolyte and provided with nonconducting members directly supporting the cells or with continuous insulating material other than paint or conducting members; or

(2) Other construction such as fiberglass or other suitable non-metallic materials.

(b) **Trays.** Trays are frames, such as crates or shallow boxes usually of wood or other nonconductive material, so constructed or treated as to be resistant to deteriorating action by the electrolyte.

480-8. Battery Locations. Battery locations shall conform to (a) and (b) below:

(a) **Ventilation.** Provisions shall be made for sufficient diffusion and ventilation of the gases from the battery to prevent the accumulation of an explosive mixture.

(b) **Live Parts.** Guarding of live parts shall comply with Section 110-17.

480-9. Vents.

(a) **Vented Cells.** Each vented cell shall be equipped with a safety vent designed to prevent destruction of the cell due to ignition of gases within the cell by an external spark or flame under normal operating conditions.

(b) **Sealed Cells.** Sealed (nonvented) cells shall be equipped with a pressure-release vent to prevent excessive accumulation of gas pressure or the battery cell shall be designed to prevent scatter of cell parts in event of a cell explosion.

Chapter 5. Special Occupancies

ARTICLE 500 — HAZARDOUS (CLASSIFIED) LOCATIONS

500-1. Scope — Articles 500 Through 503. Articles 500 through 503 cover locations in which the authority having jurisdiction judges the equipment and wiring to be subject to the conditions indicated by the classifications covered in this Article. 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.

Exception: Except as modified in Articles 500 through 503, all other applicable rules contained in this Code shall apply to electric equipment and wiring installed in hazardous locations.

For definitions of "approved" and "explosion-proof" as used in these Articles, see Article 100; "dust-ignition-proof" is defined in Section 502-1.

Equipment and associated wiring approved as intrinsically safe shall be permitted in any hazardous (classified) location for which it is approved, and the provisions of Articles 500 through 517 shall not be considered applicable to such installations. Means shall be provided to prevent the passage of gases and vapors. Intrinsically safe equipment and wiring shall not be capable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmospheric mixture in its most easily ignited concentration.

Abnormal conditions shall include accidental damage to any field installed wiring, failure of electrical components, application of over-voltage, adjustment and maintenance operations, and other similar conditions.

For further information, see Intrinsically Safe Process Control Equipment for Use in Class I Hazardous Locations (NFPA No. 493-1969).

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 nonhazardous locations and thus to reduce the amount of special equipment required. In some cases, hazards may be reduced or hazardous locations limited or eliminated by adequate positive-pressure ventilation from a source of clean air in conjunction with effective safeguards against ventilation failure. For further information see Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Locations (NFPA No. 496-1972).

It is important that the authority having jurisdiction 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 further information, see Flammable and Combustible Liquids Code (NFPA No. 30-1973); Dry Cleaning Plants (NFPA No. 32-1972); Manufacture of Organic Coatings (NFPA No. 35-1971); Solvent Extraction Plants (NFPA No. 36-1973); Storage and Handling of Liquefied Petroleum Gases (NFPA No. 58-1972); and

Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants (NFPA No. 59-1968).

For protection against static electricity hazards, see Recommended Practice on Static Electricity (NFPA 77-1972).

All conduit referred to herein shall be threaded with a standard conduit cutting die that provides $\frac{3}{4}$ -inch taper per foot. Such conduit shall be made up wrench tight to minimize sparking when fault current flows through the conduit system. Where it is impractical to make a threaded joint tight, a bonding jumper shall be utilized.

500-2. Special Precaution. Articles 500 through 503 require a form of construction of equipment and of installation that will insure safe performance under conditions of proper use and maintenance.

It is important that inspection authorities and users exercise more than ordinary care with regard to installation and maintenance.

The explosion characteristics of air mixtures of hazardous gases, vapors, or dusts vary with the specific material involved. For Class I locations, Group A, B, C, and D, the classification involves determinations of maximum explosion pressure, maximum safe clearance between parts of a clamped joint in an enclosure, and the minimum ignition temperature of the atmospheric mixture. For Class II locations, Groups E, F, and G, the classification involves the tightness of the joints of assembly and shaft openings to prevent entrance of dust in the dust-ignition-proof enclosure, the blanketing effect of layers of dust on the equipment that may cause overheating, electrical conductivity of the dust, and the ignition temperature of the dust. It is necessary, therefore, that equipment be approved not only for the class, but also for the specific group of the gas, vapor, or dust that will be present.

For purposes of testing and approval, various air mixtures (not oxygen enriched) have been grouped on the basis of their hazardous characteristics and facilities have been made available for testing and approving equipment for use in the following atmospheric groups:

For Groups A, B, C, and D, see Table 500-2.

Group E: Atmospheres containing metal dust, including aluminum, magnesium, and their commercial alloys, and other metals of similarly hazardous characteristics.

Group F: Atmospheres containing carbon black, charcoal, coal or coke dusts which have more than 8 percent total volatile material (carbon black per ASTM D1620, charcoal, coal and coke dusts per ASTM D271) or atmospheres containing these dusts sensitized by other materials so that they present an explosion hazard.

Group G: Atmospheres containing flour, starch, or grain dust.

Certain chemical atmospheres may have characteristics that require safeguards beyond those required for any of the above groups. Carbon disulfide is one of these chemicals because of its low ignition temperature, 100°C (212°F), and the small joint clearance required to arrest its flame. For a complete list noting properties of flammable liquids, gases, and solids, see Fire-Hazard Properties of Flammable Liquids, Gases, Volatile Solids (NFPA No. 325M-1969).

(a) Approval for Class and Properties. Equipment shall be approved not only for the class of location but also for the explosion properties of the specific gas, vapor, or dust that will be present. In addition, equipment shall not have exposed any surface that operates at a temperature in excess of the ignition temperature of the specific gas, vapor, or dust.

The characteristics of various atmospheric mixtures of hazardous gases, vapors, and dusts depend on the specific hazardous material involved.

(b) Marking. Approved equipment shall be marked to show the Class, Group, and operating temperature, or temperature range, based on operation in a 40°C ambient, for which it is approved.

The temperature range, if provided, shall be indicated in identification numbers, as shown in Table 500-2(b).

Identification numbers marked on equipment nameplates shall be in accordance with Table 500-2(b).

Exception No. 1: Equipment of the nonheat-producing type, such as junction boxes, conduit, and fittings and equipment of the heat producing type having a maximum temperature not more than 100°C (212° F), shall not be required to have a marked operating temperature or temperature range.

Exception No. 2: Fixed lighting fixtures marked for use in Class I Division 2 locations only, need not be marked to indicate the Group.

For purposes of testing and approval, various atmospheric mixtures (not oxygen-enriched) have been grouped on the basis of their hazardous characteristics, and facilities have been made available for testing and approving equipment for use in the atmospheric groups listed in Table 500-2. Since there is no consistent relationship between explosion properties and ignition temperature, the two are independent requirements.

(c) Temperature. The temperature marking specified in (b) above shall not exceed the ignition temperature of the specific gas or vapor to be encountered.

For information regarding ignition temperatures of gases and vapors, see Fire-Hazard Properties of Flammable Liquids, Gases, Volatile Solids (NFPA No. 325M-1969).

Formerly the temperature limit of each Group was assumed to be the lowest ignition temperature of any material in the Group, i.e., 280°C for Group D, 180°C for Group C.

To avoid revising this limit as new gases are added (see hexane in Group D and acetaldehyde in Group C), temperature will be specified in future markings.

The ignition temperature for which equipment was approved prior to this requirement shall be assumed to be as follows:

Group A—280°C (536°F)

Group B—280°C (536°F)

Group C—180°C (356°F)

Group D—280°C (536°F)

Maximum surface temperatures for equipment in Class II hazardous locations are covered in Section 502-1.

500-3. Specific Occupancies. Articles 510 through 517 cover garages, aircraft hangars, gasoline dispensing and service stations, bulk storage plants, finishing processes, and health care facilities.

500-4. Class I Locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations shall include those specified in (a) and (b) below.

Table 500-2. Chemicals by Groups

Group A Atmospheres	Group D Atmospheres
Chemical acetylene	Chemical acetone acrylonitrile ammonia ³ benzene butane 1-butanol (butyl alcohol) 2-butanol (secondary butyl alcohol) n-butyl acetate isobutyl acetate ethane
Group B Atmospheres	ethanol (ethyl alcohol) ethyl acetate ethylene dichloride gasoline heptanes hexanes isoprene
butadiene ¹ ethylene oxide ² hydrogen manufactured gases containing more than 30% hydrogen (by volume) propylene oxide ²	methane (natural gas) methanol (methyl alcohol) 3-methyl-1-butanol (isoamyl alcohol) methyl ethyl ketone methyl isobutyl ketone 2-methyl-1-propanol (isobutyl alcohol) 2-methyl-2-propanol (tertiary butyl alcohol) petroleum naphtha ⁴ octanes
Group C Atmospheres	pentanes 1-pentanol (amyl alcohol) propane 1-propanol (propyl alcohol) 2-propanol (isopropyl alcohol) propylene styrene toluene vinyl acetate vinyl chloride xylenes
acetaldehyde cyclopropane diethyl ether ethylene unsymmetrical dimethyl hydrazine (UDMH 1, 1-dimethyl hydrazine)	

¹ Group D equipment shall be permitted for this atmosphere if such equipment is isolated in accordance with Section 501-5(a) by sealing all conduit ½-inch size or larger.

² Group C equipment shall be permitted for this atmosphere if such equipment is isolated in accordance with Section 501-5(a) by sealing all conduit ½-inch size or larger.

³ For Classification of areas involving ammonia atmosphere, see Safety Code for Mechanical Refrigeration (ANSI B9.1-1971) and Safety Requirements for the Storage and Handling of Anhydrous Ammonia (ANSI K61.1-1972).

⁴ A saturated hydrocarbon mixture boiling in the range 20-135°C (68-275°F). Also known by the synonyms benzene, ligroin, petroleum ether, or naphtha.

Table 500-2(b). Identification Numbers

Degrees C	Maximum Temperature Degrees F	Identification Number
450	842	T1
300	572	T2
280	536	T2A
260	500	T2B
230	446	T2C
215	419	T2D
200	392	T3
180	356	T3A
165	329	T3B
160	320	T3C
135	275	T4
120	248	T4A
100	212	T5
85	185	T6

(a) Class I, Division 1. A Class I, Division 1 location is a location: (1) in which hazardous concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions; or (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 that might release hazardous concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

This classification usually includes locations where volatile flammable 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 equipment using volatile flammable solvents; portions of cleaning and dyeing plants where hazardous liquids are used; gas generator rooms and other portions of gas manufacturing plants where flammable gas may escape; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interiors of refrigerators and freezers in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers; 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. A Class I, Division 2 location is a location: (1) in which volatile flammable 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; or (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) that is adjacent to a Class I, Division 1

location, 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 usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which, in the judgment of the authority having jurisdiction, 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 merit consideration in determining the classification and extent of each location.

Piping without valves, checks, meters, and similar devices would not ordinarily 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.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier shall be classed as a Division 2 location if the outside of the conduit and enclosures is a nonhazardous location.

500-5. Class II Locations. Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations shall include those specified in (a) and (b) below.

(a) Class II, Division 1. A Class II, Division 1 location is a location: (1) in which combustible dust is or may be in suspension in the air continuously, intermittently, or periodically under normal operating conditions, in quantities sufficient to produce explosive or ignitable mixtures; or (2) where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes; or (3) in which combustible dusts of an electrically conductive nature may be present.

This classification usually includes the working areas of grain handling and storage plants; rooms containing grinders or pulverizers, cleaners, graders, scalpels, open conveyors or spouts, open bins or hoppers, mixers or blenders, automatic or hopper scales, packing machinery, elevator heads and boots, stock distributors, dust and stock collectors (except all-metal collectors vented to the outside), and all similar dust-producing machinery and equipment in grain-processing plants, starch plants, sugar-pulverizing plants, malting plants, hay-grinding plants, and other occupancies of similar nature; coal-pulverizing plants (except where the pulverizing equipment is essentially dust-tight); all working areas where metal dusts and powders are produced, processed, handled, packed, or stored (except in tight containers); and all other similar locations where combustible dust may, under normal operating conditions, be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Combustible dusts which are electrically nonconductive 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 conductive nonmetallic dusts include dusts from pulverized coal, coke, carbon black, and charcoal. Dusts containing magnesium or aluminum are particularly

hazardous and the use of extreme precaution will be necessary to avoid ignition and explosion.

(b) Class II, Division 2. A Class II, Division 2 location is a location in which combustible dust will not normally be in suspension in the air or will not be likely to be thrown into suspension by the normal operation of equipment or apparatus in quantities sufficient to produce explosive or ignitable mixtures, but: (1) where deposits or accumulations of such combustible dust may be sufficient to interfere with the safe dissipation of heat from electric equipment or apparatus; or (2) where such deposits or accumulations of combustible dust on, in, or in the vicinity of electric equipment might be ignited by arcs, sparks, or burning material from such equipment.

Locations where dangerous concentrations of suspended dust would not be likely, but where dust accumulations might form on, or in the vicinity of electric 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 a Class II, Division 1 location as described in (a) above, and into which explosive or ignitable concentrations of suspended dust might be communicated only under abnormal operating conditions; rooms or areas where the formation of explosive or ignitable concentrations of suspended dust is prevented by the operation of effective dust control equipment; warehouses and shipping rooms where dust-producing materials are stored or handled only in bags or containers; and other similar locations.

500-6. Class III Locations. Class III locations are those that are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitable mixtures. Class III locations shall include those specified in (a) and (b) below.

(a) Class III, Division 1. A Class III, Division 1 location is a location in which easily ignitable fibers or materials producing combustible flyings are handled, manufactured, or used.

Such locations usually 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; wood-working plants; and establishments and industries involving similar hazardous processes or conditions.

Easily ignitable fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen,istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other materials of similar nature.

(b) Class III, Division 2. A Class III, Division 2 location is a location in which easily ignitable fibers are stored or handled.

Exception: In process of manufacture.

ARTICLE 501 — CLASS I LOCATIONS

501-1. General. The general rules of this Code shall apply to the electric wiring and equipment in locations classified as Class I in Section 500-4.

Exception: As modified by this Article.

501-2. Transformers and Capacitors.

(a) **Class I, Division 1.** In Class I, Division 1 locations, transformers and capacitors shall comply with the following:

(1) **Containing Liquid That Will Burn.** Transformers and capacitors containing a liquid that will burn shall be installed only in approved vaults that comply with Sections 450-41 through 450-48, and in addition: (1) there shall be no door or other communicating opening between the vault and the hazardous area; and (2) ample ventilation shall be provided for the continuous removal of hazardous gases or vapors; and (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 Liquid That Will Burn.** Transformers and capacitors that do not contain a liquid that will burn shall: (1) be installed in vaults complying with (a)(1) above, or (2) be approved for Class I locations.

(b) **Class I, Division 2.** In Class I, Division 2 locations, transformers and capacitors shall comply with Sections 450-21 through 450-25.

501-3. Meters, Instruments, and Relays.

(a) **Class I, Division 1.** In Class I, Division 1 locations, meters, instruments, and relays, including kilowatt-hour meters, instrument transformers, resistors, rectifiers, and thermionic tubes, shall be provided with enclosures approved for Class I locations.

(b) **Class I, Division 2.** In Class I, Division 2 locations, meters, instruments, and relays shall comply with the following:

(1) **Contacts.** Switches, circuit breakers, and make-and-break contacts of pushbuttons, relays, alarm bells, and horns, shall have enclosures approved for Class I locations.

Exception: General-purpose enclosures shall be permitted, if current-interrupting contacts are:

a. Immersed in oil; or,

b. Enclosed within a chamber hermetically sealed against the entrance of gases or vapors; or,

c. In circuits that under normal conditions do not release sufficient energy to ignite a specific hazardous atmosphere mixture; i.e., are non-incendive.

(2) **Resistors and Similar Equipment.** Resistors, resistance devices, thermionic tubes, rectifiers, and similar equipment that are used in or in connection with meters, instruments, and relays shall comply with (a) above.

Exception: General-purpose type enclosures shall be permitted if such equipment is without make-and-break or sliding contacts (other than as provided in (b)(1) above) and if the maximum operating temperature of any exposed surface will not exceed 80 percent of the ignition temperature in degrees Celsius of the gas or vapor involved or has been tested and found incapable of igniting the gas or vapor.

(3) **Without Make-or-Break Contacts.** Transformer windings, impedance coils, solenoids, and other windings that do not incorporate sliding or make-and-break contacts shall be provided with enclosures that may be of the general-purpose type.

(4) **General-Purpose Assemblies.** Where an assembly is made up of components for which general-purpose enclosures are acceptable as provided in (b)(1), (b)(2), and (b)(3) above, a single general-purpose enclosure shall be acceptable for the assembly. Where such an assembly includes any of the equipment described in (b)(2) above, the maximum obtainable surface temperature of any component of the assembly shall be clearly and permanently indicated on the outside of the enclosure. Alternatively, approved equipment shall be permitted to be marked to indicate the temperature range for which it is suitable using the identification numbers of Table 500-2(b).

(5) **Fuses.** Where general-purpose enclosures are permitted in (b)(1), (b)(2), (b)(3), and (b)(4) above, fuses for overcurrent protection of the instrument circuits shall be permitted to be mounted in general-purpose enclosures if such fuses do not exceed a 3-ampere rating at 120 volts and if each such fuse is preceded by a switch complying with (b)(1) above.

(6) **Connections.** To facilitate replacements, process control instruments shall be permitted to be connected through flexible cord, attachment plug, and receptacle, provided: (1) a switch complying with (b)(1) above is provided so that the attachment plug is not depended on to interrupt current; and (2) the current does not exceed 3 amperes at 120 volts; and (3) the power-supply cord does not exceed 3 feet, is of a type approved for extra-hard usage or for hard usage if protected by location, and is supplied through an attachment plug and receptacle of the locking and grounding type; and (4) only necessary receptacles are provided; and (5) the receptacle carries a label warning against unplugging under load.

501-4. Wiring Methods. Wiring methods shall comply with (a) and (b) below.

(a) **Class I, Division 1.** In Class I, Division 1 locations, threaded rigid metal conduit or Type MI cable with termination fittings approved for the location shall be the wiring method employed. All boxes, fittings, and joints shall be threaded for connection to conduit or cable terminations, and shall be explosion-proof. Threaded joints shall be made up with at least 5 threads fully engaged. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings. Where necessary to employ flexible connections, as at motor terminals, flexible fittings approved for Class I locations shall be used.

(b) **Class I, Division 2.** In Class I, Division 2 locations, threaded rigid metal conduit, enclosed gasketed busways, or Type MI, MC, ALS, TC, or SNM cable with approved termination fittings shall be the wiring method employed. Type MI, MC, ALS, CS, TC, or SNM cable shall be installed in a manner to avoid tensile stress at the termination fittings. Boxes, fittings, and joints shall not be required to be explosion-proof except as required by Sections 501-5(b)(1) and (b)(2). Where provision must be made for limited flexibility, as at motor terminals,

flexible metal fittings, flexible metal conduit with approved fittings, liquidtight flexible metal conduit with approved fittings, or flexible cord approved for extra-hard usage and provided with approved bushed fittings shall be used. An additional conductor for grounding shall be included in the flexible cord unless other acceptable means of grounding are provided.

Exception: Wiring, which under normal conditions cannot release sufficient energy to ignite a specific hazardous atmospheric mixture by opening, shorting or grounding, shall be permitted using any of the methods suitable for wiring in ordinary locations.

For voltages over 600 volts and where adequately protected from physical damage, metallical shielded high voltage cable shall be accepted in cable trays when installed in accordance with Article 318.

501-5. Sealing and Drainage. Seals in conduit and cable systems shall comply with (a) through (f) below. Sealing compound shall be of a type approved for the conditions and use. Sealing compound shall be used in Type MI cable termination fittings to exclude moisture and other fluids from the cable insulation.

Seals are provided in conduit and cable systems to prevent the passage of gases, vapors, or flames from one portion of the electrical installation to another through the conduit. Such communication through Type MI cable is inherently prevented by construction of the cable.

(a) Conduit Seals Class I, Division 1. In Class I, Division 1 locations, conduit seals shall be located as follows:

(1) In each conduit run entering an enclosure for switches, circuit breakers, fuses, relays, resistors, or other apparatus that 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. There shall be no junction box or similar enclosure in the conduit run between the sealing fitting and the apparatus enclosure.

(2) In each conduit run of 2-inch size or larger entering an enclosure or fitting housing terminals, splices, or taps and within 18 inches of such enclosure or fitting.

See notes under Group B in Table 500-2.

(3) Where two or more enclosures for which seals are required under (a) (1) and (a) (2) above 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 shall be considered sufficient if located not more than 18 inches from either enclosure. Conduit fittings approved for Class 1 locations and similar to the "L," "T," or "Cross" type shall not be classed as enclosures where not larger than the trade size of the conduit.

(4) In each conduit run leaving the Class I, Division 1 hazardous area. The sealing fitting shall be permitted on either side of the boundary of such hazardous location, but shall be so designed and installed that any gases or vapors that may enter the conduit system within the Division 1 hazardous location 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 location.

Exception: Unbroken rigid metal conduit that passes completely through a Class I, Division 1 location with no fittings less than 12 inches beyond each boundary shall not be required to be sealed if the termination points of the unbroken conduit are in nonhazardous locations.

(b) Conduit Seals Class I, Division 2. In Class I, Division 2 locations, conduit seals shall be located as follows:

(1) For connections to enclosures that are required to be approved for Class I locations, seals shall be provided in accordance with (a) (1) and (a) (2) above. All portions of the conduit run or nipple between the seal and such enclosure shall comply with Section 501-4(a).

(2) In each conduit run passing from a Class I, Division 2 location into a nonhazardous location. The sealing fitting shall be permitted on either side of the boundary of such location, but shall be so designed and installed that any gases or vapors that may enter the conduit system within the Division 2 location will not enter or be communicated to the conduit beyond the seal. Rigid metal conduit shall be used between the sealing fitting and the point at which the conduit leaves the hazardous location, 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 location.

Exception: Unbroken rigid metal conduit that passes completely through a Class I, Division 2 location with no fittings less than 12 inches beyond each boundary shall not be required to be sealed if the termination points of the unbroken conduit are in nonhazardous locations.

(c) Class I, Divisions 1 and 2. Where required, seals in Class I, Division 1 and 2 locations shall comply with the following:

(1) **Fittings.** Enclosures for connections or equipment shall be provided with an approved integral means for sealing, or sealing fittings approved for Class I locations shall be used. Sealing fittings shall be accessible.

(2) **Compound.** Sealing compound shall be approved for the purpose, shall not be affected by the surrounding atmosphere or liquids, and shall not have a melting point of less than 93°C (200°F).

(3) **Thickness of Compounds.** In a completed seal, the minimum thickness of the sealing compound shall not be 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) **Assemblies.** In an assembly where equipment that 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 (a) (2) above.

(d) Cable Seals, Class I, Division 1. In Class I, Division 1 locations, each multiconductor cable in rigid conduit shall be considered as a single conductor, and sealed in accordance with (a) above.

Cables with an impervious continuous sheath capable of transmitting gases or vapors through the cable core shall be sealed in the hazardous location in such a manner as to prevent passage of gases or vapors into a nonhazardous location.

(e) Cable Seals, Class I, Division 2. In Class I, Division 2 locations, cable seals shall be located as follows:

(1) Cables entering enclosures which are required to be approved for Class I locations shall be sealed at the point of entrance. The sealing fitting shall comply with (b)(1) above. Multi-conductor cables shall be sealed after removing the jacket and any other coverings so that the sealing compound will surround each individual insulated conductor and the outer jacket.

(2) Cables with an impervious continuous sheath which will not transmit gases or vapors through the cable core shall not be required to be sealed except as required in (e)(1) above.

(3) Cables with an impervious continuous sheath capable of transmitting gases or vapors through the cable core shall be sealed in the hazardous location in such a manner as to prevent passage of gases or vapors into a nonhazardous location.

Exception: Cables with an unbroken impervious continuous sheath shall be permitted to pass through a Class I, Division 2 location without seals.

(4) Cables which do not have an impervious continuous sheath shall be sealed at the boundary of the hazardous and nonhazardous location in such a manner as to prevent passage of gases or vapors into a nonhazardous location.

(f) Drainage.

(1) **Control Equipment.** Where there is a probability that liquid or other condensed vapor may be trapped within enclosures for control equipment or at any point in the raceway system, approved means shall be provided to prevent accumulation or to permit periodic draining of such liquid or condensed vapor.

(2) **Motors and Generators.** Where the authority having jurisdiction judges that there is a probability that liquid or condensed vapor may accumulate within motors or generators, joints and conduit systems shall be arranged to minimize entrance of liquid. If means to prevent accumulation or to permit periodic draining are judged necessary, such means shall be provided at the time of manufacture and shall be considered an integral part of the machine.

(3) **Canned Pumps, Etc.** For canned pumps, process connections for flow, pressure, or analysis measurement, etc., that depend upon a single seal diaphragm or tube to prevent process fluids from entering the electrical conduit system, an additional approved seal or barrier shall be provided with an adequate drain between the seals in such a manner that leaks would be obvious.

See also the last paragraph of Section 500-4(b).

501-6. Switches, Circuit Breakers, Motor Controllers, and Fuses.

(a) **Class I, Division 1.** In Class I, Division 1 locations, switches, circuit breakers, motor controllers, and fuses, including pushbuttons, 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 comply with 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 make-and-break contacts are oil-immersed, and of the general-purpose type having a two-inch minimum immersion for power and a one-inch minimum immersion for control.

(2) **Isolating Switches.** General-purpose-type enclosures containing no fuses shall be permitted to enclose disconnecting and isolating switches that are not intended to interrupt current.

(3) **Fuses.** For the protection of motors, appliances, and lamps, other than as provided in (b)(4) below, standard plug or cartridge fuses shall be permitted, provided they are placed within enclosures approved for the purpose and for the location; or fuses shall be permitted if they are within general-purpose enclosures, if they are approved for the purpose, and if they are of a type in which the operating element is immersed in oil or other approved liquid or the operating element is enclosed within a chamber hermetically sealed against the entrance of gases and vapors.

(4) **Fuses or Circuit Breakers for Overcurrent Protection.** Where not more than 10 sets of approved enclosed fuses or not more than 10 circuit breakers that are not intended to be used as switches for the interruption of current are installed for branch-circuit or feeder protection in any one room, area, or section of the Class I, Division 2 location, general-purpose-type enclosures for such fuses or circuit breakers shall be permitted if the fuses or circuit breakers are for the protection of circuits or feeders supplying lamps in fixed positions only.

A set of fuses is all the fuses required to protect all the ungrounded conductors of a circuit. For example, a group of 3 fuses protecting an ungrounded 3-phase circuit, and a single fuse protecting the ungrounded conductor of an identified 2-wire single-phase circuit, is a set of fuses in each instance.

Fuses complying with (b)(3) above shall not be required to be included in counting the ten sets of fuses permitted in general-purpose enclosures.

501-7. Control Transformers and Resistors. Transformers, impedance coils, and resistors used as, or in conjunction with, control equipment for motors, generators, and appliances shall comply with (a) and (b) below.

(a) **Class I, Division 1.** In Class I, Division 1 locations, transform-

ers, impedance coils, and resistors, together with any switching mechanism associated with them, shall be provided with enclosures approved for Class I locations.

(b) **Class I, Division 2.** In Class I, Division 2 locations, control transformers and resistors shall comply with the following:

(1) **Switching Mechanisms.** Switching mechanisms used in conjunction with transformers, impedance coils, and resistors shall comply with Section 501-6(b).

(2) **Coils and Windings.** Enclosures for windings of transformers, solenoids, or impedance coils shall be permitted to be of the general-purpose type.

(3) **Resistors.** Resistors shall be provided with enclosures; and the assembly shall be approved for Class I locations, unless resistance is nonvariable and maximum operating temperature, in degrees Celsius, will not exceed 80 percent of the ignition temperature of the gas or vapor involved, or has been tested and found incapable of igniting the gas or vapor.

501-8. Motors and Generators.

(a) **Class I, Division 1.** In Class I, Division 1 locations, motors, generators, and other rotating electric machinery shall be: (1) approved for Class I locations; or (2) of the totally enclosed type supplied with positive-pressure ventilation from a source of clean air with discharge to a safe area, so arranged to prevent energizing of the machine until ventilation has been established and the enclosure has been purged with at least 10 volumes of air, and also arranged to automatically de-energize the equipment when the air supply fails; or (3) of the totally enclosed inert-gas-filled type supplied with a suitable reliable source of inert gas for pressuring the enclosure, with devices provided to insure a positive pressure in the enclosure and arranged to automatically de-energize the equipment when the gas supply fails; or (4) of a type designed to be submerged in a liquid which is flammable only when vaporized and mixed with air, or in a gas or vapor at a pressure greater than atmospheric and which is flammable only when mixed with air; and the machine is so arranged to prevent energizing it until it has been purged with the liquid or gas to exclude air, and also arranged to automatically de-energize the equipment when the supply of liquid, or gas or vapor, fails or the pressure is reduced to atmospheric. Totally enclosed motors of Types (2) or (3) shall have no external surface with an operating temperature in degrees Celsius in excess of 80 percent of the ignition temperature of the gas or vapor involved.

Appropriate devices shall be provided to detect and automatically de-energize the motor or provide an adequate alarm if there is any increase in temperature of the motor beyond designed limits. Auxiliary equipment shall be of a type approved for the location in which it is installed.

See ASTM Test Procedure (Designation D 2155-69).

(b) **Class I, Division 2.** In Class I, Division 2 locations, motors, generators, and other rotating electric 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, unless such sliding contacts, switching mechanisms, and resistance devices are provided with enclosures approved for such locations.

In Class I, Division 2 locations, the installation of open or nonexplosion-proof enclosed motors, such as squirrel-cage induction motors without brushes, switching mechanisms, or similar arc-producing devices shall be permitted.

501-9. Lighting Fixtures. Lighting fixtures shall comply with (a) or (b) below.

(a) **Class I, Division 1.** In Class I, Division 1 locations, lighting fixtures shall comply with the following:

(1) **Approved Fixtures.** Each fixture shall be approved as a complete assembly for the Class I, Division 1 location and shall be clearly marked to indicate the maximum wattage of lamps for which it is approved. Fixtures intended for portable use shall be specifically approved as a complete assembly for that use.

(2) **Physical Damage.** Each fixture shall be protected against physical damage by a suitable guard or by location.

(3) **Pendant Fixtures.** Pendant fixtures shall be suspended by and supplied through threaded rigid metal 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 Class I, Division 1 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 comply with the following:

(1) **Portable Lamps.** Portable lamps shall comply with (a)(1) above.

(2) **Fixed Lighting.** Lighting fixtures for fixed lighting shall be protected from physical damage by suitable guards or by location. Where there is danger that falling sparks or hot metal from lamps or fixtures might ignite localized concentrations of flammable vapors or gases, suitable enclosures or other effective protective means shall be provided. Where lamps are of a size or type that may, under normal operating conditions, reach surface temperatures exceeding 80 percent of the ignition temperature in degrees Celsius of the gas or vapor involved, fixtures shall comply with (a)(1) above or shall be of a type which has been tested and found incapable of igniting the gas or vapor if the ignition temperature is not exceeded.

(3) **Pendant Fixtures.** Pendant fixtures shall be suspended by threaded rigid metal 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 that are a part of an assembled fixture or of an individual lampholder shall comply with Section 501-6(b)(1).

(6) Starting Equipment. Starting and control equipment for electric-discharge lamps shall comply with Section 501-7(b).

Exception: A thermal protector potted into a thermally protected fluorescent lamp ballast if the lighting fixture is approved for locations of this Class and Division.

501-10. Utilization Equipment.

(a) Class I, Division 1. In Class I, Division 1 locations, all utilization equipment shall be approved for Class I locations.

(b) Class I, Division 2. In Class I, Division 2 locations, all utilization equipment shall comply with the following:

(1) Heaters. Electrically heated utilization equipment shall be approved for Class I locations, unless it conforms with one of the following:

(a) If the maximum operating temperature of any exposed surface will not exceed 80 percent of the ignition temperature in degrees Celsius of the gas or vapor involved when: (1) continuously energized, (2) maximum ambient temperature, and (3) 20 percent over voltage, it shall be acceptable to omit the temperature controller for the particular heater involved.

(b) If the maximum operating temperature of any exposed surface will not exceed 80 percent of the ignition temperature in degrees Celsius of the gas or vapor involved when: (1) continuously energized, (2) maximum ambient temperature, and (3) normal or rated voltage applied, a temperature controller shall be required on each heater.

(2) Motors. Motors of motor-driven utilization equipment shall comply with Section 501-8(b).

(3) Switches, Circuit Breakers, and Fuses. Switches, circuit breakers, and fuses shall comply with Section 501-6(b).

501-11. Flexible Cords, Class I, Divisions 1 and 2. A flexible cord shall be permitted only for connection between a portable lamp or other portable utilization equipment and the fixed portion of its supply circuit; and where used shall: (1) be of a type approved for extra-hard usage; and (2) contain, in addition to the conductors of the circuit, a grounding conductor complying with Section 400-23; and (3) be connected to terminals or to supply conductors in an approved manner; and (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 where the flexible cord enters boxes, fittings, or enclosures of the explosion-proof type.

Exception: As provided in Sections 501-3(b)(6) and 501-4(b).

See Section 501-13 for flexible cords exposed to liquids having a deleterious effect on the conductor insulation.

501-12. Receptacles and Attachment Plugs, Class I, Divisions 1 and 2. Receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of a flexible cord and shall be approved for Class I locations.

Exception: As provided in Section 501-3(b)(6).

501-13. Conductor Insulation Class I, Divisions 1 and 2. Where condensed vapors or liquids may collect on, or come in contact with, the insulation on conductors, such insulation shall be of a type approved for use under such conditions; or the insulation shall be protected by a sheath of lead or by other approved means.

501-14. Signaling, Alarm, Remote-Control, and Communication Systems.

(a) Class I, Division 1. In Class I, Division 1 locations, all apparatus and equipment of signaling, alarm, remote-control, and communication systems, regardless of voltage, shall be approved for Class I locations, and all wiring shall comply with Sections 501-4(a) and 501-5(a) and (c).

(b) Class I, Division 2. In Class I, Division 2 locations, signaling, alarm, remote-control, and communication systems shall comply with the following:

(1) Contacts. Switches, circuit breakers, and make-and-break contacts of pushbuttons, relays, alarm bells, and horns shall have enclosures approved for Class I locations.

Exception: General-purpose enclosures shall be permitted if current interrupting contacts are:

a. Immersed in oil; or

b. Enclosed within a chamber hermetically sealed against the entrance of gases or vapors; or

c. In circuits that under normal conditions do not release sufficient energy to ignite a specific hazardous atmospheric mixture, i.e., are non-incendive.

(2) Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes, rectifiers, and similar equipment shall comply with Section 501-3(b)(2).

(3) Protectors. Enclosures shall be provided for lightning protective devices and for fuses. Such enclosures shall be permitted to be of the general-purpose type.

(4) Wiring and Sealing. All wiring shall comply with Sections 501-4(b) and 501-5(b) and (c).

501-15. Live Parts, Class I, Divisions 1 and 2. There shall be no exposed live parts.

501-16. Grounding, Class I, Divisions 1 and 2. Wiring and equipment shall be grounded as specified in (a) through (f) below.

(a) Exposed Parts. The exposed noncurrent-carrying metal parts of equipment, such as the frames or metal exteriors of motors, fixed or portable lamps, lighting fixtures, or other utilization equipment, and cabinets, cases, and conduit, shall be grounded as specified in Article 250.

(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. Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, etc., between hazardous areas and the point of grounding for service equipment. Where flexible conduit is used as permitted in Section 501-4(b), bonding jumpers with proper fittings shall be provided around such conduit.

(c) Lightning Protection. Each ungrounded service conductor of a wiring system in a Class I location, where supplied from an overhead line 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.

See Section 502-3 for surge protection.

(d) Grounded Service Conductor Bonded to Raceway. Wiring in a Class I location, where 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, where supplied from a grounded alternating-current supply system in which no grounded conductor is a part of the service, shall be provided with a metal connection between the supply system ground and the service-equipment enclosure. The metal connection shall comply with Section 250-23(b).

(f) Multiple Grounds. Where, in the application of Section 250-21, it is necessary to abandon one or more grounding connections to avoid objectionable passage of current over the grounding conductors, the connection required in (d) and (e) above shall not be abandoned while any other grounding connection remains connected to the supply system.

ARTICLE 502 — CLASS II LOCATIONS

502-1. General. The general rules of this Code shall apply to the electric wiring and equipment in locations classified as Class II locations in Section 500-5.

Exception: As modified by this Article.

"Dust-ignition-proof," as used in this Article shall mean enclosed in a manner that will exclude ignitable amounts of dusts or amounts that might affect performance or rating and that, where installed and protected in accordance with this Code, will not permit arcs, sparks, or

heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.

Equipment installed in Class II locations shall 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 that is carbonized or excessively dry is highly susceptible to spontaneous ignition.

In general, the maximum surface temperatures under actual operating conditions shall not exceed 165°C (329°F) for equipment that is not subject to overloading and 120°C (248°F) for equipment (such as motors or power transformers) that may be overloaded.

Equipment and wiring of the type defined in Article 100 as explosion-proof shall not be required and shall not be acceptable in Class II locations unless approved for such locations.

502-2. Transformers and Capacitors.

(a) Class II, Division 1. In Class II, Division 1 locations, transformers and capacitors shall comply with the following:

(1) Containing Liquid That Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed only in approved vaults complying with Sections 450-41 through 450-48, and in addition: (1) doors or other openings communicating with the hazardous location 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, and (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 Liquid That Will Burn. Transformers and capacitors that do not contain a liquid that will burn shall: (1) be installed in vaults complying with Sections 450-41 through 450-48; or (2) be approved as a complete assembly, including terminal connections for Class II locations.

(3) Metal Dusts. No transformer or capacitor shall be installed in a location where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present.

(b) Class II, Division 2. In Class II, Division 2 locations, transformers and capacitors shall comply with the following:

(1) Containing Liquid That Will Burn. Transformers and capacitors containing a liquid that will burn shall be installed in vaults complying with Sections 450-41 through 450-48.

(2) Containing Askarel. Transformers containing askarel and rated in excess of 25 kVA shall: (1) be provided with pressure-relief vents; and (2) be provided with a means for absorbing any gases generated by arcing inside the case, or the pressure-relief vents shall be connected to a chimney or flue that 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 not over 600 volts.

502-3. Surge Protection, Class II, Divisions 1 and 2. In geographical locations where lightning disturbances are prevalent and where supplied from overhead lines, wiring systems in Class II locations shall be suitably protected against high-voltage surges. This protection shall include suitable lightning protective devices, interconnection of all grounds, and surge-protective capacitors.

Interconnection of all grounds shall 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. The intervening secondary conductors shall be permitted as the metallic connection between the secondary protective devices, if grounds for the primary and secondary devices are metallically interconnected at the supply end of the secondary system, and if the secondary devices are grounded to the raceway system at the load end of the secondary system.

Surge-protective capacitors shall be of a type designed for the specific duty, shall be connected to each ungrounded service conductor, and shall be grounded to the interior conduit system. Capacitors shall be protected by 30-ampere fuses of suitable type and voltage rating, or by automatic circuit breakers of suitable type and rating, and shall be connected to the supply conductors on the supply side of the service disconnecting means.

502-4. Wiring Methods. Wiring methods shall comply with (a) and (b) below.

(a) Class II, Division 1. In Class II, Division 1 locations, threaded rigid metal conduit or Type MI cable with termination fittings approved for the location shall be the wiring method employed. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings.

(1) Fittings and Boxes. Fittings and boxes shall be provided with threaded bosses for connection to conduit or cable terminations, shall have close fitting covers, and shall have no openings (such as holes for attachment screws) through which dust might enter or through which sparks or burning material might escape. Fittings and boxes in which taps, joints, or terminal connections are made, or that are used in locations where dusts are of a combustible electrically conductive nature, shall be approved for Class II locations.

(2) Flexible Connections. Where necessary to employ flexible connections, dust-tight flexible connectors, liquidtight 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 cords shall be provided with dust-tight seals at both ends. An additional conductor for ground-

ing shall be provided in the flexible cord unless other acceptable means of grounding is provided. Where flexible connections are subject to oil or other corrosive conditions, the insulation of the conductors shall be of a type approved for the condition or shall be protected by means of a suitable sheath.

(b) Class II, Division 2. In Class II, Division 2 locations, rigid metal conduit, electrical metallic tubing, dust-tight wireways, or Type MI, MC, ALS, CS, or SNM cable with approved termination fittings shall be the wiring method employed.

(1) Wireways, Fittings, and Boxes. Wireways, fittings, and boxes in which taps, joints, or terminal connections are made shall be designed to minimize the entrance of dust, and: (1) shall be provided with telescoping or close fitting covers or other effective means to prevent the escape of sparks or burning material, and (2) shall have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape or through which adjacent combustible material might be ignited.

(2) Flexible Connections. Where flexible connections are necessary, (a) (2) above shall apply.

502-5. Sealing, Class II, Divisions 1 and 2. Where a raceway provides communication between an enclosure that is required to be dust-ignition-proof and one that is not, suitable means shall be provided to prevent the entrance of dust into the dust-ignition-proof enclosure through the raceway. One of the following means shall be permitted: (1) a permanent and effective seal; (2) a horizontal raceway not less than 10 feet long; or (3) a vertical raceway not less than 5 feet long and extending downward from the dust-ignition-proof enclosure. Sealing fittings shall be accessible.

502-6. Switches, Circuit Breakers, Motor Controllers, and Fuses.

(a) Class II, Division 1. In Class II, Division 1 locations, switches, circuit breakers, motor controllers, and fuses shall comply with the following:

(1) Type Required. Switches, circuit breakers, motor controllers, and fuses, including pushbuttons, relays, and similar devices that are intended to interrupt current during normal operation or that are installed where dusts of a combustible electrically conductive nature may be present shall be provided with dust-ignition-proof enclosures, which, together with the enclosed equipment in each case, shall be approved as a complete assembly for Class II locations.

(2) Isolating Switches. Disconnecting and isolating switches containing no fuses and not intended to interrupt current and not installed where dusts may be of an electrically conductive nature shall be provided with tight metal enclosures that shall be designed to minimize the entrance of dust, and that shall: (1) be equipped with telescoping or close fitting covers or with other effective means to prevent the escape of sparks or burning material, and (2) have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape or through which exterior accumulations of dust or adjacent combustible material might be ignited.

(3) Metal Dusts. In locations where dust from magnesium, alu-

minum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, fuses, switches, motor controllers, and circuit breakers shall have enclosures specifically approved for such locations.

(b) **Class II, Division 2.** In Class II, Division 2 locations, enclosures for fuses, switches, circuit breakers, and motor controllers, including pushbuttons, relays, and similar devices, shall comply with (a)(2) above.

502-7. Control Transformers and Resistors.

(a) **Class II, Division 1.** In Class II, Division 1 locations, control transformers, solenoids, impedance coils, resistors, and any overcurrent devices or switching mechanisms associated with them shall have dust-ignition-proof enclosures approved for Class II locations. No control transformer, impedance coil, or resistor shall be installed in a location where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present unless provided with an enclosure approved for the specific location.

(b) **Class II, Division 2.** In Class II, Division 2 locations, transformers and resistors shall comply with the following:

(1) **Switching Mechanisms.** Switching mechanisms (including overcurrent devices) associated with control transformers, solenoids, impedance coils, and resistors shall be provided with enclosures complying with Section 502-6(a)(2).

(2) **Coils and Windings.** Where not located in the same enclosure with switching mechanisms, control transformers, solenoids, and impedance coils shall be provided with tight metal housings without ventilating openings.

(3) **Resistors.** Resistors and resistance devices shall have dust-ignition-proof enclosures approved for Class II locations.

Exception: Where the maximum normal operating temperature of the resistor will not exceed 120°C (248°F), nonadjustable resistors or resistors that are part of an automatically timed starting sequence shall be permitted to have enclosures complying with (b)(2) above.

502-8. Motors and Generators.

(a) **Class II, Division 1.** In Class II, Division 1 locations, motors, generators, and other rotating electric machinery shall be dust-ignition-proof or totally enclosed pipe-ventilated and shall be approved for Class II locations.

(b) **Class II, Division 2.** In Class II, Division 2 locations, motors, generators, and other rotating electric machinery shall be dust-ignition-proof or totally enclosed pipe-ventilated, for which maximum surface temperatures shall not exceed 120°C (248°F).

Exception: If the authority having jurisdiction believes accumulations of nonconductive nonabrasive dust will be moderate; and if machines can be easily reached for routine cleaning and maintenance, the following may be installed:

a. *Standard open-type machines without sliding contacts, centri-*

fugal or other types of switching mechanism (including motor over-current devices), or integral resistance devices.

b. Standard open-type machines with such contacts, switching mechanisms, or resistance devices enclosed within tight metal housings without ventilating or other openings.

c. Self-cleaning textile motors of the squirrel-cage type.

502-9. Ventilating Piping. Ventilating pipes for motors, generators, or other rotating electric machinery, or for enclosures for electric equipment shall be of metal not lighter than No. 24 MSG, or of equally substantial noncombustible material, and shall comply with the following: (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; and (3) be protected against physical damage and against rusting or other corrosive influences.

Ventilating pipes shall also comply with (a) and (b) below.

(a) Class II, Division 1. In Class II, Division 1 locations, ventilating pipes, including their connections to motors or to the dust-ignition-proof enclosures for other equipment, shall be dust-tight throughout their length. For metal pipes, seams and joints shall comply with one of the following: (1) be riveted and soldered; (2) be bolted and soldered; (3) be welded, or (4) be rendered dust-tight by some other equally effective means.

(b) Class II, Division 2. In Class II, Division 2 locations, ventilating 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 that might ignite dust accumulations or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints shall be permitted; and tight-fitting slip joints shall be permitted where some flexibility is necessary, as at connections to motors.

502-10. Utilization Equipment.

(a) Class II, Division 1. In Class II, Division 1 locations, all utilization equipment shall be approved for Class II locations. Where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, such equipment shall be approved for the specific location.

(b) Class II, Division 2. In Class II, Division 2 locations, all utilization equipment shall comply with the following:

(1) Heaters. Electrically heated utilization equipment shall be approved for Class II locations.

(2) Motors. Motors of motor-driven utilization equipment shall comply with Section 502-8(b).

(3) Switches, Circuit Breakers, and Fuses. Enclosures for switches, circuit breakers, and fuses shall comply with Section 502-6(a)(2).

(4) Transformers, Impedance Coils, and Resistors. Transformers, solenoids, impedance coils, and resistors shall comply with Section 502-7(b).

502-11. Lighting Fixtures. Lighting fixtures shall comply with (a) and (b) below.

(a) Class II, Division 1. In Class II, Division 1 locations, lighting fixtures for fixed and portable lighting shall comply with 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, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, fixtures for fixed or portable lighting and all auxiliary equipment shall be approved for the specific location.

(2) Physical Damage. Each fixture shall be protected against physical damage by a suitable guard or by location.

(3) Pendant Fixtures. Pendant fixtures shall be suspended by threaded rigid metal conduit stems, by 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 pendant 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 comply with 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, where not of a type approved for Class II locations, shall provide enclosures for lamps and lampholders that 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 the lamp that shall be permitted without exceeding an exposed surface temperature of 165°C (320°F) under normal conditions of use.

(3) Physical Damage. Lighting fixtures for fixed lighting shall be protected from physical damage by suitable guards or by location.

(4) Pendant Fixtures. Pendant fixtures shall be suspended by threaded rigid metal conduit stems, by 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. Where wiring between an outlet box or fitting and a pendant fixture is not enclosed in conduit, flexible cord approved for hard usage shall be used. Flexible cord shall not serve as the supporting means for a fixture.

(5) **Supports.** Boxes, box assemblies, or fittings used for the support of lighting fixtures shall be approved for the purpose.

(6) **Electric-Discharge Lamps.** Starting and control equipment for electric-discharge lamps shall comply with the requirement of Section 502-7(b).

502-12. Flexible Cords, Class II, Division 1 and 2. Flexible cords used in Class II locations shall comply with the following: (1) be of a type approved for extra-hard usage; (2) contain, in addition to the conductors of the circuit, a grounding conductor complying with Section 400-23; (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 that are required to be dust-ignition-proof.

502-13. Receptacles and Attachment Plugs.

(a) **Class II, Division 1.** In Class II, Division 1 locations, receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of the flexible cord and shall be approved for Class II locations.

(b) **Class II, Division 2.** In Class II, Division 2 locations, receptacles and attachment plugs shall be of the type providing for connection to the grounding conductor of the flexible cord and shall be so designed that connection to the supply circuit cannot be made or broken while live parts are exposed.

502-14. Signaling, Alarm, Remote-Control, and Local Loud-Speaker Intercommunication Systems.

See 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, signaling, alarm, remote-control, and local loud-speaker intercommunication systems shall comply with the following:

(1) **Wiring Methods.** Where accidental damage or breakdown of insulation might cause arcs, sparks, or high temperatures, the wiring method shall be rigid metal conduit, electrical metallic tubing, or Type MI cable with approved termination fittings. For conduit or electrical metallic tubing, the number of conductors shall be limited only by the requirement that the cross-sectional area of all conductors shall not exceed 40 percent of the area of the raceway. Where limited flexibility is desirable or where exposure to physical damage is not severe, flexible cord approved for extra-hard usage shall be permitted.

(2) **Contacts.** Switches, circuit breakers, relays, contactors, and fuses that 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 a Class II location.

Exception: Where current-breaking contacts are immersed in oil, or where the interruption of current occurs within a chamber sealed against the entrance of dust, enclosures shall be permitted to be of the general-purpose type.

(3) Resistors and Similar Equipment. Resistors, transformers, choke coils, and similar equipment that may carry other than voice currents, and rectifiers, thermionic tubes, and other heat-generating equipment shall be provided with enclosures approved for Class II locations.

(4) Rotating Machinery. Motors, generators, and other rotating electric machinery shall comply with Section 502-8(a).

(5) Combustible Electrically Conductive Dusts. Where dusts are of a combustible electrically conductive nature, all wiring and equipment shall be approved for Class II locations.

(6) Metal Dusts. Where dust from magnesium, aluminum, aluminum bronze powders, or other metals of similarly hazardous characteristics may be present, all apparatus and equipment shall be approved for the specific conditions.

(b) Class II, Division 2. In Class II, Division 2 locations, signaling, alarm, remote-control, and local loudspeaker intercommunication systems shall comply with the following:

(1) Contacts. Enclosures shall comply with (a) (2) above; or contacts shall have tight metal enclosures designed to minimize the entrance of dust, and shall have telescoping or tight-fitting covers and no openings through which, after installation, sparks or burning material might escape.

(2) Transformers and Similar Equipment. The windings and terminal connections of transformers, choke coils, and similar equipment shall be provided with tight metal enclosures without ventilating openings.

(3) Resistors and Similar Equipment. Resistors, resistance devices, thermionic tubes, rectifiers, and similar equipment shall comply with (a) (3) above.

Exception: Enclosures for thermionic tubes, nonadjustable resistors, or rectifiers for which maximum operating temperature will not exceed 120°C (248°F) shall be permitted to be of the general-purpose type.

(4) Rotating Machinery. Motors, generators, and other rotating electric machinery shall comply with Section 502-8(b).

502-15. Live Parts, Class II, Divisions 1 and 2. Live parts shall not be exposed.

502-16. Grounding, Class II, Divisions 1 and 2. Wiring and equipment shall be grounded in accordance with (a) through (f) below.

(a) Exposed Parts. Exposed noncurrent-carrying metal parts of equipment, such as the frames or metal exteriors of motors, fixed or portable lamps, lighting fixtures, or other utilization equipment, or cabinets, cases, and conduit shall be grounded as specified in Article 250.

(b) Bonding. The locknut-bushing and double-locknut type of contact shall not be depended upon for bonding purposes; but bonding jumpers with proper fittings or other approved means shall be used.

Such means of bonding shall apply to all intervening raceways, fittings, boxes, enclosures, etc., between hazardous areas and the point of grounding for service equipment. Where flexible conduit is used as permitted in Section 502-4, bonding jumpers with proper fittings shall be provided around such conduit.

(c) Lightning Protection. Each ungrounded service conductor of a wiring system in a Class II location, where supplied from an ungrounded overhead electric 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, where supplied from a grounded alternating-current supply system in which a grounded conductor is a part of the service, shall have the grounded service conductor bonded to the raceway system and to the grounding conductor for the raceway system. The bonding connection to the grounded service conductor shall be made on the supply side of the service disconnecting means.

(e) Transformer Ground Bonded to Raceway. Wiring in a Class II location, where supplied from a grounded alternating-current supply system in which no grounded conductor is a part of the service, shall be provided with a metallic connection between the supply system ground and the service-equipment enclosure. The metallic connection shall comply with Section 250-23(b).

(f) Multiple Grounds. Where, in the application of Section 250-21, it is necessary to abandon one or more grounding connections to avoid objectionable passage of current over the grounding conductors, the connection required in (d) or (e) above shall not be abandoned while any other grounding connection remains connected to the supply system.

ARTICLE 503 — CLASS III LOCATIONS

503-1. General. The general rules of this Code shall apply to electric wiring and equipment in locations classified as Class III locations in Section 500-6.

Exception: As modified by this Article.

Equipment installed in Class III locations shall 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 that is carbonized or excessively dry is highly susceptible to spontaneous ignition. The maximum surface temperatures under operating conditions shall not exceed 165°C (329°F) for equipment that is not subject to overloading, and 120°C (248°F)

for equipment (such as motors or power transformers) that may be overloaded.

For Electric Trucks see, Type Designation, Areas of Use, Maintenance, and Operation of Powered Industrial Trucks (NFPA No. 505-1973).

503-2. Transformers and Capacitors, Class III, Divisions 1 and 2. Transformers and capacitors shall comply with Section 502-2(b).

503-3. Wiring Methods. Wiring methods shall comply with (a) and (b) below.

(a) **Class III, Division 1.** In Class III, Division 1 locations, the wiring method shall be threaded rigid metal conduit or approved Type MI, MC, CS, or ALS cables.

(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, Section 502-4(a) (2) shall apply.

(b) **Class III, Division 2.** In Class III, Division 2 locations, the wiring method shall comply with (a) above.

Exception: In sections, compartments, or areas used solely for storage and containing no machinery, open wiring on insulators shall be permitted where installed in accordance with Article 320, but only on condition that protection as required by Section 320-14 be provided where conductors are not run in roof spaces and are well out of reach of sources of physical damage.

503-4. Switches, Circuit Breakers, Motor Controllers, and Fuses, Class III, Divisions 1 and 2. Switches, circuit breakers, motor controllers, and fuses, including pushbuttons, relays, and similar devices, shall be provided with tight metal enclosures designed to minimize entrance of fibers and flyings, and which shall: (1) be equipped with telescoping or close fitting covers or with other effective means to prevent escape of sparks or burning material, and (2) have no openings (such as holes for attachment screws) through which, after installation, sparks or burning material might escape, or through which exterior accumulations of fibers or flyings or adjacent combustible material might be ignited.

503-5. Control Transformers and Resistors, Class III, Divisions 1 and 2. Transformers, impedance coils, and resistors used as or in conjunction with control equipment for motors, generators, and appliances shall comply with Section 502-7(b).

Exception: In Class III, Division 1 locations where these devices are in the same enclosure with switching devices of such control equipment and are used only for starting or short-time duty, the enclosure shall comply with Section 503-4.

503-6. Motors and Generators.

(a) **Class III, Division 1.** In Class III, Division 1 locations, motors,

generators, and other rotating electric machinery shall be totally enclosed nonventilated, totally enclosed pipe-ventilated, or totally enclosed fan-cooled.

Exception: In locations where, in the judgment of the authority having jurisdiction, only moderate accumulations of lint or flyings will be likely to collect on, in, or in the vicinity of a rotating electric machine, and where such machine is readily accessible for routine cleaning and maintenance, one of the following shall be permitted:

a. Self-cleaning textile motors of the squirrel-cage types;

b. Standard open-type machines without sliding contacts, centrifugal or other types of switching mechanism, including motor overload devices; or

c. Standard open-type machines having such contacts, switching mechanisms, or resistance devices enclosed within tight metal housings without ventilating or other openings.

(b) Class III, Division 2. In Class III, Division 2 locations, motors, generators, and other rotating electric machinery shall be totally enclosed nonventilated, totally enclosed pipe-ventilated, or totally enclosed fan-cooled.

(c) Types Not Permitted, Class III, Divisions 1 and 2. Motors, generators, or other rotating electric machinery of the partially enclosed or splash-proof type shall not be installed in Class III locations.

503-7. Ventilating Piping, Class III, Divisions 1 and 2. Ventilating pipes for motors, generators, or other rotating electric machinery, or for enclosures for electric equipment shall be of metal not lighter than No. 24 MSG, or of equally substantial noncombustible material, and shall comply with the following: (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; and (3) be protected against physical damage and against rusting or other corrosive influences.

Ventilating pipes shall be sufficiently tight, including their connections, 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 that might ignite accumulations of fibers or flyings or combustible material in the vicinity. For metal pipes, lock seams and riveted or welded joints shall be permitted; and tight-fitting slip joints shall be permitted where some flexibility is necessary, as at connections to motors.

503-8. Utilization Equipment, Class III, Divisions 1 and 2.

(a) Heaters. Electrically heated utilization equipment shall be approved for Class III locations.

(b) Motors. Motors of motor-driven utilization equipment shall comply with Section 503-6.

(c) Switches, Circuit Breakers, Motor Controllers, and Fuses. Switches, circuit breakers, motor controllers, and fuses shall comply with Section 503-4.

503-9. Lighting Fixtures, Class III, Divisions 1 and 2.

(a) Fixed Lighting. Lighting fixtures for fixed lighting shall provide enclosures for lamps and lampholders that are 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 show the maximum wattage of the lamps that shall be permitted without exceeding an exposed surface temperature of 165°C (329°F) under normal conditions of use.

(b) Physical Damage. A fixture that may be exposed to physical damage shall be protected by a suitable guard.

(c) Pendant Fixtures. Pendant fixtures shall be suspended by stems of threaded rigid metal 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 the unswitched type with no exposed metal parts and without provision for receiving attachment plugs. In all other respects, portable lamps shall comply with (a) above.

503-10. Flexible Cords, Class III, Divisions 1 and 2. Flexible cords shall comply with Section 502-12.

503-11. Receptacles and Attachment Plugs, Class III, Divisions 1 and 2. Receptacles and attachment plugs shall comply with Section 502-13(b).

503-12. Signaling, Alarm, Remote-Control, and Local Loud-Speaker Intercommunication Systems, Class III, Divisions 1 and 2. Signaling, alarm, remote-control, and local loud-speaker intercommunication systems shall comply with Section 502-14(a).

503-13. Electric Cranes, Hoists, and Similar Equipment, Class III, Divisions 1 and 2. Where installed for operation over combustible fibers or accumulations of flyings, traveling cranes and hoists for material handling, traveling cleaners for textile machinery, and similar equipment shall comply with (a) through (d) below.

(a) Power Supply. Power supply to contact conductors shall be isolated from all other systems, shall be ungrounded, and shall be equipped with an acceptable recording ground detector that will give an alarm and automatically de-energize the contact conductors in case of a fault to ground, or with an acceptable ground-fault indicator that will give a visual and audible alarm, and maintain the alarm as long as power is supplied to the system and the ground fault remains.

(b) Contact Conductors. Contact conductors shall be so located or guarded as to be inaccessible to other than authorized persons and shall be protected against accidental contact with foreign objects.

(c) Current Collectors. Current collectors shall be so arranged or guarded as to confine normal sparking and prevent escape of sparks or hot particles. To reduce sparking, two or more separate surfaces of contact shall be provided for each contact conductor. Reliable means

shall be provided to keep contact conductors and current collectors free of accumulations of lint or flyings.

(d) **Control Equipment.** Control equipment shall comply with Sections 503-4 and 503-5.

503-14. Storage-Battery Charging Equipment, Class III, Divisions 1 and 2. Storage-battery charging equipment shall be located in separate rooms built or lined with substantial noncombustible materials so constructed as to adequately exclude flyings or lint and shall be well ventilated.

503-15. Live Parts, Class III, Divisions 1 and 2. Live parts shall not be exposed.

Exception: As provided in Section 503-13.

503-16. Grounding, Class III, Divisions 1 and 2. Wiring and equipment shall be grounded in accordance with Section 502-16.

ARTICLE 510 — HAZARDOUS (CLASSIFIED) LOCATIONS — SPECIFIC

510-1. Scope. Articles 511 through 517 cover occupancies or parts of occupancies that are or may be hazardous because of atmospheric concentrations of flammable liquids, gases, or vapors, or because of deposits or accumulations of materials that may be readily ignitable.

510-2. General. The general rules of this Code shall apply to electric wiring and equipment in occupancies within the scope of Articles 511 through 517, except as such rules are modified in those Articles. Where unusual conditions exist in a specific occupancy, the authority having jurisdiction shall judge with respect to the application of specific rules.

ARTICLE 511 — COMMERCIAL GARAGES, REPAIR AND STORAGE

511-1. Scope. These occupancies shall include locations used for service and repair operations in connection with self-propelled vehicles (including passenger automobiles, buses, trucks, tractors, etc.) in which volatile flammable liquids are used for fuel or power. Areas in which flammable fuel is transferred to vehicle fuel tanks shall conform to Article 514. Parking garages used for parking or storage and where no repair work is done except exchange of parts and routine maintenance requiring no use of electrical equipment, open flame, welding, or the use of volatile flammable liquids are not classified as hazardous areas,

but they shall be adequately ventilated to carry off the exhaust fumes of the engines.

For further information, see *Parking Structures NFPA 88A-1973* and *Repair Garages 88B-1973*.

511-2. Hazardous Areas. Classification under Article 500.

(a) For each floor the entire area up to a level of 18 inches above the floor shall be considered to be a Class I, Division 2 location except where the enforcing agency determines that there is mechanical ventilation providing a minimum of four air changes per hour.

(b) Any pit or depression below floor level shall be considered to be a Class I, Division 1 location which shall extend up to said floor level, except that any pit or depression in which six air changes per hour are exhausted at the floor level of the pit shall be permitted to be judged by the enforcing agency to be a Class I, Division 2 location.

(c) Areas adjacent to defined locations in which hazardous vapors are not likely to be released such as stock rooms, switchboard rooms and other similar locations shall not be classed as hazardous when mechanically ventilated at a rate of four or more air changes per hour or when effectively cut off by walls or partitions.

(d) Adjacent areas, which by reason of ventilation, air pressure differentials or physical spacing are such that in the opinion of the authority enforcing this code no hazard exists, shall be classified as non-hazardous.

(e) When fuel dispensing units (other than liquid petroleum gas which is prohibited) are located within buildings, the requirements of Article 514 shall govern.

When mechanical ventilation is provided in the dispensing area, the controls shall be interlocked so that the dispenser cannot operate without ventilation as prescribed in Section 500-4(b).

(f) 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 nonconducting 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. Unless the lamp and its cord are supported or arranged in such a manner that they cannot be used in the hazardous areas classified in Section 511-2 they shall be of a type approved for such hazardous locations.

511-3. Wiring and Equipment in Hazardous Areas. Within hazardous areas as defined in Section 511-2 wiring and equipment shall conform to applicable provisions of Article 501. Raceways embedded in a masonry wall 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 areas.

511-4. Sealing. Approved seals conforming to the requirements of Section 501-5 shall be provided, and Section 501-5(b)(2) shall apply to horizontal as well as vertical boundaries of the defined hazardous areas.

511-5. Wiring in Spaces Above Hazardous Areas.

(a) All fixed wiring above hazardous areas shall be in metallic raceways or shall be Type MI, TC, SNM, MC, CS, or Type ALS cable. Cellular metal floor raceways shall be permitted to 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 any service except electrical or compressed air.

(b) For pendants, flexible cord suitable for the type of service and approved for hard usage shall be used.

(c) When a circuit which supplies portables or pendants includes an identified grounded conductor as provided in Article 200, receptacles, attachment plugs, connectors, and similar devices shall be of polarized type, and the identified conductor of the flexible cord shall be connected to the screw shell of any lampholder or to the identified terminal of any utilization equipment supplied.

(d) Attachment plug receptacles in fixed position shall be located above the level of any defined hazardous area, or be approved for the location.

511-6. Equipment Above Hazardous Locations.

(a) **Arcing Equipment.** Equipment that is less than 12 feet above the floor level and that may produce arcs, sparks, or particles of hot metal, such as cutouts, switches, charging panels, generators, motors, or other equipment (excluding receptacles, lamps and lampholders) having make-and-break or sliding contacts, shall be of the totally enclosed type or so constructed as to prevent escape of sparks or hot metal particles.

(b) **Fixed Lighting.** Lamps and lampholders for fixed lighting that is located over lanes through which vehicles are commonly driven or that may otherwise be exposed to physical damage shall be located not less than 12 feet above floor level, unless of the totally enclosed type or so constructed as to prevent escape of sparks or hot metal particles.

511-7. Battery Charging Equipment. Battery chargers and their control equipment, and batteries being charged shall not be located within hazardous areas classified in Section 511-2.

511-8. Electric Vehicle Charging.

(a) **Cords.** Flexible cords used for charging shall be suitable for the type of service and approved for extra-hard usage. Their ampacity shall be adequate for the charging current.

(b) **Connector Rating.** Connectors shall have an ampere rating not less than the ampacity of the cord, and in no case less than 50 amperes.

(c) **Connector Design and Location.** Connectors shall be so designed and installed that they will disconnect 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 location as defined in Section 511-2.

(d) **Plug Connections to Vehicles.** Where plugs are provided for direct connection to vehicles, the point of connection shall not be within

a hazardous location as defined in Section 511-2, and where the cord is suspended from overhead, it shall be so arranged that the lowest point of sag is at least 6 inches above the floor. Where the vehicle is equipped with an approved plug that will disconnect readily, and where an automatic arrangement is provided to pull both cord and plug beyond the range of physical damage, no additional connector shall be required in the cable or at the outlet.

ARTICLE 513 — AIRCRAFT HANGARS

513-1. Definition. An aircraft hangar is a location used for storage or servicing of aircraft in which gasoline, jet fuels, or other volatile flammable liquids or flammable gases are used. It shall not include locations used exclusively for aircraft that have never contained such liquids or gases, or that have been drained and properly purged.

513-2. Classification of Locations.

(a) **Below Floor Level.** Any pit or depression below the level of the hangar floor shall be classified as a Class I, Division 1 location that shall extend up to said floor level.

(b) **Areas Not Cut Off or Ventilated.** The entire area of the hangar, including any adjacent and communicating areas not suitably cut off from the hangar, shall be classified as a Class I, Division 2 location up to a level 18 inches above the floor.

(c) **Vicinity of Aircraft.** The area within 5 feet horizontally from aircraft power plants or aircraft fuel tanks shall be classified as a Class I, Division 2 location that shall extend upward from the floor to a level 5 feet above the upper surface of wings and of engine enclosures.

(d) **Areas Suitably Cut Off and Ventilated.** Adjacent areas in which flammable liquids or vapors are not likely to be released, such as stock rooms, electrical control rooms, and other similar locations, shall not be classified as hazardous where adequately ventilated and where effectively cut off from the hangar itself by walls or partitions.

513-3. Wiring and Equipment in Hazardous Areas. All wiring and equipment that is or may be installed or operated within any of the hazardous locations defined in Section 513-2 shall comply with the applicable provisions of Article 501. All wiring installed in or under the hangar floor shall comply with the requirements for Class I, Division 1 hazardous locations. Where 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 service other than piped compressed air.

Attachment plugs and receptacles in hazardous locations shall be approved for Class I locations or shall be so designed that they cannot be energized while the connections are being made or broken.

513-4. Wiring Not Within Hazardous Areas.

(a) **Fixed Wiring.** All fixed wiring in a hangar, but not within a

hazardous location as defined in Section 513-2, shall be installed in metallic raceways or shall be Type MI, TC, SNM, MC, CS, or Type ALS cable.

Exception: Wiring in nonhazardous locations as defined in Section 513-2(d) shall be of a type recognized in Chapter 3.

(b) Pendants. For pendants, flexible cord suitable for the type of service and approved for hard usage shall be used. Each such cord shall include a separate grounding conductor.

(c) Portable Equipment. For portable utilization equipment and lamps, flexible cord suitable for the type of service and approved for extra-hard usage shall be used. Each such cord shall include a separate grounding conductor.

(d) Grounded and Grounding Conductors. Where a circuit supplies portables or pendants and includes an identified grounded conductor as provided in Article 200, receptacles, attachment plugs, connectors, and similar devices shall be of the polarized type, and the grounded conductor of the flexible cord shall be connected to the screw-shell of any lampholder or to the grounded terminal of any utilization equipment supplied. Acceptacle means shall be provided for maintaining continuity of the grounding conductor between the fixed raceway system and the noncurrent-carrying metal portions of pendant fixtures, portable lamps, and portable utilization equipment.

513-5. Equipment Not Within Hazardous Locations.

(a) Arcing Equipment. In locations other than those described in Section 513-2, equipment that is less than 10 feet above wings and engine enclosures of aircraft and that 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 the totally enclosed type or so constructed as to prevent escape of sparks or hot metal particles.

Exception: Equipment in areas described in Section 513-2(d) shall be permitted to be of the general-purpose type.

(b) Lampholders. Lampholders of metal-shell, fiber-lined types shall not be used for fixed incandescent lighting.

(c) Portable Lamps. Portable lamps that are or may be used within a hangar shall be approved for Class I locations.

(d) Portable Equipment. Portable utilization equipment that is or may be used within a hangar shall be of a type suitable for use in Class I, Division 2 locations.

513-6. Stanchions, Rostrums, and Docks.

(a) In Hazardous Location. Electric wiring, outlets, and equipment (including lamps) on or attached to stanchions, rostrums, or docks that are located or likely to be located in a hazardous location as defined in Section 513-2(c) shall comply with the requirements for Class I, Division 2 locations.

(b) Not in Hazardous Location. Where stanchions, rostrums, or docks are not located or likely to be located in a hazardous location as

defined in Section 513-2(c), wiring and equipment shall comply with Sections 513-4 and 513-5, except that such wiring and equipment not more than 18 inches above the floor in any position shall comply with (a) above. Receptacles and attachment plugs shall be of locking type that will not readily disconnect.

(c) **Mobile Type.** Mobile stanchions with electric equipment complying with (b) above shall carry at least one permanently affixed warning sign to read: "WARNING — KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

513-7. Sealing. Approved seals shall be provided in accordance with Section 501-5. Sealing requirements specified in Sections 501-5(a)(4) and 501-5(b)(2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous locations. Raceways embedded in a masonry floor or buried beneath a floor shall be considered to be within the hazardous location above the floor where any connections or extensions lead into or through such location.

513-8. Aircraft Electrical Systems. Aircraft electrical systems shall be de-energized when the aircraft is stored in a hangar, and, whenever possible, while the aircraft is undergoing maintenance.

513-9. Aircraft Battery — Charging and Equipment. Aircraft batteries shall not be charged when installed in an aircraft located inside or partially inside a hangar.

Battery chargers and their control equipment shall not be located or operated within any of the hazardous areas defined in Section 513-2, and shall preferably be located in a separate building or in an area such as defined in Section 513-2(d). Mobile chargers shall carry at least one permanently affixed warning sign to read: "WARNING — KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS." Tables, racks, trays, and wiring shall not be located within a hazardous location, and, in addition, shall comply with Article 480.

513-10. External Power Sources for Energizing Aircraft.

(a) **Not Less Than 18 Inches Above Floor.** Aircraft energizers shall be so designed and mounted that all electric equipment and fixed wiring will be at least 18 inches above floor level and shall not be operated in a hazardous location as defined in Section 513-2(c).

(b) **Marking for Mobile Units.** Mobile energizers shall carry at least one permanently affixed warning sign to read: "WARNING — KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

(c) **Cords.** Flexible cords for aircraft energizers and ground support equipment shall be approved for the type of service and extra-hard usage and shall include an equipment grounding conductor.

513-11. Mobile Servicing Equipment with Electric Components.

(a) **General.** Mobile servicing equipment (such as vacuum cleaners, air compressors, air movers, etc.) having electric 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 location defined in Section 513-2(c) and shall carry at least one permanently affixed warning sign to read: "WARNING — KEEP 5 FEET CLEAR OF AIRCRAFT ENGINES AND FUEL TANK AREAS."

(b) **Cords and Connectors.** Flexible cords for mobile equipment shall be suitable for the type of service and approved for extra-hard usage, and shall include an equipment grounding conductor. Attachment plugs and receptacles shall be approved for the location in which they are installed, and shall provide for connection of the grounding conductor to the raceway system.

(c) **Restricted Use.** Equipment not suitable for Class I, Division 2 locations shall not be operated in locations where maintenance operations likely to release flammable liquids or vapors are in progress.

513-12. Grounding. All metal raceways and all noncurrent-carrying metal portions of fixed or portable equipment, regardless of voltage, shall be grounded as provided in Article 250.

ARTICLE 514 — GASOLINE DISPENSING AND SERVICE STATIONS

514-1. Definition. A gasoline dispensing and service station is a location where gasoline or other volatile flammable liquids or liquefied flammable gases are transferred to the fuel tanks (including auxiliary fuel tanks) of self-propelled vehicles.

Other areas used as lubritoriums, service rooms, repair rooms, offices, salesrooms, compressor rooms, and similar locations shall comply with Articles 510 and 511 with respect to electric wiring and equipment.

Where the authority having jurisdiction can satisfactorily determine that flammable liquids having a flash point below 38°C (100°F), such as gasoline, will not be handled, he may classify such a location as non-hazardous.

For further information regarding safeguards for gasoline dispensing and service stations, see Flammable and Combustible Liquids Code (NFPA No. 30-1969).

514-2. Hazardous Locations.

(a) **Vicinity of Dispenser.** The space within the dispenser up to 4 feet from its base and the space within 18 inches extending horizontally from the dispenser up to 4 feet from its base shall be considered a Class I, Division 1 location. This classification shall also apply to any space below the dispenser that may contain electric wiring or equipment.

(b) **Within 20 Feet of Dispenser.** In an outside location, any area (excluding Class I, Division 1, but including buildings not suitably cut off) within 20 feet horizontally from the exterior enclosure of any dispensing pump shall be classified as a Class I, Division 2 location, which shall extend to a level 18 inches above driveway or ground level.

(c) **Vicinity of Tank Fill-Pipe.** In an outside location, any area (excluding Class I, Division 1, but including buildings not suitably cut off) within 10 feet horizontally from any tank fill-pipe shall be classified as a Class I, Division 2 location, which shall extend upward to a level 18 inches above driveway or ground level.

(d) **Below Surface.** Electric wiring and equipment, any portion of which is below the surface of locations defined as Class I, Division 1 or Division 2 in (a), (b), or (c) above shall be classified as a Class I, Division 1 location, which shall extend at least to the point of emergence above grade.

(e) **Overhead Dispensing Units.** Where the dispensing unit, including the hose and hose nozzle valve, is suspended from a canopy, ceiling, or structural support, the Class I, Division 1 location shall include the volume within the enclosure and shall also extend 18 inches in all directions from the enclosure where not suitably cut off by a ceiling or wall. The Class I, Division 2 location shall extend 2 feet horizontally in all directions beyond the Division 1 classified location and extend to grade below this classified location. In addition, the horizontal area 18 inches above grade for a distance of 20 feet, measured from a point vertically below the edge of any dispenser enclosure, shall be classified as a Division 2 location. All electric equipment integral with the dispensing hose or nozzle shall be approved for Class I locations.

(f) **Vicinity of Tank Vent-Pipe.** The spherical volume within a 3-foot radius from point of discharge of any tank vent-pipe shall be classified as a Class I, Division 1 location, and the volume between 3-foot to 5-foot radius from point of discharge of a vent shall be classified as a Class I, Division 2 location. For any vent that does not discharge upward, the cylindrical volume below both the Division 1 and 2 locations extending to the ground shall be classified as a Class I, Division 2 location. The hazardous location shall not extend beyond an unpierced wall.

(g) **Pits Below Grade.** In addition to the requirements of Section 514-1, the space within any pit, or space below grade in a lubrication room shall be classified as a Class I, Division 1 location. The area within the entire lubrication room up to 18 inches above the floor or grade, and the space within 3 feet measured in any direction from the dispensing point of a hand-operated unit dispensing Class I liquids shall be classified as a Class I, Division 2 location.

514-3. Wiring and Equipment Within Hazardous Locations. All electric equipment and wiring within hazardous locations defined in Section 514-2 shall comply with the applicable provisions of Article 501.

Exception: As permitted in Section 514-8.

For special requirements for conductor insulation, see Section 501-13.

514-4. Wiring and Equipment Above Hazardous Locations. Wiring and equipment above the hazardous locations defined in Section 514-2 shall comply with Sections 511-5 and 511-6.

514-5. Circuit Disconnects. Each circuit leading to or through a dispensing pump shall be provided with a switch or other acceptable means to disconnect simultaneously from the source of supply all conductors of the circuit, including the grounded neutral, if any.

514-6. Sealing.

(a) **At Dispenser.** An approved seal shall be provided in each conduit run entering or leaving a dispenser or any cavities or enclosures in direct communication therewith. The sealing fitting shall be the first fitting after the conduit emerges from the earth or concrete.

(b) **At Boundary.** Additional seals shall be provided in accordance with Section 501-5. Sections 501-5(a)(4) and 501-5(b)(2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous locations.

514-7. Grounding. Metal portions of dispensing pumps, metal raceways, and all noncurrent-carrying metal parts of electric equipment, regardless of voltage, shall be grounded as provided in Article 250.

514-8. Underground Wiring. Underground wiring shall be installed in rigid metal conduit, or, where buried under not less than 2 feet of earth, it shall be permitted in rigid nonmetallic conduit complying with Article 347. Where rigid nonmetallic conduit is used, an equipment grounding conductor shall be included to provide electrical continuity of the raceway system and for grounding of noncurrent-carrying metal parts.

Exception: Type MI cable shall be permitted where it is installed in accordance with Article 330.

ARTICLE 515 — BULK-STORAGE PLANTS

515-1. Definition. A bulk-storage plant is a location where gasoline or other volatile flammable liquids are stored in tanks having an aggregate capacity of one carload or more, and from which such products are distributed (usually by tank truck).

515-2. Hazardous Locations.**(a) Pumps, Bleeders, Withdrawal Fittings, Meters, and Similar Devices.**

(1) Adequately ventilated indoor locations containing pumps, bleeders, withdrawal fittings, meters, and similar devices that are located in pipe lines handling flammable liquids under pressure shall be classified as a Class I, Division 2 location within a 5-foot distance extending in all directions from the exterior surface of such devices. The Class I, Division 1 location shall also extend 25 feet horizontally from any surface of these devices and extend upward to 3 feet above floor or grade level.

See Flammable and Combustible Liquids Code (NFPA No. 30-1973) for discussion of factors influencing adequacy of ventilation required to prevent formation of hazardous vapor-air mixtures.

(2) Inadequately ventilated indoor locations containing pumps, bleeders, withdrawal fittings, meters, and similar devices that are located in pipe lines handling flammable liquids under pressure shall be classified as a Class I, Division 1 location within a 5-foot distance extending in all directions from the exterior surface of such devices. The Class I, Division 1 location shall also extend 25 feet horizontally from any sur-

face of the devices and extend upward to 3 feet above floor or grade level.

(3) Outdoor locations containing pumps, bleeders, withdrawal fittings, meters, and similar devices that are located in pipe lines handling flammable liquids under pressure shall be classified as Class I, Division 2 locations within a 3-foot distance extending in all directions from the exterior surface of such devices. The Class I, Division 2 location shall also extend up to 18 inches above grade level within 10 feet horizontally from any surface of the devices.

(b) Transfer of Flammable Liquids to Individual Containers.

(1) In outdoor locations or wherever positive and reliable mechanical ventilation is provided in indoor locations in which flammable liquids are transferred to individual containers, such locations shall be classified as a Class I, Division 1 location within 3 feet of the vent or fill opening extending in all directions. A Class I, Division 2 location shall be within the space extending between a 3-foot and 5-foot radius from the vent or fill opening extending in all directions, and including the area within a horizontal radius of 10 feet from the vent or fill opening and extending to a height of 18 inches above floor or grade levels.

See Flammable and Combustible Liquids Code (NFPA No. 30-1973) for discussion of factors pertaining to positive and reliable mechanical ventilation required to prevent formation of hazardous vapor-air mixtures.

(2) Indoor locations, in which flammable liquids are transferred to containers and where positive and reliable mechanical ventilation is not provided, shall be classified as Class I, Division 1 locations.

(c) Loading and Unloading of Tank Vehicles and Tank Cars in Outside Locations.

(1) The space extending 3 feet in all directions from the dome when loading through an open dome or from the vent when loading through a closed dome with atmospheric venting shall be classified as a Class I, Division 1 location.

(2) The space extending between a 3-foot and 5-foot radius from the dome when loading through an open dome or from the vent when loading through a closed dome with atmospheric venting shall be classified as a Class I, Division 2 location.

(3) The space extending within 3 feet in all directions from a fixed connection used in bottom loading or unloading, loading through a closed dome with atmospheric venting, or loading through a closed dome with a vapor recovery system, shall be classified as a Class I, Division 2 location. In the case of bottom loading or unloading, this classification shall also be applied to the area within a 10-foot radius from the point of connection and extending 18 inches above grade.

(d) Aboveground Tanks.

(1) The space above the roof and within the shell of a floating roof type tank shall be classified as a Class I, Division 1 location.

(2) For all types of aboveground tanks, the space within 10 feet from the shell, ends, and roof of other than a floating roof shall be classified as a Class I, Division 2 location. Where dikes are provided, the space inside the dike and extending upward to the top of the dike shall be classified as a Class I, Division 2 location.

(3) The space within 5 feet of a vent opening and extending in all directions shall be classified as a Class I, Division 1 location.

(4) The space between 5 and 10 feet of a vent opening and extending in all directions shall be classified as a Class I, Division 2 location.

For underground tanks, see Article 514.

(e) Pits.

(1) Any pit or depression, any part of which lies within a Division 1 or Division 2 location as defined herein, shall be classified as a Class I, Division 1 location unless provided with positive and reliable mechanical ventilation.

(2) Any such location that is provided with positive and reliable mechanical ventilation shall be classified as a Class I, Division 2 location.

See Flammable and Combustible Liquids Code (NFPA No. 30-1973) for discussion of factors pertaining to positive and reliable mechanical ventilation required to prevent formulation of hazardous vapor-air mixtures.

(3) Any pit or depression not within a Division 1 or Division 2 location as defined herein, but that contains piping, valves, or fittings, shall be classified as a Class I, Division 2 location.

(f) Garages for Tank Vehicles. Storage and repair garages for tank vehicles shall be classified as a Class I, Division 2 location up to 18 inches above floor or grade level.

Exception: Where in the judgment of the authority having jurisdiction, conditions warrant more severe classification or a greater extent of the hazardous location.

(g) Adjacent Locations. Office buildings, boiler rooms, and similar locations, that are outside the limits of hazardous locations as defined herein and are not used for handling or storage of volatile flammable liquids or containers for such liquids, shall not be classified as hazardous locations.

515-3. Wiring and Equipment Within Hazardous Locations. All electric wiring and equipment within the hazardous locations defined in Section 515-2 shall comply with the applicable provisions of Article 501.

Exception: As permitted in Section 515-5.

515-4. Wiring and Equipment Above Hazardous Locations. All fixed wiring above hazardous locations shall be in metallic raceways or be Type ALS, CS, MI, TC, SNM, or Type MC cable. Fixed equipment that 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 the totally enclosed type or be so constructed as to prevent escape of sparks or hot metal particles. Portable lamps or other utilization equipment and their flexible cords shall comply with the provisions of Article 501 for the class of location above which they are connected or used.

515-5. Underground Wiring.

(a) Wiring Method. Underground wiring shall be installed in rigid metal conduit, or where buried under not less than 2 feet of earth, shall be permitted in rigid nonmetallic conduit or in the form of cable ap-

proved for the purpose. Where cable is used, it shall be enclosed in rigid metal conduit from the point of lowest buried cable level to the point of connection to the aboveground raceway.

(b) Insulation. Conductor insulation shall comply with Section 501-13.

(c) Nonmetallic Wiring. Where rigid nonmetallic conduit or cable with a nonmetallic sheath is used, an equipment grounding conductor shall be included to provide for electrical continuity of the raceway system and for grounding of noncurrent-carrying metal parts.

515-6. Sealing. Approved seals shall be provided in accordance with Section 501-5. Sealing requirements in Sections 501-5(a)(4) and 501-5(b)(2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous locations. Buried raceways under defined hazardous locations shall be considered to be within such locations.

515-7. Gasoline Dispensing. Where gasoline dispensing is carried on in conjunction with bulk station operations, the applicable provisions of Article 514 shall apply.

515-8. Grounding. All metal raceways and all noncurrent-carrying metal parts of electric equipment shall be grounded as provided in Article 250.

ARTICLE 516 — FINISHING PROCESSES

516-1. Definition. This Article covers locations where paints, lacquers, or other flammable finishes are regularly or frequently applied by spraying, dipping, brushing, or by other means; where volatile flammable solvents or thinners are used; and where readily ignitable deposits or residues from such paints, lacquers, or finishes may occur.

For further information regarding safeguards for finishing processes, such as guarding, fire protection, posting of warning signs, and maintenance, see NFPA Standard for Spray Application Using Flammable and Combustible Materials, No. 33-1973, Dip Tanks Containing Flammable or Combustible Liquids (NFPA No. 34-1971). For additional information regarding ventilation, see Blower and Exhaust Systems, Dust, Stock and Vapor Removal, or Conveying. (NFPA No. 91-1973).

516-2. Hazardous Locations. Classification is with respect to the effects of and exposure to flammable vapors, and in some cases, deposits of paint spray residue.

For deposits and residues, see Sections 516-3(b) and (c).

(a) Class I, Division 1 Locations. The interiors of spray booths and their exhaust ducts; all space within 20 feet horizontally in any direction and 10 feet vertically 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 classified as Class I, Division 1 locations.

(b) **Class I, Division 2 Locations.** The following spaces shall be considered Class I, Division 2 locations unless the authority having jurisdiction judges otherwise.

(1) For extensive open spraying, all space outside of but within 20 feet horizontally and 10 feet vertically of the Class I, Division 1 location as defined in Section 516-2(a), and not separated from it by partitions. See Figure 1.

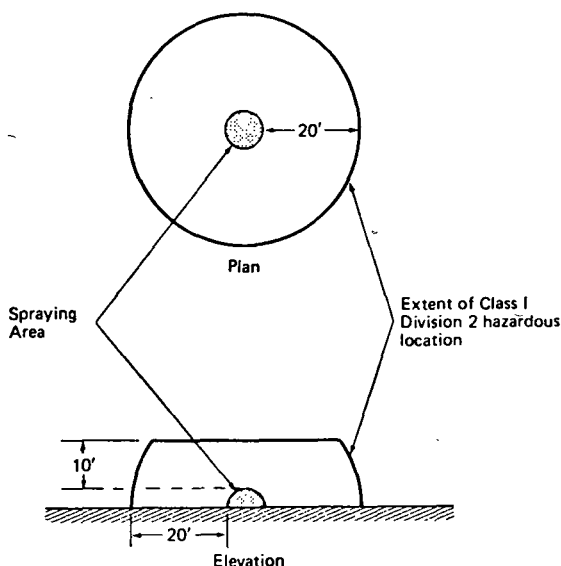
(2) For spraying operations conducted within a closed top, open face or front spray booth, the space shown in Figures 2 and 3, and the space within 3 feet in all directions from openings other than the open face or front.

The Class I, Division 2 location shown in Figures 2 and 3 shall extend from the open face or front of the spray booth in accordance with the following:

(a) If the ventilation system is interlocked with the spraying equipment so as to make the spraying equipment inoperable when the ventilation system is not in operation, the space shall extend 5 feet from the open face or front of the spray booth, and as otherwise shown in Figure 2.

(b) If the ventilation system is not interlocked with the spraying equipment so as to make the spraying equipment inoperable when the ventilation system is not in operation, the space shall extend 10 feet from the open face or front of the spray booth, and as otherwise shown in Figure 3.

Fig. 1



(3) For spraying operations conducted within an open top spray booth, the space 5 feet above the booth and within the space shown in Figure 3 as a Class I, Division 2 location adjacent to openings.

(4) For spraying operations confined to an enclosed spray booth, the space within 3 feet in all directions from any openings in the spray booth.

(5) All space within the room but beyond the limits for Class I, Division 1 as defined in Section 516-2(a) for dip tanks and drain boards, and for other hazardous operations.

(c) **Adjacent Locations.** Adjacent locations that are cut off from the defined hazardous locations by tight partitions without communicating openings, and within which hazardous vapors are not likely to be released, shall be classified as nonhazardous unless the authority having jurisdiction judges otherwise.

(d) **Nonhazardous Locations.** Locations utilizing drying, curing, or fusion apparatus and provided with positive mechanical ventilation adequate to prevent formation of flammable concentrations of vapors, and provided with effective interlocks to de-energize all electric equipment (other than equipment approved for Class I locations) in case the ventilating equipment is inoperative, may be classified as nonhazardous where the authority having jurisdiction so judges.

For further information regarding safeguards, see Ovens and Furnaces, Design, Location and Equipment (NFPA No. 86A-1973).

Fig. 2

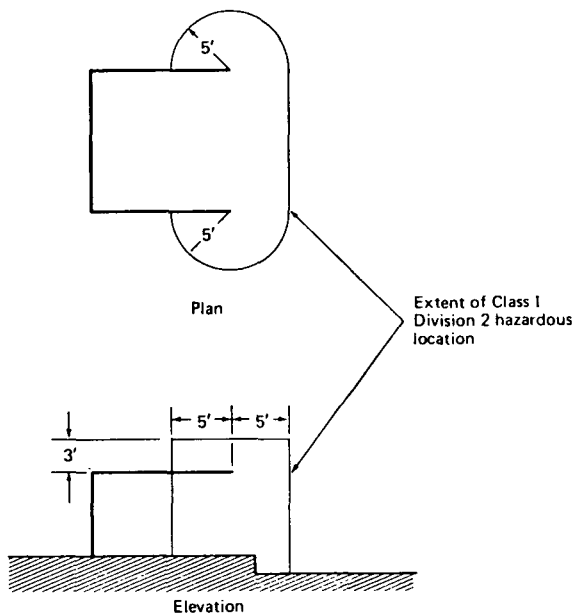
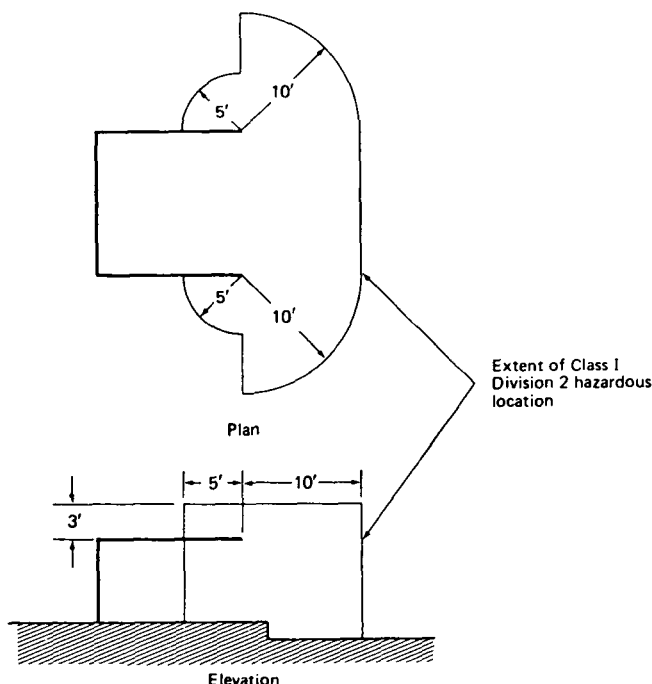


Fig. 3



516-3. Wiring and Equipment in Hazardous Locations.

(a) **Wiring and Equipment — Vapors.** All electric wiring and equipment within the hazardous location (containing vapor only — not residues) defined in Section 516-2 shall comply with the applicable provisions of Article 501.

(b) **Wiring and Equipment — Vapors and Residues.** Unless approved for both readily ignitable deposits and the flammable vapor location, no electric equipment shall be installed or used where it may be subject to hazardous accumulations of readily ignitable deposits or residues, as the susceptibility to spontaneous heating and ignition of some residues may be greatly increased at temperatures above normal. Type MI cable and wiring in threaded rigid metal conduit may be installed in such locations, if the explosion-proof boxes or fittings contain no taps, splices, or terminal connections that may possibly become loose in service and thereby cause abnormal temperatures on external surfaces of boxes or fittings.

(c) **Illumination.** Illumination of readily ignitable areas through panels of glass or other transparent or translucent material shall be permitted only if it complies with the following: (1) fixed lighting units are used as the source of illumination; (2) the panel effectively isolates the

hazardous location from the area in which the lighting unit is located; (3) the lighting unit is approved for its specific location; (4) the panel is of a material or is so protected that breakage will be unlikely; and (5) the arrangement is such that normal accumulations of hazardous residue on the surface of the panel will not be raised to a dangerous temperature by radiation or conduction from the source of illumination.

(d) Portable Equipment. Portable electric lamps or other utilization equipment shall not be used within a hazardous location during operation of the finishing process. When such lamps or utilization equipment are used during cleaning or repairing operations, they shall be of a type approved for Class I, Group D, Division 1 locations, and all exposed metal parts shall be effectively grounded.

(e) Electrostatic Equipment. Electrostatic spraying or detearing equipment shall be installed and used only as provided in Section 516-4.

For further information, see NFPA Standard for Spray Application Using Flammable and Combustible Materials (NFPA No. 33-1973).

516-4. Fixed Electrostatic Equipment. This Section shall apply to any equipment using electrostatically charged elements for the atomization, charging, and/or precipitation of hazardous materials for coatings on articles or for other similar purposes in which the charging or atomizing device is attached to a mechanical support and is not hand-held or manipulated. Where fixed electrostatic spraying and detearing equipment is installed, such equipment shall be of an approved type and shall comply with (a) through (h) below.

(a) Power and Control Equipment. Transformers, power packs, control apparatus, and all other electric portions of the equipment shall be installed outside of the hazardous location as defined in Section 516-2 or be of a type approved for the location.

Exception: High-voltage grids, electrodes, electrostatic atomizing heads, and their connections shall be permitted within the hazardous location.

(b) Electrostatic Equipment: Electrodes and electrostatic atomizing heads shall be: (1) located in suitable noncombustible booths or enclosures provided with adequate mechanical ventilation; (2) adequately supported in permanent locations; and (3) effectively insulated from ground. Electrodes and electrostatic atomizing heads that are permanently attached to their bases, supports, or reciprocators shall be considered as complying with this Section. Insulators shall be nonporous.

Fine-wire elements, where used, shall be under tension at all times and be of unknicked hardened steel or material of comparable strength.

(c) High-Voltage Leads. High-voltage leads shall be properly insulated and protected from mechanical injury or exposure to destructive chemicals. Any exposed element at high voltage shall be effectively and permanently supported on suitable insulators and shall be effectively guarded against accidental contact or grounding. An automatic means shall be provided for grounding the electrode system when the primary of its high voltage supply is electrically de-energized for any reason.

(d) Separation of Goods From Electrostatic Equipment. A safe distance of at least twice the sparking distance shall be maintained between goods being painted and electrodes or electrostatic atomizing heads or

conductors. A suitable sign indicating this safe distance shall be conspicuously posted near the assembly.

(e) Support of Goods. Goods being coated using this process shall be supported on conveyors or hangers. The conveyors or hangers shall be so arranged as to assure that the parts being coated are electrically connected to ground and to maintain safe distances between goods and the electrodes or electrostatic atomizing heads at all times. Goods shall be supported to prevent such swinging or movement which would reduce the clearance to less than that specified in (d) above.

(f) Automatic Controls. Electrostatic apparatus shall be equipped with automatic means which will rapidly de-energize the high voltage elements under any of the following conditions: (1) stoppage of ventilating fans or failure of ventilating equipment from any cause; (2) stoppage of the conveyor carrying goods through the high-voltage field; (3) occurrence of a ground or excessive current leakage at any point in the high-voltage system; (4) reduction of clearances below that specified in (d) above.

(g) Grounding. All electrically conductive objects within the charging influence of the electrodes except those required by the process to be at high voltage shall be adequately grounded. This requirement shall apply to paint containers, wash cans, guards, and any other electrically conductive objects or devices in the area. The equipment shall carry a prominent permanently installed warning regarding the necessity for grounding these objects.

(h) Isolation. Safeguards such as adequate booths, fencing, railings or other means shall be placed about the equipment so that they, either by their location or character or both, assure that a safe isolation of the process is maintained from plant storage or personnel. If mechanical guards are used, such guards shall be at least 5 feet from processing equipment.

516-5. Electrostatic Hand-Spraying Equipment. This Section shall apply to any equipment using electrostatically charged elements for the atomization, charging, and/or precipitation of materials for coatings on articles, or for other similar purposes in which the atomizing device is hand-held or manipulated during the spraying operation. Electrostatic hand-spraying equipment and devices used in connection with paint-spraying operations shall be of approved types and shall comply with (a) through (f) below.

(a) General. The high-voltage circuits shall be designed so as not to produce a spark of sufficient intensity to ignite the most hazardous of those vapor-air mixtures likely to be encountered, nor result in appreciable shock hazard upon coming in contact with a grounded object under all normal operating conditions. The electrostatically charged exposed elements of the hand gun shall be capable of being energized only by an actuator which also controls the paint supply.

(b) Power Equipment. Transformers, power packs, control apparatus, and all other electric portions of the equipment shall be located outside of the hazardous location or be approved for the location.

Exception: The hand gun itself and its connections to the power supply shall be permitted within the hazardous area.

(c) **Handle.** The handle of the spraying gun shall be electrically connected to ground by a metallic connection and be so constructed that the operator in normal operating position is in intimate electrical contact with the grounded handle to prevent build-up of a static charge on the operator's body. Signs indicating the necessity for grounding other persons entering the spray area shall be conspicuously posted.

(d) **Electrostatic Equipment.** All electrically conductive objects in the spraying area shall be adequately grounded. This requirement shall apply to paint containers, wash cans, and any other electrically conductive objects or devices in the area. The equipment shall carry a prominent, permanently installed warning regarding the necessity for this grounding feature.

(e) **Support of Objects.** Objects being painted shall be maintained in metallic contact with the conveyor or other grounded support. Hooks shall be regularly cleaned to insure this contact, and areas of contact shall be sharp points or knife edges where possible. Points of support of the object shall be concealed from random spray where feasible; and where the objects being sprayed are supported from a conveyor, the point of attachment to the conveyor shall be so located as to not collect spray material during normal operation.

(f) **Ventilation.** The spraying operation shall take place within a spray area that is adequately ventilated to remove solvent vapors released from the operation. The electric equipment shall be interlocked with the spraying area ventilation so that the equipment cannot be operated unless the ventilating fans are in operation.

516-6. Powder Coating. This Section shall apply to processes in which combustible dry powders are applied. The hazards associated with combustible dusts are present in such a process to a degree, depending upon the chemical composition of the material, particle size, shape, and distribution.

The hazards associated with combustible dusts are inherent in this process. Generally speaking, the hazard rating of the powders employed is dependent upon the chemical composition of the material, particle size, shape and distribution.

(a) **Electric Equipment and Sources of Ignition.** Electric equipment and other sources of ignition shall conform to the requirements of Article 502. Portable electrical lamps and other utilization equipment shall not be used within a hazardous area during operation of the finishing processes. When such lamps or utilization equipment are used during cleaning or repairing operations, they shall be of a type approved for Class II, Division 1 locations, and all exposed metal parts shall be effectively grounded.

(b) **Fixed Electrostatic Spraying Equipment.** The provisions of Sections 516-4 and (a) above shall apply to fixed electrostatic spraying equipment.

(c) **Electrostatic Hand-Spraying Equipment.** The provisions of Sections 516-5 and (a) above shall apply to electrostatic hand-spraying equipment.

(d) **Electrostatic Fluidized Beds.** Electrostatic fluidized beds and associated equipment shall be of approved types. The high-voltage circuits shall be so designed that any discharge produced when the charging

electrodes of the bed are approached or contacted by a grounded object shall not be of sufficient intensity to ignite any powder-air mixture likely to be encountered nor to result in an appreciable shock hazard.

(1) Transformers, power packs, control apparatus, and all other electric portions of the equipment shall be located outside the powder-coating area or shall otherwise comply with the requirements of (a) above.

Exception: The charging electrodes and their connections to the power supply shall be permitted within the powder-coating area.

(2) All electrically conductive objects within the powder-coating area shall be adequately grounded. The powder-coating equipment shall carry a prominent, permanently installed warning regarding the necessity for grounding these objects.

(3) Objects being coated shall be maintained in electrical contact with the conveyor or other support in order to insure proper grounding. Hangers shall be regularly cleaned to insure effective electrical contact, and areas of electrical contact shall be sharp points or knife edges where possible.

(4) The electric equipment shall be interlocked with a ventilation system so that the equipment cannot be operated unless the ventilating fans are in operation.

516-7. Wiring and Equipment Above Hazardous Locations.

(a) **Wiring.** All fixed wiring above the hazardous locations shall be in metal raceways or shall be Type MI, TC, SNM, MC, CS, or Type ALS cable. Cellular metal floor raceways shall be permitted only for supplying ceiling outlets or extensions to the area below the floor of a hazardous location, but such raceways shall have no connections leading into or through the hazardous location above the floor unless suitable seals are provided. No electric conductor shall be installed in any cell or header that contains a pipe for steam, water, air, gas, drainage, or for other than the electrical service.

(b) **Equipment.** Equipment that may produce arcs, sparks, or particles of hot metal, such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, motors, or other equipment having make-and-break or sliding contacts, where installed above a hazardous location or above a location where freshly finished goods are handled, shall be of the totally enclosed type or be so constructed as to prevent escape of sparks or hot metal particles.

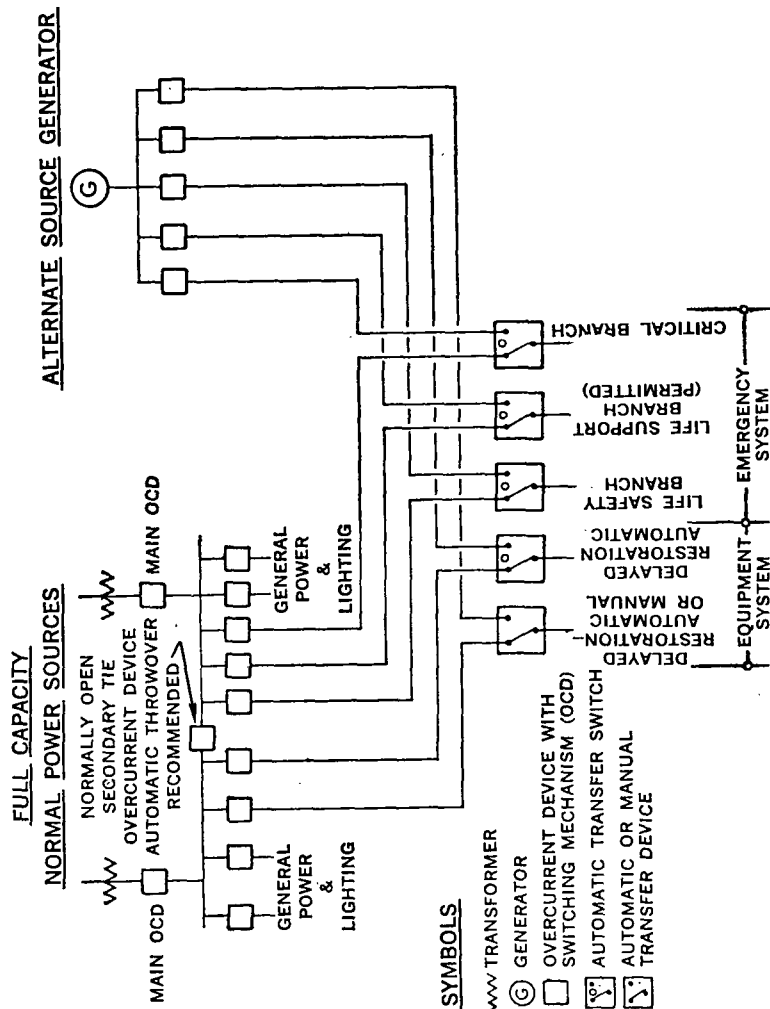
516-8. Grounding. All metal raceways and all noncurrent-carrying metal parts of fixed or portable equipment, regardless of voltage, shall be grounded as provided in Article 250.

ARTICLE 517 — HEALTH CARE FACILITIES

A. General

517-1. Scope. The provisions of this Article shall apply to health care facilities. For additional requirements see Article 660 for medical X-ray equipment and Article 665 for therapeutic high-frequency equipment.

Diagram 517-1. Typical Diagram for Essential Electrical Systems



517-2. Definitions.

Alternate Power Source. One or more generator sets intended to provide power during the interruption of the normal electrical service or the public utility electrical service intended to provide power during interruption of service normally provided by the generating facilities on the premises.

Anesthetizing Location. Any area in which it is intended to administer any flammable or nonflammable inhalation anesthetic agents in the course of examination or treatment and includes operating rooms, delivery rooms, emergency rooms, anesthetizing rooms, corridors, utility rooms and other areas when used for induction of anesthesia with flammable or nonflammable anesthetizing agents.

Anesthetizing-Location Receptacle. A receptacle designed to accept the attachment plugs listed for use in such locations.

Continuous Power System. An electrical system, independent of the alternate source which supplies power without appreciable interruption (1-cycle or less).

Critical Branch. A sub-system of the emergency system consisting of feeders and branch circuits supplying energy to task illumination and selected receptacles serving areas and functions related to patient care, and which can be connected to alternate power sources by one or more transfer switches.

Critical Patient Care Area. A section (rooms, wards or portions of wards) designated for the treatment of critically ill patients.

Critical System. A system of feeders and branch circuits in Nursing Homes and Residential Custodial Care Facilities arranged for connection to the alternate power source to restore service to certain critical receptacles, task illumination and equipment.

Emergency System. A system of feeders and branch circuits meeting the requirements of Article 700, connected to alternate power sources by a transfer switch and supplying energy to an extremely limited number of prescribed functions vital to the protection of life and patient safety, with automatic restoration of electrical power within 10 seconds of power interruption.

Equipment System. A system of feeders and branch circuits arranged for delayed, automatic or manual connection to the alternate power source and which serves primarily 3-phase power equipment.

See Appendix A of Essential Electrical Systems for Health Care Facilities, NFPA No. 76A-1973.

Essential Electrical Systems. Systems comprised of alternate sources of power, transfer switches, overcurrent protective devices, distribution cabinets, feeders, branch circuits, motor controls, and all connected electrical equipment, designed to provide designated areas with continuity of electrical service during disruption of normal power sources, and also designed to minimize the interruptive effects of disruption within the internal wiring system.

Flammable Anesthetics. Gases or vapors such as fluoroene, cyclopropane, divinyl ether, ethyl chloride, ethyl ether, and ethylene, which

may form flammable or explosive mixtures with air, oxygen, or reducing gases such as nitrous oxide.

Flammable Anesthetizing Location. Any operating room, delivery room, anesthetizing room, corridor, utility room, or any other area if used or intended for the application of flammable anesthetics.

Health Care Facilities. Buildings or parts of buildings that contain, but are not limited to, hospitals, nursing homes, extended-care facilities, clinics, and medical and dental offices, whether fixed or mobile.

Immediate Restoration of Service. Automatic restoration of operation with an interruption of not more than 10 seconds as applied to those areas and functions served by the Emergency System, except for areas and functions for which Article 700 otherwise makes specific provisions.

Life Safety Branch. A sub-system of the Emergency System consisting of feeders and branch circuits, meeting the requirements of Article 700 and intended to provide adequate power needs to insure safety to patients and personnel, and which can be connected to alternate power sources by one or more transfer switches.

Life Support Branch. A system of feeders and branch circuits connected to the alternate power source by a transfer switch and functioning as a component of the Emergency System that serves only selected receptacles or fixed equipment in critical patient care areas where electrical service may be necessary for patient survival.

Line Isolation Monitor. A test instrument designed to continually check the balanced and unbalanced impedance from each line of an isolated circuit to ground and equipped with a built-in test circuit to exercise the alarm without adding to the leakage current hazard.

"Line isolation monitor" was formerly known as "ground contact indicator."

Nurses' Stations. Areas intended to provide a center of nursing activity for a group of nurses working under one nurse supervisor and serving bed patients, where the patient calls are received, nurses are dispatched, nurses' notes written, inpatient charts prepared, and medications prepared for distribution to patients. Where such activities are carried on in more than one location within a nursing unit, all such separate areas are considered a part of the nurses' station.

Patient Grounding Point. A jack or terminal bus which serves as the collection point for redundant grounding of electric appliances serving a patient vicinity, and for grounding conductive furniture or nonelectric equipment within reach of a patient or a person who may touch him.

Patient Vicinity. The space with surfaces likely to be contacted by the patient or an attendant who can touch him. This represents a space 6 feet beyond the reach of the patient.

Reference Grounding Point. A terminal bus which is an extension of the equipment grounding bus and is a convenient collection point for grounding all electric appliances, equipment and exposed conductive surfaces in a patient vicinity.

Room Bonding Point. A grounding terminal bus which serves as a collection point for grounding exposed metal or conductive building surfaces in a room.

Task Illumination. Provision for the minimum lighting required to carry out necessary tasks in the described areas, including safe access to supplies and equipment, and access to exits.

B. General Area Wiring Systems

517-3. Grounding. In locations intended for occupancy by patients at any time, all noncurrent-carrying conductive surfaces of electrical equipment that are subject to personal contact shall be grounded by an insulated copper conductor, sized in accordance with Table 250-95, installed with the circuit conductors supplying these receptacles and equipment.

517-4. Wiring Methods. Except as modified in this Article, wiring methods shall comply with the applicable requirements of Chapters 1 through 4 of this Code.

C. Essential Electrical Systems

For additional information, see Essential Electrical Systems for Health Care Facilities; NFPA 76A-1973 and Installation of Centrifugal Fire Pumps. NFPA No. 20-1972.

517-10. General.

(a) Part C applies to hospitals, nursing homes, residential custodial care facilities and other health care facilities serving patients who are unable to provide for their own safety.

(b) Essential Electrical Systems shall consist of two parts:

(1) In Hospitals, the Emergency System and the Equipment System. The systems shall be capable of supplying a limited amount of power and lighting service considered essential for life safety, life support and effective operation during the time the normal electrical service is interrupted for any reason.

See Diagram 517-1.

(2) In Nursing Homes and Residential Custodial Care Facilities, the Emergency System and the Critical System. The systems shall be capable of supplying an amount of power and lighting service considered essential for life safety and effective operation during the time the normal service is interrupted for any reason.

(c) Each essential system shall have adequate capacity and rating for the operation of all lighting and equipment it serves.

517-11. Emergency System — Hospitals.

(a) The Emergency System shall be permitted to consist of three parts: the life safety branch, the critical branch, and the life support branch. These branches shall be limited to circuits essential to specified functions.

(b) A life safety branch and a critical branch shall be required in all hospitals.

(1) The life safety branch shall serve illumination, alarm and alert-

ing equipment which shall be operable at all times for protection of life during emergencies.

(2) The critical branch shall serve lighting and receptacles in critical patient care areas.

(3) The life support branch shall be permitted to be installed as a component of the emergency system. When provided, it shall serve only selected receptacles or fixed equipment in critical patient care areas where electrical service may be necessary for patient survival.

(c) The feeders for the emergency system shall be physically separated from the normal wiring or protected in such a way as to minimize the possibility of simultaneous interruption.

(d) The life safety branch, life support branch, and critical branch of the Emergency System shall be run in metal raceways.

These branches shall be kept entirely independent of all other wiring and equipment and shall not enter the same raceways, boxes or cabinets with each other or other wiring.

Exception No. 1: As permitted in 517-11(b)(3).

Exception No. 2: In transfer switches.

Exception No. 3: In exit or emergency lighting fixtures supplied from two sources.

(e) Only those functions utilizing illumination or equipment which are listed in Sections 517-12, -13, and -14 shall be connected to the Emergency System.

(f) All branches of the Emergency System shall be so installed and connected to the alternate source of power that all lighting and equipment shall be automatically restored to operation within 10 seconds after interruption of the normal source.

517-12. Life Safety Branch — Hospitals. The life safety branch of the Emergency System shall serve the lighting, receptacles and other equipment which are related to the safety of life as follows:

For additional information see Essential Electrical Systems for Health Care Facilities, NFPA No. 76A-1973.

(1) Illumination of means of egress, such as lighting required for corridors, passageways, stairways and landings at exit doors, and all necessary ways of approach to exits.

See Life Safety Code, NFPA No. 101-1973, Section 5-10.

(2) Exit signs and directional signs.

See Life Safety Code, NFPA No. 101-1973, Section 5-11.

(3) Alarm systems, including: fire alarms actuated at manual stations, electric water-flow alarm devices in connection with sprinkler systems, automatic fire or smoke or products of combustion detection devices.

See Life Safety Code, NFPA No. 101-1973, Sections 6-3, 10-1 and 10-2.

(4) Alarms required for systems used for the piping of nonflammable medical gases.

See Nonflammable Medical Gas Systems, NFPA No. 56F-1973.

(5) Hospital communication systems when these are intended for issuing instructions during emergency conditions, including local power requirements for the telephone system.

(6) Generator-set location, including task illumination and selected receptacles.

517-13. Critical Branch Hospitals. The critical branch of the Emergency System shall serve only the following areas and functions related to patient care:

(1) Isolating transformers serving anesthetizing locations.

(2) Task illumination and selected receptacles in: (a) infant nurseries; (b) medication preparation areas; (c) pharmacy dispensing areas; (d) selected acute nursing areas; (e) psychiatric bed areas (task illumination only); (f) nurses' stations (unless adequately lighted by corridor luminaires); (g) ward treatment rooms; (h) surgical and obstetrical suites; (i) angiographic labs; (j) cardiac catheterization labs; (k) coronary care units; (l) delivery rooms; (m) dialysis units; (n) emergency room treatment areas; (o) human physiology labs; (p) intensive care units; (q) operating rooms; (r) post-operative recovery rooms.

517-14. Life Support Branch — Hospitals.

(a) The life support branch when installed shall supply selected receptacles or fixed equipment in critical patient care areas where electrical service may be necessary for patient survival as designated by the governing authority of the hospital.

(b) The power systems in the above locations shall be permitted to be served by an uninterruptible power supply.

517-15. Equipment Systems — Hospitals.

(a) The Equipment System shall be so installed and connected to the alternate source that equipment listed in Section 517-15(d) shall be automatically restored to operation at appropriate time-lag intervals following the restoration of the emergency system to operation. This arrangement shall also provide for reconnection of equipment listed in Sections 517-15(e) and (f) by either delayed, automatic, or manual operation.

(b) The Equipment Systems shall be permitted in raceways and boxes with general wiring.

(c) The Equipment System shall be connected to equipment listed in Sections 517-15(d) and (e). Connection to equipment listed in Section 517-15(f) shall be permitted.

(d) The following components of the Equipment System shall be arranged for automatic restoration of operation: (1) central vacuum and medical air systems serving medical and surgical functions; (2) sump pumps and other equipment including associated control systems and alarms required to operate for the safety of essential apparatus.

(e) The following required components of the Equipment System shall be arranged for either automatic or manual connection to the alternate power source:

(1) Heating equipment for heating of operating, delivery, labor, recovery, and patient rooms, and intensive care units and nurseries.

Exception: Patient room heating during disruption of normal source under either of the following conditions:

- a. The outside air design temperature is higher than -7°C , ($+20^{\circ}\text{F}$).*

This is based on the median of extremes as shown in the 1967 edition of the American Society of Heating, Air Conditioning and Refrigeration Engineers Handbook of Fundamentals.

b. The hospital is served by at least two utility services, each supplied by separate generating sources or a network distribution system fed by two or more generators. The utility services shall be routed, connected, and protected so that a fault any place between the generators and the hospital will not likely cause an interruption of more than one of the utility services.

(2) Elevator service that reaches every patient floor, ground floors, and floors on which surgical suites and obstetrical delivery suites are located. This shall include connections for cab lighting and control and signal systems.

In instances where interruption of power results in an elevator stopping between floors, the provision of throw-over facilities permits the temporary operation of any elevator to release patients or other persons who may be trapped between floors.

(3) Supply and exhaust ventilating systems for laboratory fume hoods, and surgical suites, obstetrical suites, infant nurseries, and emergency treatment spaces where such areas contain no windows.

(f) The following components of the equipment systems shall be permitted to be arranged for either automatic or manual connection to the alternate source:

(1) Selected autoclaving equipment if electrically heated or controlled.

(2) Other selected equipment in locations such as kitchens, laundries, radiological and central refrigeration rooms.

Where heavy interruption currents can be anticipated, the transferred load may be reduced by use of multiple transfer devices. For example, elevator feeders may cause less hazard to electrical continuity if they are fed through individual transfer devices.

517-20. Systems — Nursing Homes and Residential Custodial Facilities.

(a) The requirements of this paragraph shall apply to any nursing home or residential custodial care facility.

Exception: Any freestanding building used for health care other than inpatient hospital care which meets all the requirements of (1), (2), and (3) below inclusive.

1. Maintains admitting and discharge policies that preclude the provision of care for any patient or resident who may need to be sustained by line-operated electro-mechanical means such as electric respirators, suction apparatus, external heart pacers and other life support apparatus.

2. Offers no surgical treatment requiring general anesthesia.

3. Provides automatic battery operated systems or equipment that will be effective for 4 or more hours and is otherwise in accordance with Section 700-6(e) and will be capable of supplying power for light-

ing for exit signs, exit corridors, stairways, nursing stations, medication preparation areas, boiler rooms, and communication areas and supplies battery power to operate all alarm systems.

(b) The Emergency System in nursing homes and residential custodial care facilities shall be so installed and connected to the alternate power source so that all functions specified herein shall be automatically restored to operation within ten seconds after interruption of the normal source. The Emergency System shall supply only the following lighting, receptacles, and equipment which are related to the safety of life:

(1) Illumination of means of egress as necessary for corridors, passageways, stairways, landings, and exit doors, and all ways of approach to exits.

See Life Safety Code, NFPA No. 101-1973, Section 5-10.

(2) Exit signs and exit directional signs.

See Life Safety Code, NFPA No. 101-1973, Section 5-11.

(3) Sufficient lighting in dining and recreation areas to provide illumination to exit ways.

(4) Alarm systems including:

(a) Fire alarms activated at manual stations, by electric water flow alarm devices in connection with sprinkler systems, and by automatic fire or smoke or products of combustion detection devices.

See Life Safety Code, NFPA No. 101-1973, Sections 6-3 and 10-136.

(b) Alarms required for systems used for the piping of non-flammable medical gas.

See Standard for Nonflammable Medical Gas systems, NFPA No. 56F-1973.

(5) Communication systems where these are used for issuing instructions during emergency conditions.

(6) Generator set location, task illumination, and selected receptacles.

(c) The critical system shall be so installed and connected to the alternate power source that equipment listed in 517-20(c)(1) shall be automatically restored to operation at appropriate time lag intervals following the restoration of the Critical System to operation. Its arrangement shall also provide for the additional connection of equipment listed in 517-20(c)(2) by either delayed automatic or manual operation.

(1) The following equipment shall be arranged for automatic connection to the alternate power source:

(a) Patient Care Areas — task illumination and selected receptacles in: (1) Medication preparation areas; (2) Pharmacy dispensing areas; (3) Nurses' stations (unless adequately lighted by corridor luminaries).

(b) Sump pumps and other equipment required to operate for the safety of major apparatus including associated control systems and alarms.

(c) Elevator cab lighting and communication systems.

(2) The following equipment shall be arranged for either automatic or manual connection to the alternate power source:

(a) Heating equipment to provide heating for patient rooms.

Exception: Heating of patient rooms during disruption of the normal source shall not be required under either of the following conditions:

(1) The design temperature is higher than $+20^{\circ}\text{F}$, based on the Median of Extremes as shown in the current edition of the ASHRAE Handbook of Fundamentals.

(2) The facility is served by two or more electrical services supplied from separate generators or a utility distribution network having multiple power input sources and arranged to provide mechanical and electrical separation so that a fault between the facility and the generating sources is not likely to cause an interruption of more than one of the facility service feeders.

(b) Where provided, elevator service that reaches every patient floor and ground floor. This shall include connections for cab lighting and control and signal systems. In instances where interruption of power would result in elevators stopping between floors, it may be desirable to provide throw-over facilities to allow the temporary operation of any elevator for the release of patients or other persons who may be confined between floors.

517-30. Power Sources.

(a) Essential electrical systems shall have a minimum of two independent sources of power: a normal source generally supplying the entire health care facility and an alternate source(s) for use when the normal source is interrupted.

(b) The alternate source of power shall be a generator set(s) driven by some form of prime mover, and located on the premises.

Exception: Where the normal source consists of generating units on the premises, the alternate source shall be either another generating set or an external utility service.

(c) All equipment shall be located to minimize the hazards that might cause complete failure of the equipment, such as floods, fires and icing.

(d) Electrical characteristics of the generator set(s) shall be suitable for the operation of all lighting and equipment to be served.

A higher degree of electrical service continuity will be provided where facilities are two separate full-capacity external services (Section 700-6(c)), connected in such a manner as to pick up the load automatically and so arranged that the load will not be transferred to the generator set(s) if either external service is energized.

517-40. Switching and Overcurrent Protection.

(a) The emergency system and the equipment system in hospitals shall be so arranged that in the event of interruption of the normal power source, an alternate power source shall be automatically connected within 10 seconds to the distribution panels connected to the emergency system and to the time-delay and/or manually operated switches connected to the equipment system. The emergency system and critical system in Nursing Homes and Residential Custodial Care Facilities shall be so arranged that in the event of interruption of the normal power source, an alternate power source shall be automatically connected within 10 seconds to the distribution panels connected to the emergency system and to the time delay and/or manually operated

switches connected to the critical system. Where one or more generators are provided in addition to one or more external services as alternate sources, the automatic connection sequence shall connect either the alternate external service or the generator(s), whichever is arranged for automatic connection.

If the external service and the generator(s) are both arranged for automatic connection, the order of connection to these alternate power sources is an optional design choice.

(b) Automatic switching equipment shall be approved for emergency service and shall be designed and installed with interlocking provisions that will prevent interconnection of normal and alternate sources or any two separate sources of power in any operation of the automatic switching equipment. The equipment shall be so connected that the load is served by the normal power source, except when the normal source is interrupted. Controls and switching equipment shall be so arranged that interruption of the normal sources automatically starts an alternate source generator, automatically disconnects the interrupted normal source of power, and connects the alternate source of power in proper sequence. If a generator is the only alternate source of power time shall be allowed, but not more than 10 seconds, for the generator to attain rated voltage before its connection. Upon transfer from the normal power source to the alternate power source, the loads connected to the emergency system shall be automatically energized immediately. The loads connected onto the equipment system in hospitals and critical systems in nursing homes and residential custodial care facilities shall be connected either automatically or manually after a time delay in such sequential manner as not to overload the generator.

When the normal power source is restored, the automatic transfer devices shall disconnect the alternate source and restore service connection to the normal power source, permitting the operation of manual switches to reconnect the normal power source.

For automatic operation, the provision of a 15-minute or longer time-delay will avoid short-time re-establishment of the normal service and the possibility of erratic operation of the transfer switch.

(c) The provisions of Section 700-18 shall apply to switches installed in exit lighting circuits.

Exception: As provided in Section 700-20(b) switching arrangements to transfer corridor lighting in patient areas to fixtures designed for night lighting.

For more details, see Life Safety Code, NFPA No. 101-1973.

(d) The provisions of Section 700-18, with respect to the location and installation of switches in lighting circuits other than those controlling exit lighting and exit directional signs, shall apply. Personnel ordinarily assigned to work in an area illuminated by fixtures connected to the Emergency System shall be considered as authorized personnel.

This paragraph applies particularly to ungrounded circuits in anesthetizing locations connected to emergency systems.

(e) The life safety branch, the life support branch, the critical branch and the equipment system in hospitals and critical systems in nursing homes and residential custodial care facilities shall be protected by

overcurrent devices so that interruption of service in other wiring systems, due to internal failure shall not interrupt supply to these branches or systems.

It is extremely important that the various overcurrent devices in the essential electrical systems be coordinated to protect against cascading operation on short circuit faults. Primary consideration should also be given to prevent overloading of equipment by limiting the possibilities of large current inrushes due to instantaneous re-establishment of connections to heavy loads.

(f) The electrical characteristics of the transfer switches shall be suitable for the connected load.

The capacity of transfer switches shall be adequate to carry full-load currents and to withstand the thermal and electromagnetic effects of short circuit currents.

517-41. Ground Fault Protection.

(a) When ground-fault protection is provided in the normal service disconnecting means, at least one more step of ground fault protection, downstream toward the load, in each feeder shall be provided. Such protection shall consist of overcurrent devices and current transformers or other equivalent protective equipment which shall cause the feeder disconnecting devices to open.

(b) Main and feeder ground-fault protection shall be fully selective such that the feeder device and not the main device shall open on ground faults on the load side of the feeder device. A 6-cycle minimum separation between the main and feeder ground-fault tripping bands shall be provided. Operating time of the disconnecting devices shall be considered in selecting the time spread between these two bands to achieve 100 percent selectivity.

D. Patient Care Areas

517-50. General.

(a) It is the purpose of Part D to specify the performance criteria and/or wiring methods which will minimize electrical hazards by the maintenance of adequately low-potential differences between conductive surfaces which could be contacted by a patient.

In a health care facility, it is difficult to prevent the occurrence of a conductive or capacitive path from the patient's body to some grounded object, because that path may be established accidentally or through instrumentation directly connected to the patient. Other electrically conductive surfaces which may make an additional contact with the patient, or instruments which may be connected to the patient, then become possible sources of electric currents which can traverse the patient's body. The hazard is increased as more apparatus is associated with the patient, and therefore more intensive precautions must be taken. A special problem is presented by the patient with an externalized electric conductor connected to his heart. He may be electrocuted at current levels so low that special consideration must be given to the design of the patient electrical environment. He requires additional protection in the design of appliances, insulation of his catheter and control of medical practice.

(b) Patient Care areas shall be classified into one of the three following categories:

(1) **General Care Area.** Areas where patients ordinarily have only incidental contact with electrical devices.

(2) **Critical Care Area, Controlled.** Areas where patients ordinarily are intentionally exposed to electrical devices, and where the governing body requires protection (insulation) of externalized cardiac conductors from contact with conductive surfaces other than those designed for connection to such cardiac conductors.

(3) **Critical Care Area, Uncontrolled.** Areas where patients ordinarily are intentionally exposed to electrical devices and where the governing body makes no requirements for protection of externalized cardiac conductors from contact with conductive surfaces other than those designed for the purpose.

(c) The designation of areas in the health care facility in accordance with the classification of patients shall be the responsibility of the governing body of the facility.

517-51. Performance.

(a) Any two exposed conductive surfaces in the patient vicinity shall not exceed the following potential differences at frequencies of 1000 Hertz or less measured across a 1000 ohm resistance.

(1) **General Care Areas.** 500 mv under normal operation.

(2) **Critical Care Areas, Controlled.** 100 mv under normal operation.

(3) **Critical Care Areas, Uncontrolled.** 100 mv under normal operation or under conditions of line-to-ground fault.

Exception: Permanently installed x-ray equipment.

(b) **Special Requirements.** The following requirements in both categories shall not apply to small portable nonelectric devices such as bed pans, chairs, and the like.

(1) **General Care Areas.** Each patient bed location shall be provided with a minimum of four single or two duplex receptacles, each receptacle shall be grounded by means of an insulated copper conductor sized in accordance with Table 250-95.

Each patient bed location shall be supplied by at least two branch circuits of either the normal system and/or the essential electrical system.

The equipment grounding terminal bars of the normal and essential electrical system panelboards shall be bonded together with an insulated continuous, stranded copper bonding jumper not smaller than No. 10.

(2) **Critical Care Areas.** Each patient bed location shall be provided with a minimum of six single or three duplex receptacles, and grounded to the reference grounding point by means of an insulated copper equipment grounding conductor.

Each patient bed location shall be supplied by at least two branch circuits at least one of which shall be an individual branch circuit from a single panelboard of either the normal system and/or the essential electrical system.

Each patient bed location shall be provided with a patient grounding point, grounded to the reference grounding point by means of an insulated continuous, stranded copper conductor, not smaller than No. 10. The patient grounding point shall contain one or more jacks, approved

for the purpose to facilitate the grounding of nonelectric portable equipment.

All exposed conductive surfaces of portable equipment used in the patient vicinity, including those on double-insulated and nonelectric beds shall be grounded to the reference grounding point.

The equipment grounding terminal bars of the normal and essential electrical system panelboards shall be bonded together with an insulated continuous, stranded copper conductor, not smaller than No. 10.

One or more room bonding points shall be provided, and shall be grounded to the reference point by means of an insulated continuous, stranded copper conductor, not smaller than No. 10.

All exposed conductive surfaces in the patient vicinity shall be bonded to the room bonding point(s) by means of an insulated continuous, stranded copper conductor, not smaller than No. 10, run in either a centric or looped manner, or combinations thereof.

Any of the grounding and bonding points in Section 517-51(b) (2) shall be permitted to be combined into a single point.

One patient bed location shall not be served by more than one reference grounding point.

(3) When a grounded electrical distribution system is used, grounding of all metallic raceways shall be assured by means of grounding bushings on all conduit terminations at the panelboard and by means of an insulated, continuous, stranded, copper conductor, not smaller than No. 12, extended from the grounding bus in the panelboard to the conduit grounding bushings.

(4) When an isolated ungrounded system is used to supply power to any area other than anesthetizing locations, it shall conform to the requirements of Sections 517-63(b) and (d), except that the audible and visual indicators of the line isolation monitor shall be permitted to be remotely located if desired.

(5) The use of an isolated ungrounded power source limits the first-fault ground current to a low magnitude; therefore, it shall not be necessary to provide a low ground circuit impedance by running the grounding conductor in the same enclosure as the circuit conductors.

(6) Means of frequent, periodic testing for continuity between the patient ground and any grounded surface shall be provided. The continuity tester shall be permitted to be either permanently mounted or portable and shall be approved for the purpose.

(7) The equipment grounding conductor for special purpose receptacles such as the operation of mobile x-ray equipment shall be extended to the reference grounding points for all locations likely to be served from such receptacles. When such a circuit is served from an isolated ungrounded system, the grounding conductor need not be run with the power conductors; however, the equipment grounding terminal of the special purpose receptacle shall be connected to the reference grounding point.

(c) Permanently Installed X-Ray Equipment.

(1) In addition to the grounding requirements of Article 660, permanently installed X-ray systems shall have a patient grounding point as described in (b) above, located as close as possible to the patient

support, and be connected to the metal frame of the patient support by a separate, insulated, continuous, stranded, copper conductor, not smaller than No. 4.

(2) The patient grounding point shall be connected to the grounding conductor serving the X-ray equipment by an insulated, stranded, copper conductor not smaller than No. 10.

(3) The permanently installed X-ray system including all equipment powered from the X-ray generator power supply shall not be required to be powered by an isolated system. The equipment grounding conductors associated with the equipment shall have a maximum DC resistance of 0.025 ohms, as measured between the chassis and the patient ground point.

517-52. Additional Protective Techniques.

(a) An isolated power system, comprising an isolating transformer or its equivalent, with a line isolation monitor, to supply ungrounded circuits, shall be permitted as part of a system to improve electrical safety, provided that the components of the system are so designed and installed that they meet the requirements for similar systems specified for anesthetizing locations in Section 517-63.

(b) 125-volt, single-phase, 15- and 20-ampere receptacles supplying locations which are commonly subject to wet conditions shall be provided with Ground Fault Circuit Interrupters if interruption of power under fault conditions can be tolerated, or an isolated power system if such interruption cannot be tolerated.

E. Inhalation Anesthetizing Locations

For further information regarding safeguards for anesthetizing locations, see Inhalation Anesthetics Standard, NFPA No. 56A-1973.

517-60. Anesthetizing Locations Classifications.

(a) Hazardous Location.

(1) Any room or space in which flammable anesthetics or volatile flammable disinfecting agents are stored shall be considered to be a Class I, Division 1 location throughout.

(2) In a flammable anesthetizing location, 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.

(b) **Other Than Hazardous Locations.** The term "other than hazardous locations" shall apply to any operating rooms, delivery rooms, anesthesia rooms, corridors, utility rooms, and other areas permanently used for or intended for the exclusive use of nonflammable anesthetizing agents.

Confirmation of other than hazardous locations shall be accomplished by a written policy by the hospital administration prohibiting the use of flammable anesthetics and posting of rooms. In such cases, the rooms are excluded from the requirements of Section 517-61, 517-62, 517-63(f) (2), and 517-63(f) (3) as applied to X-ray systems only.

517-61. Wiring and Equipment Within Hazardous Areas.

(a) In hazardous areas referred to in Section 517-60, all fixed wiring and equipment, and all portable equipment, including lamps and other utilization equipment, operating at more than 8 volts between conductors, shall conform to the requirements of Sections 501-1 through 501-15 and Sections 501-16(a) and (b) for Class I, Division 1 locations. All such equipment shall be specifically approved for the hazardous atmospheres involved.

(b) 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.

(c) Flexible cords, which are or may be used in hazardous areas for connection to portable utilization equipment, including 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 conductor for grounding. 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) Receptacles and attachment plugs in hazardous areas shall be listed for use in Class I, Group C hazardous locations, and shall have provision for the connection of a grounding conductor.

517-62. Wiring and Equipment in Nonhazardous or Above Hazardous Anesthetizing Areas.

(a) Wiring above a hazardous area as referred to in Section 517-60 or in a nonflammable anesthetizing area shall be installed in rigid raceways or shall be Type MI cable, Type ALS cable, Type CS cable, or Type MC cable which employs a continuous, impervious metallic sheath.

(b) 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 the totally enclosed type or so constructed as to prevent escape of sparks or hot metal particles.

(c) Surgical and other lighting fixtures shall conform to Section 501-9(b).

Exception No. 1: The surface temperature limitations set forth in Section 501-9(b)(2) shall not apply.

Exception No. 2: Integral or pendant switches which are located above and cannot be lowered into the hazardous area shall not be required to be explosion-proof.

(d) Approved seals shall be provided in conformance with Section 501-5, and Section 501-5(a)(4) shall apply to horizontal as well as to vertical boundaries of the defined hazardous areas.

Exception: Seals shall be permitted within 18 inches of the point at which a conduit emerges from a wall forming the boundary of an anesthetizing location if all of the following conditions are met:

a. The junction box, switch or receptacle contains a seal-off device between the arcing contacts and the conduit.

b. The conduit is continuous (without coupling or fitting) between

the junction box and the sealing fitting within 18 inches of the point where the conduit emerges from the wall.

(e) Anesthetizing-location receptacles and attachment plugs in non-hazardous or above hazardous anesthetizing areas shall be listed for hospital use for services of prescribed voltage, frequency, rating, and number of conductors with provision for the connection of the grounding conductor. This requirement shall apply to attachment plugs and receptacles of the two-pole, 3-wire grounding-type for single-phase 125-volt AC service.

(f) Plugs and receptacles for connection of 250V, 50-ampere and 60-ampere AC medical equipment for use in nonhazardous areas of flammable anesthetic Anesthetizing Locations and in nonflammable Anesthetizing Locations shall be so arranged that the 60-ampere receptacle will accept either the 50-ampere or the 60-ampere plug. 50-ampere receptacles shall be designed so as not to accept the 60-ampere attachment plug. The plugs shall be of the two-pole, 3-wire design with a third contact connecting to the (green or green with yellow stripe) equipment grounding conductor of the electrical system.

517-63. Circuits in Anesthetizing Locations.

(a) Except as provided in Section 517-63(f) and (g), each circuit within, or partially within, an anesthetizing location as referred to in Section 517-60 shall be controlled by a switch having a disconnecting pole in each circuit conductor, and shall be isolated from any distribution system supplying areas other than anesthetizing locations. Such isolation shall be acceptable by means of one or more transformers having no electrical connection between primary and secondary windings, by means of motor-generator sets, or by means of suitably isolated batteries.

(b) Circuits supplying primaries of isolating transformers shall operate at not more than 300 volts between conductors, and shall be provided with proper overcurrent protection. Secondary voltage of such transformers shall not exceed 300 volts between conductors, and all circuits supplied from such secondaries shall be ungrounded and shall have an approved overcurrent device of proper rating in each conductor. Circuits supplied from batteries or from generators or motor-generator sets shall be ungrounded, and shall be protected against overcurrent in the same manner as transformer-fed secondary circuits.

(c) Transformers, motor-generator sets, batteries and battery chargers, together with their overcurrent devices, shall be installed in non-hazardous locations, and shall conform to the requirements of this Code for such locations.

(d) Line Isolation Monitor.

(1) In addition to the usual control and overcurrent protective devices, each isolated power system shall be provided with a continually operating line isolation monitor, approved for the purpose, that indicates possible leakage or fault currents from either isolated conductor to ground. The monitor shall be designed so that a green signal lamp, conspicuously visible to persons in the anesthetizing location, remains lighted when the system is adequately isolated from ground; an adjacent red signal lamp and an audible warning signal (remote if de-

sired) shall be energized when the total hazard index (consisting of possible resistive and capacitive leakage currents) from either isolated conductor to ground reaches a threshold value of 2 milliamperes under nominal line voltage conditions. The line isolation monitor is not to alarm for a fault hazard index of less than 0.7 milliamperes.

Exception: A system may be designed to operate at a lower threshold value of total hazard index. A line isolation monitor for such a system may be approved with the provision that the fault hazard index may be reduced but not to less than 35 percent of the corresponding threshold value of the total hazard index, and the monitor hazard index is to be correspondingly reduced to no more than 50 percent of the alarm threshold value of the total hazard index.

Such systems contribute little additional electrical safety and are used for special applications.

(2) The line isolation monitor shall be designed to have sufficient internal impedance such that when properly connected to the isolated system the maximum internal current that can flow through the line isolation monitor, when any point of the isolated system is grounded, shall be one milliampere.

Reduction of the monitor hazard index, provided this reduction results in an increased "not alarm" threshold value for the fault hazard index, will increase circuit capacity.

(3) An ammeter calibrated in the total hazard index of the system (contribution of the fault hazard index plus monitor hazard index) shall be mounted in a plainly visible place on the line isolation monitor with the "alarm on" (total hazard index = 2 milliamperes) zone at approximately the center of the scale. It is desirable to locate the ammeter so that it is conspicuously visible to persons in the anesthetizing location.

Exception: The line isolation monitor may be a composite unit, with a sensing section cabled to a separate display panel section on which the alarm and/or test functions are located.

(e) A branch circuit supplying an anesthetizing location shall supply no other location. The insulation of the branch circuit conductors on the secondary side of isolated power supplies shall have a dielectric constant of 3.5 or less. Wire pulling compounds that increase the dielectric constant shall not be used on the secondary conductors of the isolated power supplies.

(f) Branch circuits supplying only fixed lighting fixtures in nonhazardous areas of anesthetizing locations other than surgical lighting fixtures, or supplying only approved permanently installed X-ray equipment shall be permitted to be supplied by a conventional grounded system, provided: (1) wiring for grounded and ungrounded circuits does not occupy the same raceways; (2) the lighting fixtures and the X-ray equipment (except the enclosed X-ray tube and the metal-enclosed high-voltage leads to the tube) are located at least 8 feet above the floor or outside the anesthetizing location; and (3) switches for the grounded circuits are located outside of the anesthetizing location.

(g) Components of an isolated power center approved for the purpose and its grounded primary feeder shall be permitted to be located

in an anesthetizing location provided it is located in an other than hazardous area.

Note 1: For a description of approved permanently installed X-ray equipment, see Sections 3384, 3385, 3432, 3433, 4435, and 4437 of the Inhalation Anesthetics Standard, NFPA No. 56A-1973.

Note 2: Remote-control stations for remote-control switches shall be permitted in the anesthetizing location if the remote-control circuit is energized from the ungrounded distribution system.

517-64. Low-Voltage Equipment and Instruments.

(a) Low-voltage equipment which is frequently in contact with the bodies of persons or has exposed current-carrying elements shall:

- (1) Operate on an electrical potential of 8 volts or less, or
- (2) Be approved as intrinsically safe or double-insulated equipment,
- (3) Be moisture resistant.

(b) Power shall be supplied to low-voltage equipment from:

(1) An individual isolating transformer (autotransformers shall not be used) connected to an outlet receptacle by means of an anesthetizing location cord and attachment plug, or

(2) A common isolating transformer installed in a nonhazardous location, or

(3) Individual dry-cell batteries, or

(4) Common batteries made up of storage cells located in a non-hazardous location.

(c) Isolating-type transformers for supplying low-voltage circuits shall:

(1) Have approved means for insulating the secondary circuit from the primary circuit, and

(2) Have the core and case grounded in an approved manner.

(d) Resistance or impedance devices shall be permitted to control low-voltage equipment but shall not be used to limit the maximum input voltage.

(e) Battery-powered appliances shall not be capable of being charged while in operation unless their charging circuitry incorporates an integral isolating-type transformer.

(f) Any receptacle or attachment plug used on low-voltage circuits shall be of a type which does not permit interchangeable connection with circuits of higher voltage.

Any interruption of the circuit, even circuits as low as 8 volts, either by any switch, or loose or defective connections anywhere in the circuit, may produce a spark sufficient to ignite flammable anesthetic agents. (See Section 352 of the Inhalation Anesthetics Standard, NFPA No. 56A-1973.)

517-65. Other Equipment.

(a) Suction, pressure, or insufflation equipment involving electrical elements, and located or used within a hazardous area shall be approved for Class I locations.

(b) X-ray equipment installed or operated in an anesthetizing location as defined in Section 517-2 shall be provided with approved means for preventing accumulation of electrostatic charges. All X-ray control

devices, switches, relays, meters, and transformers shall be totally enclosed, and where installed or operated within a hazardous area, shall be approved for Class I, Group C locations. High-voltage wiring shall be effectively insulated from ground and adequately guarded against accidental contact. The entire installation shall comply with Article 660.

(c) Equipment for generating high-frequency currents or voltages used in electrocautery, diathermy, television, etc., where installed or used in an anesthetizing location, shall conform to Sections 517-61 and 517-62.

517-66. Grounding. In any anesthetizing area, all metallic raceways, and all noncurrent-carrying conductive portions of fixed or portable equipment including the conductive floor shall be grounded.

Exception: Equipment operating at not more than 8 volts between conductors shall not be required to be grounded.

F. Communications, Signaling Systems, and Data Systems

517-80. Critical Patient Care Areas. Isolation and grounding equivalent to that required for the electrical distribution systems in this Article for these areas shall also be provided. See also Articles 725 and 800.

An acceptable alternate means of providing isolation for patient/nurse call systems is by the use of only nonelectrified signaling, communication or control devices held by the patient or within reach of the patient.

ARTICLE 518 — PLACES OF ASSEMBLY

518-1. Scope. This Article covers all buildings or that part of a building or structure designed or intended for use by 100 or more persons for assembly purposes, such as dining, meetings, entertainment, lectures, bowling, worship, dancing or exhibition, and includes museums, gymnasiums, armories, group rooms, mortuaries, skating rinks, pool rooms, places of awaiting transportation, places for deliberation (court rooms), places for sporting events, and similar purposes.

When any such building structures or portion thereof contain a projection booth or stage platform or area for the presentation of theatrical or musical production, either fixed or portable, the wiring for that area shall comply with all applicable provisions of Article 520.

For methods of determining population capacity, see local building code or in its absence Life Safety Code (NFPA No. 101-1973).

518-2. Other Articles.

(a) Hazardous areas located in any assemblage occupancy shall be installed in accordance with Article 500 — Hazardous Locations.

(b) In exhibition halls used for display booths, as in trade shows, the temporary wiring shall be installed in accordance with Article 305 — Temporary Wiring, except that approved portable cables and cords shall be permitted to be laid on floors where protected from contact by the general public.

518-3. Wiring Methods. The fixed wiring methods shall be metal raceways, nonmetallic raceways encased in not less than 2 inches of concrete, Type ALS cable, Type CS cable, mineral-insulated metal-sheathed cable, or Type MC cable.

Exception No. 1: Nonmetallic-sheathed cable, Type AC metal-clad cable, and rigid nonmetallic conduit shall be permitted to be installed in those buildings or portions thereof that are not required to be fire rated construction by the applicable building code.

Exception No. 2: As provided in Article 640, Sound Reproduction and Similar Equipment, in Article 800, Communication Circuits, and in Article 725 for Class 2 and Class 3 remote control and signaling circuits, and in Article 760 for fire protective signaling circuits.

Fire rated construction is the fire-resistive classification used in building codes.

ARTICLE 520 — THEATERS AND SIMILAR LOCATIONS

A. General

520-1. Scope. This Article covers all buildings or that part of a building or structure designed or intended to be used for dramatic, musical, motion picture projection, or similar purposes and to areas of motion picture and television studios which incorporate assembly areas.

520-2. Motion-Picture Projectors. Motion-picture equipment and its installation and use shall comply with Article 540.

520-3. Sound Reproduction. Sound-reproducing equipment and its installation shall comply with Article 640.

520-4. Wiring Methods. The fixed wiring method shall be metal raceways, nonmetallic raceways encased in at least 2 inches of concrete, Type ALS cable, Type CS cable, mineral-insulated metal-sheathed, or Type MC cable.

Exception No. 1: As provided in Article 640 for sound reproduction, in Article 800 for communication circuits, and in Article 725 for Class 2 and Class 3 remote-control and signaling circuits, and in Article 760 for fire protective signaling circuits.

Exception No. 2: The wiring for stage set lighting and stage effects and other wiring that is not fixed as to location shall be permitted with approved portable cables and approved flexible cords.

520-5. Number of Conductors in Raceway. The number of conductors permitted in any metal conduit or electrical metallic tubing for border or stage pocket circuits or for remote-control conductors shall not exceed the percentage fill shown in Table 1 of Chapter 9. Where contained within an auxiliary gutter or a wireway, the sum of the cross-sectional areas of all contained conductors at any cross section shall not exceed 20 percent of the interior cross-sectional area of the auxiliary gutter or wireway. The 30-conductor limitation of Sections 362-5 and 374-5 shall not apply.

520-6. Enclosing and Guarding Live Parts. Live parts shall be enclosed or guarded to prevent accidental contact by persons and objects. All switches shall be of the externally operable type. Dimmers, including rheostats, shall be placed in cases or cabinets that enclose all live parts.

B. Fixed Stage Switchboard

520-21. Dead Front. Stage switchboards shall be of the dead-front type and shall comply with Part C of Article 384 unless approved for the purpose.

520-22. Guarding Back of Switchboard. Stage switchboards having exposed live parts on the back of such boards shall be enclosed by the building walls, wire mesh grills, or by other methods approved for the purpose. The entrance to this enclosure shall be by means of a self-closing door.

520-23. Control and Overcurrent Protection of Receptacle Circuits. Means shall be provided at a stage lighting switchboard to which load circuits are connected for individual overcurrent protection of stage lighting branch circuits and stage and gallery receptacles used for portable stage equipment. Where the stage switchboard contains dimmers to control nonstage lighting, the locating of the overcurrent protective devices for these branch circuits at the stage switchboard shall be permitted.

520-24. Metal Hood. A stage switchboard that is not completely enclosed dead-front and dead-rear or recessed into a wall shall be provided with a metal hood extending the full length of the board to protect all equipment on the board from falling objects.

520-25. Dimmers. Dimmers shall comply with (a) through (d) below.

(a) Disconnection and Overcurrent Protection. Where dimmers are installed in ungrounded conductors, each dimmer shall have overcurrent protection not greater than 125 percent of the dimmer rating, and shall be disconnected from all ungrounded conductors when the master or individual switch or circuit breaker supplying such dimmer is in the open position.

(b) Resistance- or Reactor-Type Dimmers. Resistance- or series reactor-type dimmers may be placed in either the grounded or the ungrounded conductor of the circuit. Where designed to open either the supply circuit to the dimmer or the circuit controlled by it, the dimmer shall then comply with Section 380-1. Resistance or reactor type dimmers placed in the grounded neutral conductor of the circuit shall not open the circuit.

(c) Autotransformer-Type Dimmers. The circuit supplying an autotransformer-type dimmer shall not exceed 150 volts between conductors. The grounded conductor shall be common to the input and output circuits.

(d) Solid-State Type Dimmers. The circuit supplying a solid-state dimmer shall not exceed 150 volts between conductors unless the dimmer is specifically approved for higher voltage operation. When a grounded conductor supplies a dimmer, it shall be common to the input

and output circuits. Dimmer chassis shall be connected to the equipment ground conductor.

See Section 210-9 for circuits derived from autotransformers.

520-26. Type of Switchboard. Stage switchboard shall be either one or a combination of the following types:

(a) **Manual.** Dimmers and switches are operated by handles mechanically linked to the control devices.

(b) **Remotely Controlled.** Devices are operated electrically from a pilot type control console or panel. Pilot control panels shall either be part of the switchboard or shall be permitted to be at another location.

520-27. Stage Switchboard Feeders. Feeders supplying stage switchboards shall be one of the following:

(a) A single feeder disconnected by a single disconnect device.

(b) Multiple feeders disconnected and/or protected by separate devices in an intermediate stage switchboard, provided that all feeders are part of a single system: Where multiple feeders are used, all conductors are to be of the same length. Neutral conductors of multiple feeders shall be combined; however, neutral conductors shall be arranged so that the sum of the neutral conductors in a given wireway is of adequate ampacity to carry the maximum unbalanced phase current which shall be permitted to be supplied by other feeder conductors in the same wireway.

C. Stage Equipment — Fixed

520-41. Circuit Loads. Footlights, border lights, and proscenium side lights shall be so arranged that no branch circuit supplying such equipment will carry a load exceeding 20 amperes.

Exception: Where heavy-duty lampholders only are used, such circuits shall be permitted to comply with Article 210 for circuits supplying heavy-duty lampholders.

520-42. Conductor Insulation. Foot, border, proscenium, or portable strip light fixtures and connector strips shall be wired with conductors having insulation suitable for the temperatures at which the conductors will be operated and not less than 125°C (257°F).

See Table 310-13 for conductor types.

520-43. Footlights.

(a) Where metal trough construction is employed for footlights, the trough containing the circuit conductors shall be made of sheet metal not lighter than No. 20 MSG 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.

(b) Where the metal trough construction specified in Section 520-43(a) is not used, footlights shall consist of individual outlets with lampholders, wired with rigid or flexible metal conduit, Type ALS cable, Type CS cable, or mineral-insulated metal-sheathed cable. The circuit conductors shall be soldered to the lampholder terminals. Disappearing footlights shall be so arranged that the current supply will be automatically disconnected when the footlights are replaced in the recess designed for them.

520-44. Borders and Proscenium Sidelights.

(a) **General.** Borders and proscenium sidelights shall be: (1) constructed as specified in Section 520-43; (2) suitably stayed and supported; and (3) 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.

(b) **Cables for Border Lights.** Cables for supply to border lights shall be Type S, SO, ST, or STO flexible cable as provided in Table 400-4. The cables shall be suitably supported. Such cables shall be employed only where flexible conductors are necessary.

520-45. Receptacles. Receptacles intended for the supply of arc lamps shall be rated at not less than 50 amperes and shall be supplied by conductors not smaller than No. 6. Receptacles intended for the supply of incandescent lamps shall be rated at not less than 20 amperes and shall be supplied by conductors not smaller than No. 12. Attachment plugs for arc and incandescent receptacles shall not be interchangeable.

520-46. Stage Pockets. Receptacles intended for the connection of portable stage lighting equipment shall be mounted in suitable pockets or enclosures and shall comply with Section 520-45.

520-47. Lamps in Scene Docks. Lamps installed in scene docks shall be so located and guarded as to be free from physical damage and shall provide an air space of not less than 2 inches between such lamps and any combustible material.

520-48. Curtain Motors. Curtain motors having brushes or sliding contacts shall comply with one of the conditions in (a) through (f) below.

(a) Be of the totally enclosed, enclosed-fan-cooled, or enclosed-pipe-ventilated type.

(b) Be enclosed in separate rooms or housings built of noncombustible material so constructed as to exclude flyings or lint, and properly ventilated from a source of clean air.

(c) Have the 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 the brush or sliding-contact end of the motor enclosed by a wire screen or perforated metal and the lower half enclosed by solid metal covers.

(f) Have wire screens or perforated metal placed at the commutator or brush ends. No dimension of any opening in the wire screen or perforated metal shall exceed .05 inch, regardless of the shape of the opening and of the material used.

520-49. Flue Damper Control. Where stage flue dampers are released by an electrical device, the circuit operating the device 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 authority having jurisdiction. The device shall be designed for the full voltage of the circuit to which it is connected, no resistance being inserted. The device shall be located in the

loft above the scenery and shall be enclosed in a suitable metal box having a tight, self-closing door.

D. Portable Switchboards on Stage

520-51. Supply. Portable switchboards shall be supplied only from outlets provided for the purpose. Such outlets shall include externally operable, enclosed fused switches or circuit breakers mounted on the stage wall or at the permanent switchboard in locations readily accessible from the stage floor.

520-52. Overcurrent Protection. Circuits from portable switchboards directly supplying equipment containing incandescent lamps of not over 300 watts shall be protected by overcurrent devices having a rating or setting of not over 20 amperes. Circuits for lampholders over 300 watts shall be permitted where overcurrent protection complies with Article 210. Other circuits shall be provided with overcurrent devices with a rating or setting not higher than the current required for the connected load.

520-53. Construction. Portable switchboards for use on stages shall comply with (a) through (j) below.

(a) **Enclosure.** Portable switchboards shall be placed within an enclosure of substantial construction, which shall be permitted to 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 MSG and shall be well galvanized, enameled, or otherwise properly coated to prevent corrosion or be of a corrosion-resistant material.

(b) **Live Parts.** There shall be no exposed live parts within the enclosure.

Exception: For dimmer faceplates as provided in (e) below.

(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 faceplates shall be so arranged that accidental contact cannot be readily made with the faceplate contacts.

(f) **Interior Conductors.** All conductors within the switchboard enclosure shall be stranded and shall be asbestos-covered Type AA or other types approved for an operating temperature of 200°C (392°F).

Each conductor shall have an ampacity at least equal to the rating of the circuit breaker, switch, or fuse which it supplies.

Exception: Conductors for incandescent lamp circuits having overcurrent protection of not over 20 amperes.

Conductors shall be enclosed in metal wireways or be 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 rated or set at not over 15 amperes.

(h) **Supply Connections.** The supply to a portable switchboard shall be by means of Type S, SO, ST, or STO flexible cord terminating within the switchboard enclosure or in an externally operable fused master switch or circuit breaker. The supply cable shall have sufficient ampacity to carry the total load connected to 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.

E. Stage Equipment — Portable

520-61. Arc Lamps. Arc lamps shall be listed.

520-62. Portable Plugging Boxes. Portable plugging boxes shall comply with (a) through (c) below.

(a) **Enclosure.** The construction shall be such that no current-carrying part will be exposed.

(b) **Receptacles and Overcurrent Protection.** Each receptacle shall have a rating of not less than 30 amperes, and shall have overcurrent protection installed in an enclosure equipped with self-closing doors.

(c) **Busbars and Terminals.** Busbars shall have an ampacity equal to the sum of the ampere ratings of all the receptacles. Lugs shall be provided for the connection of the master cable.

520-63. Bracket Fixture Wiring.

(a) **Bracket Wiring.** Brackets for use 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.

Exception: Externally wired brackets or other fixtures shall be permitted where wired with cords designed for hard usage that extend through scenery and without joint or splice in canopy of fixture back and terminate in an approved type stage connector located, where practical, within 18 inches of the fixture.

(b) **Mounting.** Fixtures shall be securely fastened in place.

520-64. Portable Strips. Portable strips shall be constructed in accordance with the requirements for border lights and proscenium side lights in Section 520-44(a). The supply cable shall be protected by bushings where it passes through metal and shall be so arranged that tension on the cable will not be transmitted to the connections.

See Section 520-42 for wiring of portable strips.

520-65. Festoons. Joints in festoon wiring shall be staggered where practicable. Lamps enclosed in lanterns or similar devices of combustible material shall be equipped with guards.

520-66. Special Effects. Electrical devices used for simulating lighting, waterfalls, and the like shall be so constructed and located that

flames, sparks, or hot particles cannot come in contact with combustible material.

520-67. Cable Connectors. Cable connectors for flexible conductors shall be so constructed that tension on the cord or cable will not be transmitted to the connections. The female half of the connector shall be attached to the line end of the cord or cable.

See Section 400-10 for pull at terminals.

520-68. Conductors for Portables. Flexible conductors used to supply portable stage equipment shall be Type S, SO, ST, or STO.

Exception: Reinforced cord shall be permitted to supply stand lamps where the cord is not subject to severe physical damage and is protected by an overcurrent device rated at not over 20 amperes.

F. Dressing Rooms

520-71. Pendant Lampholders. Pendant lampholders shall not be installed in dressing rooms.

520-72. Lamp Guards. All incandescent lamps in dressing rooms, where less than 8 feet from the floor, shall be equipped with open-end guards riveted to the outlet box cover or otherwise sealed or locked in place.

520-73. Switches Required. All lights and receptacles in dressing rooms shall be controlled by wall switches installed in the dressing rooms. Each switch controlling receptacles shall be provided with a pilot light to indicate when the receptacles are energized.

G. Grounding

520-81. Grounding. All metal raceways shall be grounded. The metal frames and enclosures of equipment, including border lights, shall be grounded.

Exception: The frames and enclosures of portable equipment on grounded circuits operating at not over 150 volts to ground and not within reach of grounded surfaces need not be grounded.

Grounding, where employed, shall be in accordance with Article 250.

ARTICLE 530 — MOTION-PICTURE STUDIOS AND SIMILAR LOCATIONS

A. General

530-1. Scope. The requirements of this Article shall apply to television studios (except as covered in Section 520-1), motion-picture studios, exchange, factory, laboratory, stage, or a portion of the building in which motion-picture films more than $\frac{7}{8}$ inch in width are manufactured, exposed, developed, printed, cut, edited, rewound, repaired, or stored.

For the purpose of this Article, a motion-picture studio is one in which photographic film is used to record action. A television studio shall mean one which employs the use of electronic cameras only.

For methods of protecting against cellulose nitrate film hazards, see Standard for the Storage and Handling of Cellulose Nitrate Motion Picture Film (NFPA No. 40-1967).

B. Stage or Set

530-11. Permanent Wiring. The permanent wiring shall be Type ALS cable, Type CS cable, Type MI cable, or in approved metal raceways.

Exception: Communication circuits, and sound recording and reproducing equipment shall be permitted to be wired as permitted by Articles 640 and 800.

530-12. Portable Wiring. The wiring for stage set lighting, stage effects, and other wiring not fixed as to location shall be done with portable cables and flexible cords approved for the purpose. This requirement shall not apply to portable lamps or other electric equipment used as properties in a motion picture set, on a studio stage or lot, or on location.

530-13. Stage Lighting and Effects Control. Switches used for studio stage set lighting and effects (on the stages and lots and on location) shall be of the externally operable type. Where contactors are used as the disconnecting means for fuses, an individual externally operable switch, such as a tumbler switch, for the control of each contactor shall be located at a distance of not more than 6 feet from the contactor, in addition to remote-control switches.

Exception: A single externally operable switch shall be permitted to simultaneously disconnect all the contactors on any one location board, where located at a distance of not more than 6 feet from the location board.

530-14. Plugging Boxes. Each receptacle of plugging boxes shall be rated at not less than 30 amperes.

530-15. Enclosing and Guarding Live Parts.

(a) Live parts shall be enclosed or guarded to prevent accidental contact by persons and objects.

(b) All switches shall be of the externally operable type.

(c) Rheostats shall be placed in approved cases or cabinets that enclose all live parts, having only the operating handles exposed.

(d) Current-carrying parts of "bull-switches," "location boards," "spiders," and plugging boxes shall be so enclosed, guarded, or located that persons cannot accidentally come into contact with them or bring conductive material into contact with them.

530-16. Portable Lamps. Portable lamps and work lights shall be equipped with portable cords, composition or metal-sheathed porcelain sockets, and substantial guards.

Exception: Portable lamps used as properties in a motion picture set or television stage set, on a studio stage or lot, or on location.

530-17. Portable Arc Lamps. Portable arc lamps shall be substantially constructed. The arc shall be provided with an enclosure designed to retain sparks and carbons and to prevent persons or materials from coming into contact with the arc or bare live parts. The enclosures shall be ventilated. All switches shall be of the externally operable type.

530-18. Overcurrent Protection — Short-Time Rating.*

General. Automatic overcurrent protective devices (circuit breakers or fuses) for motion-picture studio stage set lighting and the stage cables for such stage set lighting shall be as given in (a) through (e) below.

Note: *Special consideration is given to motion-picture studios and similar locations because filming periods are of short duration.

(a) Stage Cables. Stage cables for stage set lighting shall be protected by means of overcurrent devices set at not more than 400 percent of the values given in Tables 310-16 through 310-19 and Table 400-5.

(b) Feeders. In buildings used primarily for motion-picture production, the feeders from the substations to the stages shall be protected by means of overcurrent devices (generally located in the substation) having suitable ampere rating. The overcurrent devices shall be permitted to be multipole or single-pole gang-operated. No pole or overcurrent device shall be required in the neutral conductor. The overcurrent device setting for each feeder shall not exceed 400 percent of the ampacity of the feeder, as given in Table 310-16 for the kind of insulation used.

(c) Location Boards. Overcurrent protection (fuses or circuit breakers) shall be provided at the "location boards." Fuses in the "location boards" shall have an ampere rating of not over 400 percent of the ampacity of the cables between the "location boards" and the plugging boxes.

(d) Plugging Boxes. Where plugging boxes are not provided with overcurrent 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 not be over 400 percent of the safe ampacity of the cables or cords as given in Tables 310-16, 310-17, and 400-5 for the kind of insulation used.

(e) Lighting. Work lights, stand lamps, and fixtures shall be connected to plugging boxes by means of plugs containing two cartridge fuses not larger than 20 amperes, or they shall be permitted to be connected to special outlets on circuits protected by fuses or circuit breakers rated at not over 20 amperes. Plug fuses shall not be used unless they are on the load side of the fuse or circuit breakers on the "location boards."

530-19. Sizing of Feeder Conductors for Television Studio Sets.

(a) General. It shall be permissible to apply the demand factors listed in Table 530-19(a) to that portion of the maximum possible connected load for studio or stage set lighting for all permanently installed feeders between substations and stages and to all permanently installed subfeeders between the main stage switchboard and stage distribution centers or location boards.

Table 530-19(a). Demand Factors for Stage Set Lighting

Total Stage Set Lighting Load (Wattage)	Feeder Demand Factor
First 50,000 or less at	100%
Next 50,001 to 100,000 at	75%
Next 100,001 to 200,000 at	60%
All over 200,000	50%

(b) **Portable Feeders.** A demand factor of 50 percent of maximum possible connected load shall be permitted for all portable feeders.

530-20. Grounding. Metal-clad cable, metal raceways, and all non-current-carrying metal parts of appliances, devices, and equipment shall be grounded as specified in Article 250. This shall not apply to pendant and portable lamps, to stage lighting and stage sound equipment, nor to other portable or semiportable special stage equipment operating at not over 150 volts to ground.

C. Dressing Rooms

530-31. Dressing Rooms. Fixed wiring in dressing rooms shall be installed in accordance with wiring methods covered in Chapter 3. Wiring for portable dressing rooms shall be approved for the purpose.

D. Viewing, Cutting, and Patching Tables

530-41. Lamps at Tables. Only composition or metal-sheathed, porcelain, keyless lampholders equipped with suitable means to guard lamps from physical damage and from film and film scrap shall be used at patching, viewing, and cutting tables.

E. Film Storage Vaults

530-51. Lamps in Cellulose Nitrate Film Storage Vaults. Lamps in cellulose nitrate film storage vaults shall be rigid fixtures of the glass enclosed and gasketed type. Lamps shall be controlled by a switch having a pole in each ungrounded conductor. This switch shall be located outside of the vault and provided with a pilot light to indicate whether the switch is on or off. This switch shall disconnect from all sources of supply all ungrounded conductors terminating in any outlet in the vault.

530-52. Motors and Other Equipment in Cellulose Nitrate Film Storage Vaults. No receptacles outlets, electric motors, heaters, portable lights, or other portable electric equipment shall be located in film storage vaults.

F. Substations

530-61. Substations. Wiring and equipment of over 600 volts shall comply with Article 710.

530-62. Low-Voltage Switchboards. On 600 volts or less, switchboards shall comply with Article 384.

530-63. Overcurrent Protection of DC Generators. Three-wire DC gen-

erators shall have protection consisting of overcurrent devices having an ampere rating or setting in accordance with the generator ampere rating. Single-pole or double-pole overcurrent devices shall be permitted, and no pole or overcurrent coil shall be required in the neutral lead (whether it is grounded or ungrounded).

530-64. Working Space and Guarding. Working space and guarding in permanent fixed substations shall comply with Sections 110-16 and 110-17.

For guarding of live parts on motors and generators, see Sections 430-11 and 430-14.

Exception: Switchboards of not over 250 volts DC between conductors, when located in substations or switchboard rooms accessible to qualified persons only, shall not be required to be dead-front.

530-65. Portable Substations. Wiring and equipment in portable substations shall conform to the Sections applying to installations in permanent fixed substations, but, due to the limited space available, the working spaces shall be permitted to be reduced, provided that the equipment shall be so arranged that the operator can do his work safely, and so that other persons in the vicinity cannot accidentally come into contact with current-carrying parts or bring conducting objects into contact with them while they are energized.

530-66. Grounding at Substations. Noncurrent-carrying metal parts shall be grounded.

Exception: Frames of DC circuit breakers installed on switchboards.

ARTICLE 540 — MOTION-PICTURE PROJECTORS

A. General

540-1. Scope. This Article covers motion-picture projectors and associated equipment of the professional and nonprofessional types.

For further information, see Storage and Handling of Cellulose Nitrate Motion Picture Film (NFPA No. 40-1967).

B. Equipment and Projectors of the Professional Type

540-10. Professional Projector — Definition. The professional projector employs a 35-millimeter film which is $1\frac{3}{8}$ inch wide and has on each edge 5.4 perforations per inch. Wider film, such as 70-millimeter, shall be permitted.

540-11. Enclosure. The professional type of projector, such as is commonly used in theaters and motion-picture houses, shall be located in an enclosure approved for the purpose. Such enclosure shall not be considered as a hazardous location as defined in Article 500.

540-12. Motor-Driven Projectors. Motor-driven projectors shall be approved for the purpose as an assembly or shall comply with all of the following conditions:

- (a) A listed projector shall be used.
- (b) A listed projector lamp shall be used.

(c) Motors shall be so designed or guarded as to prevent ignition of film by sparks or arcs.

- (d) Projectors shall be in charge of a qualified operator.

540-13. Conductors Size. Conductors supplying outlets for arc projectors of the professional type shall not be smaller than No. 8 and shall be of sufficient size for the projector employed. Conductors for incandescent-type projectors shall conform to normal wiring standards as provided in Section 210-24.

540-14. Conductors on Lamps and Hot Equipment. Asbestos-covered conductors Type AA or other types of insulated conductors having a maximum operating temperature of 200°C (392°F) shall be used on all lamps or other equipment where the ambient temperature at the conductors as installed will exceed 50°C (122°F).

540-15. Flexible Cords. Cords approved for hard service in Table 400-4 shall be used on portable equipment.

540-16. Lamp Guards. Incandescent lamps in projection rooms or booths shall be provided with an approved lamp guard unless otherwise protected by noncombustible shades or other enclosures.

540-17. Location of Equipment. Motor-generator sets, transformers, rectifiers, rheostats, and similar equipment for the supply or control of current to arc lamps on projectors shall, if practicable, be located in separate rooms. Where placed in the projector room, they shall be so located or guarded that arcs or sparks cannot come in contact with film, and motor-generator sets shall have the commutator end or ends protected as provided in Section 520-48.

540-19. Equipment Prohibited. Switches, overcurrent devices, or other equipment not normally required or used for projectors, sound reproduction, flood, or other special-effect lamps or other equipment shall not be installed in such booths or rooms.

Exception: Remote-control switches for the control of auditorium lights or a switch for the motor operating the curtain at the motion-picture screen.

540-20. Approval. Projectors and enclosures for arc or incandescent lamps, rectifiers, transformers, rheostats, and similar equipment shall be listed.

540-21. Marking. Projectors and other equipment as set forth in Section 540-20 shall be marked with the name or trademark of the maker and with the voltage and current for which they are designed.

C. Nonprofessional-Type Projectors

540-30. Definition. The nonprofessional projector employs film other than that used on professional-type projectors.

540-31. Booth Not Required. Projectors of the nonprofessional or miniature type, when employing only approved slow-burning (cellulose acetate or equivalent) film, shall be permitted to be operated without a booth.

540-32. Approval. Projectors, lamp enclosures, and current-controlling devices and similar devices shall be listed as component parts of the projector equipment.

540-33. Source of Illumination. The source of illumination shall be a lamp or a type listed for stereopticon use or for motion-picture projection.

540-34. Marking. Projectors shall be marked with: (1) the name or trademark of the maker; (2) the current and voltage for which they are designed; and (3) for projectors of this type using the standard 35-millimeter film, the wording "For use with slow-burning films only."

540-35. Nonprofessional Film Making. The slow-burning (cellulose acetate or equivalent) film shall have a permanent distinctive marker for its entire length identifying the manufacturer and the slow-burning character of the film stock.

D. Sound Recording and Reproduction

540-50. Sound Recording and Reproduction. Sound recording and reproduction equipment shall comply with Article 640.

ARTICLE 545 — MANUFACTURED BUILDING

A. General

545-1. Scope. This Article covers requirements for a manufactured building and/or building components as herein defined.

545-2. Other Articles. Wherever the requirements of other Articles of this Code and Article 545 differ, the requirements of Article 545 shall apply.

545-3. Definitions.

(a) Manufactured Building: "Manufactured Building" means any building which is of closed construction and which is made or assembled in manufacturing facilities on or off the building site for installation, or assembly and installation, on the building site, other than mobile homes or recreational vehicles.

(b) Building Component: "Building Component" means any subsystem, subassembly, or other system designed for use in or integral with or as part of a structure, which can include structural, electrical, mechanical, plumbing and fire protection systems and other systems affecting health and safety.

(c) Building System: "Building System" means plans, specifications and documentation for a system of manufactured building or for a type or a system of building components, which can include structural, electrical, mechanical, plumbing, and fire protection systems, and other systems affecting health and safety, and including such variations thereof as are specifically permitted by regulation, and which variations are submitted as part of the building system or amendment thereto.

(d) Closed Construction: "Closed Construction" means any building, building component, assembly or system manufactured in such a manner that all-concealed parts or processes of manufacture cannot be inspected before installation at the building site without disassembly, damage, or destruction.

545-4. Wiring Methods: All raceway and cable wiring methods included in this Code and such other wiring systems specifically intended and approved for use in manufactured building shall be permitted with approved fittings and with fittings approved for manufactured building. Where wiring devices with integral enclosures are used, sufficient length of conductor shall be provided to facilitate replacement.

545-5. Service-Entrance Conductors: Service-entrance conductors shall meet the requirements of Article 230. Provisions shall be made to route the service-entrance conductors from the service equipment to the point of attachment of the service.

545-6. Installation of Service-Entrance Conductors: Service-entrance conductors shall be installed after erection at the building site.

Exception: Where point of attachment is known prior to manufacture.

545-7. Service-Equipment Location: The service equipment shall be located at a readily accessible point nearest to the entrance of the conductors either inside or outside the building.

545-8. Protection of Conductors and Equipment: Protection shall be provided for exposed conductors and equipment during processes of manufacturing, packaging, in transit, and erection at the building site.

545-9. Outlet Boxes: Outlet boxes of dimensions other than those required in Tables 370-6(a) (1) and 370-6(a) (2) shall be permitted to be installed when tested and approved to applicable standards.

Where mounted in walls of closed construction, boxes not over 100 cubic inches in size approved for the purpose shall be affixed with approved anchors or clamps so as to provide a rigid and secure installation.

545-10. Receptacle or Switch with Integral Enclosure: A receptacle or switch with integral enclosure and mounting means, when tested and approved to applicable standards, shall be permitted to be installed.

545-11. Bonding and Grounding: Prewired panels and/or building components shall provide for the bonding and/or grounding of all exposed metals likely to become energized, in accordance with Article 250, Part E, F, and G.

545-12. Grounding Electrode Conductor: The grounding electrode conductor shall meet the requirements of Article 250, Part J. Provisions shall be made to route the grounding electrode conductor from the service equipment to the point of attachment of the grounding electrode.

545-13. Component Interconnections: Fittings and connectors which are intended to be concealed at the time of on-site assembly, when tested and approved to applicable standards shall be permitted for on-site interconnection of modules or other building components. Such fit-

tings and connectors shall be equal to the wiring method employed in insulation, temperature rise, fault-current withstand and shall be capable of enduring the vibration and minor relative motions occurring in the components of manufactured building.

ARTICLE 550 — MOBILE HOMES AND MOBILE HOME PARKS

550-1. Scope.

(a) The provisions of this Article cover the electrical conductors and equipment installed within or on mobile homes, the conductors that connect mobile homes to a supply of electricity, and the installation of electrical wiring, fixtures, equipment and appurtenances related to electrical installations within a mobile home park up to the mobile home service-entrance conductors or, if none, the mobile home service equipment.

Wherever the requirements of other Articles of this Code and Article 550 differ, the requirements of Article 550 shall apply.

For requirements on body and frame design, construction, and the installation of plumbing and heating systems in mobile homes, refer to Standard for Mobile Homes (NFPA No. 501B-1973).

(b) A mobile home not intended as a dwelling unit, as for example, equipped for sleeping purposes only, contractor's on-site offices, construction job dormitories, mobile studio dressing rooms, banks, clinics, mobile stores, or intended for the display or demonstration of merchandise or machinery, shall not be required to meet the provisions of this Article pertaining to the number or capacity of circuits required. It shall, however, meet all other applicable requirements of this Article if provided with an electrical installation intended to be energized from a 115-volt or 115/230-volt AC power supply system.

(c) Mobile homes installed in other than mobile home parks shall comply with the provisions of this Article.

(d) The provisions of this Article apply to mobile homes intended for connection to a wiring system nominally rated 115/230-volts, 3-wire AC, with grounded neutral.

550-2. Definitions.

Distribution Panelboard: See definition of panelboard in Article 100.

Feeder Assembly: The overhead or under-chassis feeder conductors, including the grounding conductor, together with the necessary fittings and equipment or a power-supply cord approved for mobile home use, designed for the purpose of delivering energy from the source of electrical supply to the distribution panelboard within the mobile home.

Mobile Home: A factory-assembled structure or structures equipped with the necessary service connections and made so as to be readily movable as a unit or units on their own running gear and designed to be used as a dwelling unit(s) without a permanent foundation.

The phrase "without a permanent foundation" indicates that the support system is constructed with the intent that the mobile home placed thereon will be moved from time to time at the convenience of the owner.

Mobile Home Accessory Building or Structure: Any awning, cabana, ramada, storage cabinet, carport, fence, windbreak or porch established for the use of the occupant of the mobile home upon a mobile home lot.

Mobile Home Lot: A designated portion of a mobile home park designed for the accommodation of one mobile home and its accessory buildings or structures for the exclusive use of its occupants.

Mobile Home Park: A contiguous parcel of land which is used for the accommodation of occupied mobile homes.

Mobile Home Service Equipment: The equipment containing the disconnecting means, overcurrent protective devices, and receptacles or other means for connecting a mobile home feeder assembly.

Park Electrical Wiring Systems: All of the electrical wiring, fixtures, equipment and appurtenances related to electrical installations within a mobile home park, including the mobile home service equipment.

A. Mobile Homes

550-3. Power Supply.

(a) The mobile home service equipment shall be located adjacent to the mobile home and not mounted in or on the mobile home. The power supply to the mobile home shall be a feeder assembly consisting of not more than 3 mobile home power-supply cords, each rated 50 amperes or a permanently installed circuit.

Exception: A mobile home that is factory-equipped with gas or oil-fired central heating equipment and cooking appliances shall be permitted to be provided with a mobile home power-supply cord rated 40 amperes.

(b) If the mobile home has a power-supply cord, it shall be permanently attached to the distribution panelboard or to a junction box permanently connected to the distribution panelboard, with the free end terminating in an attachment plug cap.

(c) Cords with adapters and pigtail ends, extension cords, and similar items shall not be attached to, or shipped with, a mobile home.

(d) A suitable clamp or the equivalent shall be provided at the distribution panelboard knockout to afford strain relief for the cord to prevent strain from being transmitted to the terminals when the power supply cord is handled in its intended manner.

(e) The cord used shall be of an approved type with four conductors, one of which shall be identified by a continuous green color or a continuous green color with one or more yellow stripes for use as the grounding conductor.

(f) The attachment plug cap shall be a 3-pole 4-wire grounding type, rated 50 amperes, 125/250 volts with a configuration as shown in Figure 550-3(f) and intended for use with the 50-ampere, 125/250 receptacle configuration shown in Figure 550-3(f). It shall be molded of butyl rubber, neoprene, or other approved materials which have been

found suitable for the purpose, and shall be molded to the flexible cord so that it adheres tightly to the cord at the point where the cord enters the attachment plug cap. If a right-angle cap is used, the configuration shall be so oriented that the grounding member is farthest from the cord.

Complete details of the 50-ampere plug and receptacle shown in Figure 550-3(f) can be found in ANSI Standard Dimensions of Caps, Plugs and Receptacles, C73.17-1972.

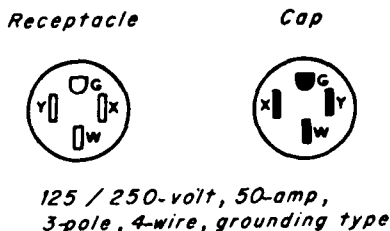


Figure 550-3(f). 50-ampere 125/250 volt receptacle and attachment-plug-cap configurations, 3-pole 4-wire grounding types, used for mobile home supply cords and mobile home parks.

(g) The overall length of a power-supply cord, measured from the end of the cord, including bared leads, to the face of the attachment plug cap shall not be less than 21 feet and shall not exceed 36½ feet. The length of the cord from the face of the attachment plug cap to the point where the cord enters the mobile home shall not be less than 20 feet.

(h) The power-supply cord shall bear the following marking: "For use with mobile homes — 40 amperes" or "For use with mobile homes — 50 amperes."

(i) The point of entrance of the feeder assembly to the mobile home shall be in the exterior wall, floor, or roof, in the rear third section (away from the coupler) of the mobile home.

(j) Where a separately metered appliance is installed in the mobile home, or where the calculated load of the mobile home is between 50 amperes and 150 amperes, up to three 50-ampere power-supply cords may be installed when permitted by the authority having jurisdiction, or a feeder assembly as provided for in Section 550-3(a) or 550-3(k) shall be permitted. The additional power-supply cords shall be located not more than 12 inches away from the point of entrance of the main power-supply cord. They shall not be interconnected on either the line side or the load side, except that the grounding means shall be electrically interconnected.

(k) Where the calculated load exceeds 150 amperes or where a permanent feeder is used, the supply shall be by means of:

(1) One mast weatherhead installation installed in accordance with Article 230 containing 4 continuous, insulated, color-coded, feeder conductors, one of which shall be an equipment grounding conductor; or,

(2) An approved metal raceway from the disconnecting means in the mobile home to the underside of the mobile home with provisions for the attachment to a suitable junction box or fitting to the raceway on the underside of the mobile home (with or without conductors as in Section 550-3(k)(1)).

550-4. Disconnecting Means and Branch-Circuit Protective Equipment.

The branch-circuit equipment shall be permitted to be combined with the disconnecting means as a single assembly. Such a combination shall be permitted to be designated as a distribution panelboard. If a fused distribution panelboard is used, the maximum fuse size for the mains shall be plainly marked, with lettering at least $\frac{1}{4}$ inch high and visible when fuses are changed.

Plug fuses and fuseholders shall be tamper-resistant, Type "S," enclosed in dead-front fuse panelboards.

See Section 110-22 concerning identification of each disconnecting means and each service, feeder, or branch circuit at the point where it originated and the type marking needed.

(a) **Disconnecting Means.** A single disconnecting means shall be provided in each mobile home consisting of a circuit breaker, or a switch and fuses and their accessories installed in a readily accessible location near the point of entrance of the supply cord or conductors into the mobile home. The main circuit breakers or fuses shall be plainly marked "Main." This equipment shall contain a solderless type of grounding connector or bar for the purposes of grounding with sufficient terminals for all grounding conductors. The neutral bar termination of the grounded circuit conductors shall be insulated. The disconnecting equipment shall have a rating suitable for the connected load. The distribution equipment, either circuit breaker or fused type, shall be located a minimum of 24 inches from the bottom of such equipment to the floor level of the mobile home.

Where more than one power-supply cord is installed, disconnecting means shall be provided for each cord and shall be permitted to be combined in a single equipment but without electrical interconnections other than for grounding purposes.

A distribution panelboard main circuit breaker shall be rated 50 amperes and employ a 2-pole circuit breaker rated 40 amperes for a 40-ampere supply cord, or 50 amperes for a 50-ampere supply cord. A distribution panelboard employing a disconnect switch and fuses shall be rated 60 amperes and shall employ a single 2-pole 60-ampere fuseholder with 40- or 50-ampere main fuses for 40- or 50-ampere supply cords, respectively. The outside of the distribution panelboard shall be plainly marked with the fuse size.

The distribution panelboard shall be permitted just inside a closet entry if the location is such that a clear space of 6 inches to easily ignitable materials is maintained in front of the distribution panelboard, and the distribution panelboard door can be extended to its full open position (at least 90 degrees). A clear working space at least 30 inches wide and 30 inches in front of the distribution panelboard shall be provided. This space shall extend from floor to the top of the distribution panelboard.

(b) Branch-Circuit Protective Equipment. Branch-circuit distribution equipment shall be installed in each mobile home and shall include overcurrent protection for each branch circuit consisting of either circuit breakers or fuses.

The branch-circuit overcurrent devices shall be rated: (1) not more than the circuit conductors; and (2) not more than 150 percent of the rating of a single appliance rated 10 amperes or more which is supplied by an individual branch circuit; but (3) not more than the fuse size marked on the air conditioner or other motor-operated appliance.

A 15-ampere multiple receptacle shall be acceptable when connected to a 20-ampere laundry circuit.

(c) Two-Pole Circuit Breakers. When circuit breakers are provided for branch-circuit protection, 230-volt circuits shall be protected by a 2-pole common or companion trip, or handle-tied paired circuit breakers.

(d) Electrical Nameplates. A metal nameplate on the outside adjacent to the feeder assembly entrance shall read: "This Connection for 120/240-Volt, 3-Pole, 4-Wire, 60 Hertz, . . . Ampere Supply." The correct ampere rating shall be marked in the blank space.

550-5. Branch Circuits. The number of branch circuits required shall be determined in accordance with (a) through (c) below.

(a) Lighting. Based on 3 watts per square foot times outside dimensions of the mobile home (coupler excluded) divided by 115 volts to determine the number of 15- or 20-ampere lighting area circuits, e.g.,

$$\frac{3 \times \text{Length} \times \text{Width}}{115 \times 15 \text{ (or 20)}} = \text{No. of 15- (or 20-) ampere circuits.}$$

(b) Portable Appliances. For the small appliance load in kitchen, pantry, family room, dining room, and breakfast rooms of mobile homes, two or more 20-ampere appliance branch circuits in addition to the branch circuits specified in Section 550-5(a) shall be provided for all receptacle outlets in these rooms, and such circuits shall have no other outlets. Receptacle outlets supplied by at least two appliance receptacle branch circuits shall be installed in the kitchen.

(c) General Appliances. (Including furnace, water heater, range, and central or room air conditioner, etc.) There shall be one or more circuits of adequate rating in accordance with the following:

(1) Ampere rating of fixed appliances not over 50 percent of circuit rating if lighting outlets (receptacles, other than kitchen, dining area, and laundry, considered as lighting outlets) are on the same circuit;

(2) For fixed appliances on a circuit without lighting outlets, the sum of rated amperes shall not exceed the branch-circuit rating for other than motor loads or 80 percent of the branch-circuit rating for air conditioning or other motor loads;

(3) The rating of a single portable appliance on a circuit having no other outlets shall not exceed 80 percent of the circuit rating;

(4) The rating of range branch circuit shall be based on the range demand as specified for ranges in Section 550-11(b)(5).

For the laundry branch circuit, see Section 220-3(c).

For central air conditioning, see Article 440.

550-6. Receptacle Outlets.

(a) All receptacle outlets: (1) shall be of grounding type; (2) shall be installed according to Section 210-7; and (3) except when supplying specific appliances, receptacles shall be parallel-blade, 15-ampere, 125-volt, either single or duplex.

For ground-fault circuit-interrupter requirements, refer to Section 210-8(a).

(b) There shall be an individual outlet of the grounding type for each cord-connected fixed appliance installed.

(c) **Receptacle Outlets Required.** Except in the bath and hall areas, receptacle outlets shall be installed at all wall spaces 2 feet wide or more, so that no point along the floor line is more than 6 feet, measured horizontally, from an outlet in that space. Except as explained in the following, receptacle outlets are not required for wall spaces occupied by kitchen or wardrobe cabinets.

In addition, a receptacle outlet shall be installed: (1) Over or adjacent to counter tops in the kitchen (at least one on each side of the sink if counter tops are on each side and 12 inches or more in width); (2) Adjacent to the refrigerator and free-standing gas-range space; (3) At counter top spaces for built-in vanities; (4) At counter top spaces under wall-mounted cabinets.

(d) Receptacle outlets shall not be installed within or adjacent to a shower or bathtub space.

550-7. Fixtures and Appliances.

(a) Electrical materials, devices, appliances, fittings, and other equipment installed, intended for use in, or attached to the mobile home shall be approved for the application and shall be connected in an approved manner when in service. Facilities shall be provided to securely fasten appliances when the mobile home is in transit. (See Section 550-9 for provisions on grounding.)

(1) Specifically approved pendant-type fixtures or pendant cords shall be permitted in mobile homes.

(2) If a lighting fixture is provided over a bathtub or in a shower stall, it shall be of the approved enclosed and gasketed type.

(3) The switch for shower lighting fixtures and exhaust fans located over a tub or in a shower stall shall be located outside the tub or shower space.

(b) Every appliance shall be accessible for inspection, service, repair, or replacement without removal of permanent construction.

550-8. Wiring Methods and Materials. Except as specifically limited in this Section, the wiring methods and materials included in this Code shall be used in mobile homes.

(a) Nonmetallic outlet boxes shall be acceptable only with nonmetallic cable.

(b) Nonmetallic cable located 15 inches or less above the floor, if exposed, shall be protected from physical damage by covering boards, guard strips, or conduit. Cable likely to be damaged by stowage shall be so protected in all cases.

(c) Metal-clad and nonmetallic cables shall be permitted to pass through the centers of the wide side of 2-inch by 4-inch studs. However, they shall be protected where they pass through 2-inch by 2-inch studs or at other studs or frames where the cable or armor would be less than 1½ inches from the inside or outside surface. Steel plates on each side of the cable, or a tube, with not less than No. 16 MSG wall thickness, shall be required to protect the cable. These plates or tubes shall be securely held in place.

(d) Where metallic faceplates are used, they shall be effectively grounded.

(e) If the range, clothes dryer, or similar appliance is connected by metal-clad cable or flexible conduit, a length of free cable or conduit should be provided to permit moving the appliance. The cable or flexible conduit should be adequately secured to the wall. If the range, clothes dryer, or similar appliance is connected by metal-clad cable or flexible conduit, a length of not less than three feet of free cable or conduit shall be provided to permit moving the appliance. Type NM or type SE cable shall not be used to connect a range or dryer. This shall not prohibit the use of type NM or type SE cable between the branch circuit overcurrent protective device and a junction box or range or dryer receptacle.

This does not prohibit the use of Type NM cable between the branch-circuit overcurrent protective device and a range or dryer receptacle.

(f) Threaded rigid conduit shall be provided with a locknut inside and outside the box, and a conduit bushing shall be used on the inside. Rigid nonmetallic conduit shall be permitted. Inside ends of the conduit shall be reamed.

(g) Switches shall be rated as follows:

(1) For lighting circuits, switches shall have a 10-ampere 120-125-volt rating; or higher, if needed for the connected load.

(2) For motors or other loads, switches shall have ampere or horsepower ratings, or both, adequate for loads controlled. (An "AC general-use" snap switch shall be permitted to control a motor 2 horse-

power or less with full-load current not over 80 percent of the switch ampere rating.)

(h) At least 4 inches of free conductor shall be left at each outlet box except where conductors are intended to loop without joints.

(i) **Under-Chassis Wiring.** (Exposed to Weather).

(1) When outdoor or under-chassis line-voltage wiring is exposed to moisture or physical damage, it shall be protected by rigid metal conduit. The conductors shall be suitable for wet locations.

Exception: Electrical metallic tubing shall be permitted when closely routed against frames and equipment enclosures.

(2) The cables or conductors shall be Type NMC, TW, or equivalent.

(j) Outlet boxes of dimensions less than those required in Table 370-6(a) shall be permitted provided the box has been tested and approved for the purpose.

(k) Boxes, fittings and cabinets shall be securely fastened in place.

Exception: Snap-in type boxes or boxes provided with special wall or ceiling brackets that securely fasten boxes in walls or ceilings shall be permitted.

(l) Appliances having branch-circuit terminal connections which operate at temperatures higher than 60°C (140°F) shall have circuit conductors as described in (1) and (2) below:

(1) Branch-circuit conductors having an insulation suitable for the temperature encountered shall be permitted to be run directly to the appliance.

(2) Conductors having an insulation suitable for the temperature encountered shall be run from the appliance terminal connection to a readily accessible outlet box placed at least one foot from the appliance. These conductors shall be in a suitable raceway which shall extend for at least 4 feet.

550-9. Grounding. Grounding of both electrical and nonelectrical metal parts in a mobile home shall be through connection to a grounding bus in the mobile home distribution panelboard. The grounding bus shall be grounded through the green-colored conductor in the supply cord or the feeder wiring to the service ground in the service-entrance equipment located adjacent to the mobile home location. Neither the frame of the mobile home nor the frame of any appliance shall be connected to the neutral conductor in the mobile home.

(a) **Insulated Neutral.**

(1) The grounded circuit conductor (neutral) shall be insulated from the grounding conductors and from equipment enclosures and other grounded parts. The grounded (neutral) circuit terminals in the distribution panelboard and in ranges, clothes dryers, counter-mounted cooking units, and wall-mounted ovens shall be insulated from the equipment enclosure. Bonding screws, straps, or buses in the distribution panelboard or in appliances shall be removed and discarded.

(2) Connections of ranges and clothes dryers with 115/230-volt, 3-wire ratings shall be made with 4-conductor cord and 3-pole, 4-wire grounding-type plugs, or by Type AC metal-clad cable or conductors enclosed in flexible metal conduit.

For 115-volt rated devices, a 3-conductor cord and a 2-pole, 3-wire grounding-type plug shall be permitted.

(b) Equipment Grounding Means.

(1) The green-colored grounding wire in the supply cord or permanent feeder wiring shall be connected to the grounding bus in the distribution panelboard or disconnecting means.

(2) In the electrical system, all exposed metal parts, enclosures, frames, lamp fixture canopies, etc., shall be effectively bonded to the grounding terminal or enclosure of the distribution panelboard.

(3) Cord-connected appliances, such as washing machines, clothes dryers, refrigerators, and the electrical system of gas ranges, etc., shall be grounded by means of an approved cord with grounding conductor and grounding-type attachment plug.

(c) Bonding of Noncurrent-Carrying Metal Parts.

(1) All exposed noncurrent-carrying metal parts that may become energized shall be effectively bonded to the grounding terminal or enclosure of the distribution panelboard. A bonding conductor shall be connected between each distribution panelboard and an accessible terminal on the chassis.

(2) Grounding terminals shall be of the solderless type and approved as pressure-terminal connectors recognized for the wire size used. The bonding conductor shall be solid or stranded, insulated or bare, and shall be No. 8 copper minimum, or equal. The bonding conductor shall be routed so as not to be exposed to physical damage.

(3) Metallic gas, water, and waste pipes and metallic air circulating ducts shall be considered bonded if they are connected to the terminal on the chassis (see Section 550-9(c)(1)) by clamps, solderless connectors, or by suitable grounding-type straps.

(4) Any metallic roof and exterior covering shall be considered bonded if (a) the metal panels overlap one another and are securely attached to the wood or metal frame parts by metallic fasteners, and (b) if the lower panel of the metallic exterior covering is secured by metallic fasteners at a cross member of the chassis by two metal straps per mobile home unit or section at opposite ends.

The bonding strap material shall be a minimum of 4 inches in width of material equivalent to the skin or a material of equal or better electrical conductivity. The straps shall be fastened with paint-penetrating fittings, such as screws and starwashers or equivalent.

550-10. Testing. Dielectric Strength Test. The wiring of each mobile home shall be subjected to a 1-minute, 900-volt, dielectric strength test (with all switches closed) between live parts (including neutral) and the mobile home ground. Alternatively, the test shall be permitted to be performed at 1,080 volts for 1 second. This test shall be performed after branch circuits are complete and after fixtures or appliances are installed.

Exception: Fixtures or appliances which are approved shall not be required to withstand the dielectric strength test.

550-11. Calculations. The following method shall be employed in computing the supply-cord and distribution-panelboard load for each

feeder assembly for each mobile home in lieu of the procedure shown in Article 220 and shall be based on a 3-wire, 115/230-volt supply with 115-volt loads balanced between the two legs of the 3-wire system.

(a) Lighting and Small Appliance Load:

Lighting Watts: Length times width of mobile home (outside dimensions, exclusive of coupler) times 3 watts per square foot; e.g.,
 $\text{Length} \times \text{width} \times 3 = \dots\dots\dots \text{lighting watts.}$

Small Appliance Watts: Number of circuits times 1,500 watts for each 20-ampere appliance receptacle circuit (see definition of Appliance, Portable with note); e.g.,

$\text{Number of circuits} \times 1,500 = \dots\dots\dots \text{small appliance watts.}$

Total: Lighting watts plus small appliance = $\dots\dots\dots$ total watts.

First 3,000 total watts at 100 percent plus remainder at 35 percent = $\dots\dots\dots$ watts to be divided by 230 volts to obtain current (amperes) per leg.

(b) Total load for determining power supply is the summation of:

(1) Lighting and small appliance load as calculated in Section 550-11(a).

(2) Nameplate amperes for motors and heater loads (exhaust fans, air conditioners,* electric, gas, or oil heating).**

* Omit smaller of these two, except include blower motor if used as air conditioner evaporator motor.

** When an air conditioner is not installed and a 40-ampere power supply cord is provided, allow 15 amperes per leg for air conditioning.

(3) 25 percent of current of largest motor in (2).

(4) Total of nameplate amperes for: disposal, dishwasher, water heater, clothes dryer, wall-mounted oven, cooking units.

Where number of these appliances exceeds 3, use 75 percent of total.

(5) Derive amperes for free-standing range (as distinguished from separate ovens and cooking units) by dividing values below by 230 volts.

Nameplate Rating	Use
10,000 watts or less	80 percent of rating
10,001-12,500 watts	8,000 watts
12,501-13,500 watts	8,400 watts
13,501-14,500 watts	8,800 watts
14,501-15,500 watts	9,200 watts
15,501-16,500 watts	9,600 watts
16,501-17,500 watts	10,000 watts

(6) If outlets or circuits are provided for other than factory-installed appliances, include the anticipated load.

See following Example for illustration of application of this calculation.

Example

A mobile home is 70 × 10 feet and has two portable appliance circuits, a 1000-watt 230-volt heater, a 200-watt 115-volt exhaust fan, a 400-watt 115-volt dishwasher and a 7000-watt electric range.

Lighting and small appliance load

Lighting $70 \times 10 \times 3 =$	2100 watts,
Small appliance $1500 \times 2 =$	3000 watts
	<u>5100 watts</u>
1st 3000 watts at 100%	3000
Remainder $(5,100 - 3,000 = 2,100)$ at 35%	<u>735</u>
	3735

$$\frac{3735}{230} = 16 \text{ amperes per leg}$$

1000 watt (heater) $\div 230 =$	4.4 amp
200 watt (fan) $\div 115 =$	1.7 amp
400 watt (dishwasher) $\div 115 =$	3.5 amp
7000 watt (range) $\times .8 \div 230 =$	24. amp

Amperes per leg

	<i>A</i>	<i>B</i>
Lighting and appliances	16	16
Heater (230 volt)	4	4
Fan (115 volt)	2	—
Dishwasher (115 volt)	—	4
Range	<u>24</u>	<u>24</u>
Totals	46	48

Based on the higher current calculated for either leg, use one 50-ampere supply cord.

(c) Optional Method of Calculation for Lighting and Appliance Load.

For mobile homes, the optional method for calculating lighting and appliance load shown in Section 220-30 and Table 220-30 shall be permitted.

550-12. Wiring of Expandable Units and Dual Units.

(a) Expandable or dual-unit mobile homes shall use fixed-type wiring methods and materials for connecting such units to each other.

(b) Expandable or dual-unit mobile homes not having permanently installed feeders, and which are to be moved from one location to another, shall be permitted to have disconnecting means with branch-circuit protective equipment in each unit when so located that after assembly or joining together of units, the requirements of Section 550-3(j) are met.

550-13. Outdoor Outlets, Fixtures, Air-Cooling Equipment, Etc.

(a) Outdoor fixtures and equipment shall be recognized for outdoor use. Outdoor receptacle or convenience outlets shall be of a gasketed-cover type.

(b) A mobile home provided with a receptacle outlet designed to energize heating and/or air-conditioning equipment located outside the mobile home, shall have permanently affixed, adjacent to the outlet receptacle, a metal tag which reads:

This Connection is for Air-Conditioning Equipment
Rated at Not More Than Amperes, at
..... Volts, 60 Hertz.

The correct voltage and ampere rating shall be given. The tag shall be not less than 0.020 inch, etched brass, stainless steel, anodized or alclad aluminum or equivalent. The tag shall not be less than 3 inches by 1¾ inches minimum size.

B. Mobile Home Parks

550-21. Distribution System. The mobile home park secondary electrical distribution system to mobile home lots shall be single-phase, 115/230 volts, nominal. For the purpose of Part B, where the park service exceeds 240 volts, transformers and secondary distribution panelboards shall be treated as services.

See Table 550-22 for calculation of load.

550-22. Calculated Load.

(a) Park electrical wiring systems shall be calculated on the basis of not less than 16,000 watts (at 115/230 volts) per each mobile home service. The demand factors which are set forth in Table 550-22 shall be considered the minimum allowable demand factors which shall be permitted in calculating load on feeders and service. No demand factor shall be allowed for any other load, except as provided in this Code.

Table 550-22
Demand Factors for Feeders and Service-Entrance Conductors

Number of Mobile Home Lots	Demand Factor (Percent)
1	100
2	55
3	44
4	39
5	33
6	29
7-9	28
10-12	27
13-15	26
16-21	25
22-40	24
41-60	23
61 and over	22

(b) The demand factor for a given number of lots shall apply to all lots indicated.

Example: 20 lots calculated at 25 percent of 16,000 watts result in a permissible demand of 4,000 watts per lot or a total of 80,000 watts for 20 lots.

(c) Mobile home lot feeder circuit conductors shall have adequate capacity for the loads supplied, and shall be rated at not less than 100 amperes at 115/230 volts.

550-23. Mobile Home Service Equipment.

(a) Mobile home service equipment shall be rated at not less than 100 amperes, and provision shall be made for connecting a mobile home feeder assembly by a permanent wiring method. Power outlets used as mobile home service equipment shall also be permitted to contain receptacles rated up to 50 amperes with appropriate overcurrent protection. Fifty-ampere receptacles shall conform to the configuration shown in Figure 550-3(f).

Complete details on the 50-ampere attachment plug cap configuration can be found in American National Standard Dimensions of Caps, Plugs and Receptacles, ANSI C73.17-1972.

(b) Mobile home service equipment shall also contain a means for connecting a mobile home accessory building or structure or additional electrical equipment located outside a mobile home by a fixed wiring method.

(c) Additional receptacles shall be permitted for connection of electrical equipment located outside the mobile home, and all such 120-volt, single-phase, 15- and 20-ampere receptacles shall be protected by approved ground-fault circuit protection for personnel.

ARTICLE 551—RECREATIONAL VEHICLES AND RECREATIONAL VEHICLE PARKS

A. Recreational Vehicles

551-1. Scope.

(a) The provisions of Part A cover the electrical conductors and equipment installed within or on recreational vehicles and also the conductors that connect them to a supply of electricity. Wherever the requirements of other Articles of this Code and Article 551 differ, the requirements of Article 551 shall apply.

For requirements on the installation of plumbing and heating systems in recreational vehicles, refer to Standard for Recreational Vehicles (NFPA No. 501C-1972).

(b) A recreational vehicle not used for the purposes as defined in Section 551-2 shall not be required to meet the provisions of Part A pertaining to the number or capacity of circuits required. It shall, however, meet all other applicable requirements of this Article if the recreational vehicle is provided with an electrical installation intended to be energized from a 115- or 115/230-volt, AC power-supply system.

(c) Part A covers battery and direct-current power (12-volt or less) systems, combination electrical systems, generator installations, and nominal 115- or 115/230-volt systems.

551-2. Definitions. (See Article 100 for other definitions.)

Air-Conditioning or Comfort-Cooling Equipment: All of that equipment intended or installed for the purpose of processing the treatment of air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space.

Camping Trailer: A vehicular portable unit mounted on wheels and constructed with collapsible partial side walls which fold for towing by another vehicle and unfold at the campsite to provide temporary living quarters for recreational, camping, or travel use. (See "Recreational Vehicle.")

Converter: A device which changes electrical energy from one form to another, as from alternating current to direct current.

Dead Front (As applied to switches, circuit breakers, switchboards, and distribution panelboards): So designed, constructed and installed that no current-carrying parts are normally exposed on the front.

Disconnecting Means: The necessary equipment usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors in a recreational vehicle and intended to constitute the means of cutoff for the supply to that recreational vehicle.

Receptacles used as disconnecting means shall be accessible (as applied to wiring methods) and capable of interrupting their rated current without hazard to the operator.

Distribution Panelboard: A single panel or 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 cut-out box placed in or against a wall or partition and accessible only from the front.

Low-Voltage: An electromotive force rated nominal 24 volts, nominal or less, supplied from a transformer, converter, or battery.

Motor Home: A vehicular unit designed to provide temporary living quarters for recreational, camping or travel use built on or permanently attached to a self-propelled motor vehicle chassis or on a chassis cab or van which is an integral part of the completed vehicle. (See "Recreational Vehicle.")

Power-Supply Assembly: The conductors, including the grounding conductors, insulated from one another, the connectors, attachment plug caps, and all other fittings, grommets, or devices installed for the purpose of delivering energy from the source of electrical supply to the distribution panel within the recreational vehicle.

Recreational Vehicle: A vehicular type unit primarily designed as temporary living quarters for recreational, camping, or travel use, which either has its own motive power or is mounted on or drawn by another vehicle. The basic entities are: travel trailer, camping trailer, truck camper and motor home.

Transformer: A device, which when used, will raise or lower the voltage of alternating current of the original source.

Travel Trailer: A vehicular unit mounted on wheels, designed to provide temporary living quarters for recreational, camping, or travel use, of such size or weight as not to require special highway movement permits when drawn by a motorized vehicle, and with a living area of less than 220 square feet, excluding built-in equipment (such as wardrobes, closets, cabinets, kitchen units or fixtures) and bath and toilet rooms. (See "Recreational Vehicle.")

Truck Camper: A portable unit constructed to provide temporary living quarters for recreational, travel, or camping use, consisting of a roof, floor, and sides, designed to be loaded onto and unloaded from the bed of a pick-up truck. (See "Recreational Vehicle.")

551-3. Low-Voltage Systems.

(a) **Low-Voltage Circuits.** Low-voltage circuits furnished and installed by the recreational vehicle manufacturer, other than those related to braking, are subject to this Code. Circuits supplying lights subject to Federal or State regulations shall be in accordance with applicable government regulations, but shall not be lower than provided by this Code.

(b) Low-Voltage Wiring Materials.

(1) Copper conductors shall be used for low-voltage circuits.

(2) The insulation of low-voltage conductors shall be rated at least 60°C.

(3) Conductors furnished and installed by the recreational vehicle manufacturer shall have a minimum of 30 mils thermoplastic insulation or equal.

(4) The insulation of outdoor or under-chassis wire shall be moisture and heat resistant, Type THW or equivalent.

(5) Single-wire, low-voltage conductors shall be of the stranded type.

Exception: Metal chassis or frame shall be permitted as the return path for exterior lighting. Terminals for connection to the chassis or frame shall be of the solderless type and approved for the size and type wire used. Mechanical connections to the frame or chassis shall be made secure.

(c) Low-Voltage Wiring Methods.

(1) Conductors shall be protected against physical damage and shall be secured. Where insulated conductors are clamped to the structure, the conductor insulation shall be supplemented by an additional wrap or layer of equivalent material, except that jacketed cables need not be so protected. Wiring shall be routed away from sharp edges, moving parts or heat sources.

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

(3) Battery and direct-current circuits shall be physically separated

by at least a 1/2-inch gap or other approved means, from circuits of a different power source. Acceptable methods shall be by clamping, routing, or equivalent means which ensure permanent total separation.

(d) Battery Installations. Storage batteries subject to the provisions of this Code shall be securely attached to the vehicle and installed in an area vaportight to the interior and ventilated directly to the exterior of the vehicle. When batteries are installed in a compartment, the compartment shall be ventilated with openings of not less than 2 square inches at the top and 2 square inches at the bottom. Batteries shall not be installed in a compartment containing spark or flame producing equipment.

(e) Overcurrent Protection.

(1) Low-voltage circuit wiring shall be protected by overcurrent protective devices rated not in excess of the ampacity of copper conductors, as follows:

Wire Size	Ampacity	Wire Type
18	6	Stranded only
16	8	Stranded only
14	15	Stranded or Solid
12	20	Stranded or Solid
10	30	Stranded or Solid

(2) Circuit breakers or fuses shall be of an approved type, including automotive types. Fuseholders shall be clearly marked with maximum fuse size.

For further information, see Society of Automotive Engineers (SAE) Standard J554-1968, and Standard for Electric Fuses, ANSI C118.1-1973 and Underwriters' Laboratories, Inc. Standard for Automotive Glass Tube Fuses, UL 275b-1973.

(3) Higher current-consuming direct-current appliances such as pumps, compressors, heater blowers and similar motor-driven appliances shall be installed in accordance with the manufacturer's instructions.

Motors which are controlled by automatic switching or by latching-type manual switches shall be protected in accordance with Section 430-32(c).

(4) The overcurrent protective device shall be installed in an accessible location on the vehicle as close as practical to the point where the power supply connects to the vehicle circuits. If located outside the recreational vehicle, the device shall be protected against weather and physical damage.

(f) Switches. Switches shall be rated at not less than the connected load.

551-4. Combination Electrical Systems.

(a) General. Vehicle wiring suitable for connection to a battery or direct-current supply source shall be permitted to be connected to a 115-volt source provided that the entire wiring system and equipment are rated and installed in full conformity with Part A requirements covering

115-volt electrical systems. Circuits fed from alternating-current transformers shall not supply direct-current appliances.

(b) Voltage Converters (115-Volt Alternating Current to Low-Voltage Direct Current). The 115-volt alternating current side of voltage converters shall be wired in full conformity with Part A requirements for 115-volt electrical systems. Converters supplied as an integral part of an approved appliance shall not be subject to the above. All converters and transformers shall be listed and shall be used within their marked electrical ratings.

(c) Dual-Voltage Fixtures or Appliances. Fixtures or appliances having both 115-volt and low-voltage connections shall be approved for dual voltage.

(d) Autotransformers. Autotransformers shall not be used.

(e) Receptacles and Plug Caps. When a recreational vehicle is equipped with a 120-volt or 120/240-volt alternating-current system and/or a low-voltage system, receptacles and plug caps of the low-voltage system shall differ in configuration from those of the 120- or 120/240-volt system.

(f) Identification.

(1) When a vehicle equipped with a battery or direct-current system has an external connection for low-voltage power, the receptacle shall have a configuration that will not accept 120-volt power. The vehicle shall have permanently affixed on the outside wall, adjacent to the point of entrance of the power supply conductors, a tag which reads:

THIS CONNECTION IS FOR LOW-VOLTAGE BATTERY OR DIRECT CURRENT ONLY. DO NOT CONNECT TO 120 OR 240 VOLTS AC.

(2) The tag shall be 3 inches by 1¾ inches minimum size, made of etched, metal-stamped or embossed brass, stainless steel, anodized or alclad aluminum not less than 0.020 inch thick, or other approved material (e.g., 0.005-inch plastic laminates).

551-5. Generator Installations.

(a) Mounting. Generators shall be mounted in such a manner as to be effectively bonded to the recreational vehicle chassis.

(b) Generator Protection. Equipment shall be installed to ensure that the generator is disconnected when the vehicle is energized from an outside source and to ensure that the outside source is disconnected when the vehicle is energized by the generator. The generator field shall be protected by appropriately rated, approved equipment.

(c) Installation of Storage Batteries and Generators. Storage batteries and internal-combustion-driven generator units (subject to the provisions of this Code) shall be secured in place to avoid displacement from vibration and road shock and shall be installed in a compartment which is vaportight to the interior of the vehicle.

(d) Ventilation of Generator Compartments. Compartments accommodating internal-combustion-driven generator units shall be provided with approved ventilation in accordance with instructions provided by the manufacturer of the generator unit.

(e) **Location of Internal-Combustion-Engine Generator Exhaust.** Exhaust from generator internal-combustion engines shall not terminate adjacent to the vehicle gasoline-tank filler-spout inlet.

(f) **Supply Conductors.** Supply conductors from the generators to the junction box (having a blank cover) on the compartment wall shall be of the stranded type installed in flexible conduit.

551-6. 115- or 115/230-Volt, Nominal Systems.

(a) **General Requirements.** The electrical equipment and material of recreational vehicles indicated for connection to a wiring system nominally rated 115 volts, 2-wire with ground, or a wiring system nominally rated 115/230 volts, 3-wire with ground, shall be approved and installed in accordance with the requirements of Part A.

(b) **Materials and Equipment.** Electrical materials, devices, appliances, fittings, and other equipment installed, intended for use in, or attached to the recreational vehicle shall be approved for the purpose. All products shall be used only in the manner in which they have been tested and found suitable for the intended use.

551-7. Receptacle Outlets Required.

(a) Receptacle outlets shall be installed at wall spaces 2 feet wide or more so that no point along the floor line is more than 6 feet, measured horizontally, from an outlet in that space.

Exception No. 1: Bath and hall areas.

Exception No. 2: Wall spaces occupied by kitchen cabinets, wardrobe cabinets, built-in furniture, behind doors which may open fully against a wall surface, or similar facilities.

(b) Receptacle outlets shall be installed:

(1) Adjacent to counter tops in the kitchen (at least one on each side of the sink if counter tops are on each side and are 12 inches or over in width).

(2) Adjacent to the refrigerator and gas range space, except when a gas-fired refrigerator or cooking appliance, requiring no external electrical connection, is factory-installed.

(3) Adjacent to counter top spaces (and built-in vanities) which cannot be reached from a receptacle required in Section 551-7(b)(1) by a cord of 6 feet without crossing a traffic area, cooking appliance or sink.

(c) When installed adjacent to a bathroom lavatory, the receptacle outlet shall be a minimum of 30 inches from the floor. The receptacle outlet shall be permitted in an approved lighting fixture. A receptacle outlet shall not be installed in a tub or combination shower compartment.

(d) A receptacle shall not be installed in a face-up position in any counter top or similar horizontal surfaces within the living area.

551-8. Branch Circuits Required. The branch circuits required in a recreational vehicle shall conform to Section 551-19 and be determined in accordance with subparagraphs (a), (b), (c) or (d) below. When provisions are made to facilitate future installations of an electrical

appliance, the anticipated load of such appliance shall be counted in the total rating of fixed appliances (e.g., air-conditioning prewiring).

(a) Recreational vehicles with not more than 8 lighting and receptacle outlets combined shall have either:

(1) One 15-ampere general-purpose branch circuit to supply these outlets, provided the total rating of fixed appliances connected to this circuit does not exceed 600 watts, or

(2) One 20-ampere general-purpose branch circuit to supply these outlets, provided the total rating of fixed appliances connected to this circuit does not exceed 1,000 watts.

Vehicles wired in accordance with (a)(1) or (a)(2) above shall not be equipped with electrical heating or cooking appliances.

(b) Recreational vehicles with more than 8 lighting and receptacle outlets combined shall have one 20-ampere appliance branch circuit, and either:

(1) One 15-ampere branch circuit to supply these outlets, provided this circuit does not supply receptacles in the cooking and dining area(s) or electrical heating or cooking appliances, and provided the total rating of fixed appliances connected to this circuit does not exceed 600 watts, or

(2) One 20-ampere branch circuit, to supply these outlets, provided this circuit does not supply receptacles in the cooking and dining area(s) or electrical heating or cooking appliances, and provided the total rating of fixed appliances connected to this circuit does not exceed 1,000 watts.

(c) Recreational vehicles having a distribution panelboard and a feeder assembly rated not less than 30 amperes shall be permitted to serve the following circuits:

(1) One 20-ampere circuit for use with air conditioner rated not more than 16 amperes.

(2) One 20-ampere portable appliance circuit and/or;

(3) One 15-ampere branch circuit for lights and receptacles and fixed appliances rated not more than 600 watts.

(d) **Calculations for Lighting and Appliance Load.** When Section 551-8(b) (relative to recreational vehicles with more than 8 lighting and receptacle outlets combined) is not applied, the following method shall be employed in computing the power-supply assembly and distribution panelboard load for the recreational vehicle:

A. Lighting. Length times width of vehicle (outside dimensions, exclusive of hitch and cab) times 3 watts per square foot, e.g.,

Length x width x 3 = _____ lighting watts.

B. Small Appliance. Number of circuits times 1,500 watts for each 20-ampere appliance receptacle circuit, e.g.,

Number of Circuits x 1,500 _____ small appliance watts.

C. Total. Lighting watts plus small appliance watts = _____ total watts.

D. First 3,000 total watts at 100 percent plus remainder at 35 percent = _____ watts to be divided by voltage to obtain current (amperes) per leg.

		Amperes per Leg	
		A	B
Lighting and small appliance current (amperes) per leg (from D above) =			
E. Add nameplate amperes for motors and heater loads (exhaust fans, air conditioners*, electric, gas, or oil heating*) =			
* Omit smaller of these two except include any motor common to both functions.			
F. Add 25 percent of amperes of largest motor in E =			
G. Add nameplate amperes for:**			
Disposal			
Water Heater			
Wall-Mounted Ovens			
Cooking Units			
TOTAL			

** When number of appliances is four or more, use 75 percent of total.

H. Add amperes for free-standing range as distinguished from separate ovens and cooking units. Derive from following table by dividing watts by 230 volts.

Range	Nameplate Rating (watts)	Use (watts)
(Free-standing range as distinguished from separate oven and cooking units)	10,000 or less	80 percent of rating
	10,001-12,500	8,000
	12,501-13,500	8,400
	13,501-14,500	8,800
	14,501-15,500	9,200
	15,501-16,500	9,600
	16,501-17,500	10,000

		Amperes per Leg	
		A	B
I. If outlets or circuits are provided for other than factory-installed major appliances, the anticipated load shall be added for each.			
TOTAL =			

When the total for Legs A and B are unequal, use the larger to determine the distribution panelboard and supply cord rating. (Service amperes shall not exceed supply cord rating. See Section 551-10.)

551-9. Branch-Circuit Protection.

(a) The branch-circuit overcurrent devices shall be rated:

(1) Not more than the circuit conductors; and

(2) Not more than 150 percent of the rating of a single appliance rated 10 amperes or more and supplied by an individual branch circuit; but

(3) Not more than the fuse size marked on an air conditioner or other motor-operated appliances.

(b) A 20-ampere fuse or circuit breaker shall be considered adequate protection for fixture leads, cords, or portable appliances, and No. 14 tap conductors, not over 6 feet long for recessed lighting fixtures.

(c) If more than one outlet or load is on a branch circuit, a 15-ampere receptacle shall be considered protected by a 20-ampere fuse or circuit breaker.

551-10. Power-Supply Assembly.

(a) Recreational vehicles wired in accordance with Section 551-8(a)(1) shall use an approved 15-ampere, or larger, main power-supply assembly.

(b) Recreational vehicles wired in accordance with Section 551-8(a)(2) shall use an approved 20-ampere, or larger, main power-supply assembly.

(c) Recreational vehicles wired in accordance with Section 551-8(b) or 551-8(c) shall use an approved 30-ampere, or larger, main power-supply assembly.

(d) In accordance with Section 551-8(c), any recreational vehicle with a rating in excess of 30 amperes, 115 volts, shall use an approved 40-ampere or 50-ampere 115/230-volt power-supply assembly.

Exception No. 1: When the calculated load of the recreational vehicle exceeds 30 amperes, 115 volts, a second power-supply cord shall be permitted. Where a two-cord supply system is installed, they shall not be interconnected on either the line side or the load side. The grounding circuits and grounding means shall be electrically interconnected.

Exception No. 2: For a dual-supply source consisting of a generator and a power supply cord, see Section 551-12.

551-11. Distribution Panelboard.

(a) A listed and appropriately rated distribution panelboard or other equipment specifically listed for the purpose shall be used. The distribution panelboard shall be of the insulated neutral type, with the grounding bar attached to the metal frame of the panelboard or other approved grounding means.

(b) The distribution panelboard shall be installed in a readily accessible location and shall be permitted in a closet.

(c) The distribution panelboard shall be of the dead-front type and shall consist of one or more circuit breakers or Type S fuseholders. A main disconnecting means shall be provided where fuses are used or where more than two circuit breakers are employed.

551-12. Dual-Supply Source.

(a) Where a dual-supply system, consisting of a generator and a power-supply cord is installed, the feeder from the generator shall be protected by an overcurrent protective device. Installation shall be in accordance with Sections 551-5(a) and 551-5(b).

(b) Calculation of loads shall be in accordance with Section 551-8(d).

(c) The two supply sources shall not be required to be of the same capacity.

(d) If the AC generator source exceeds 30 amperes, 115 volts, it shall be permissible to wire either as a 115-volt system or a 115/230-volt system, providing an overcurrent protective device of the proper rating is installed in the feeder.

(e) The external power-supply assembly shall be permitted to be less than the calculated load but not less than 30 amperes and shall have overcurrent protection not greater than the capacity of the external power-supply assembly.

551-13. Means for Connecting to Power Supply.

(a) **Assembly.** The power-supply assembly or assemblies shall be factory-supplied or factory-installed when of the permanently connected type as specified herein:

(1) **Separable.** When a separable power-supply assembly consisting of a cord with a female connector and molded attachment plug cap is provided, the vehicle shall be equipped with a permanently mounted, approved, male-recessed-type motor-base receptacle wired directly to the distribution panelboard by an approved wiring method. The attachment plug cap shall be of an approved type.

(2) **Permanently Connected.** Each power-supply assembly shall be connected directly to the terminals of the distribution panelboard or conductors within an approved junction box and provided with means to prevent strain from being transmitted to the terminals. The ampacity of the conductors between each junction box and the terminals of each distribution panelboard shall be at least equal to the ampacity of the power-supply cord. The supply end of the assembly shall be equipped with an attachment plug of the type described in Section 551-13(c). Where the cord passes through the walls or floors, it shall be protected by means of conduit and bushings or equivalent.

(b) **Cord.** The cord set shall be approved for use with recreational vehicles. The cord shall be not less than 20 feet as measured from the point of entrance to the recreational vehicle or the face of the motor-base attachment plug nor more than 26½ feet in length overall to the face of the attachment plug at the supply end.

(c) Attachment Plugs.

(1) Recreational vehicles having only one 15-ampere branch circuit as permitted by Section 551-8(a)(1) shall have an attachment plug which shall be 2-pole, 3-wire, grounding-type, rated 15 amperes, 125 volts, conforming to the configuration shown in Figure 551-13(c).

Complete details of this configuration can be found in American National Standard ANSI C73.11-1972.

(2) Recreational vehicles having only one 20-ampere branch cir-

cuit as permitted in Section 551-8(a)(2) shall have an attachment plug which shall be 2-pole, 3-wire, grounding-type, rated 20 amperes, 125 volts, conforming to the configuration shown in Figure 551-13(c).

Complete details of this configuration can be found in American National Standard ANSI C73.12-1972.

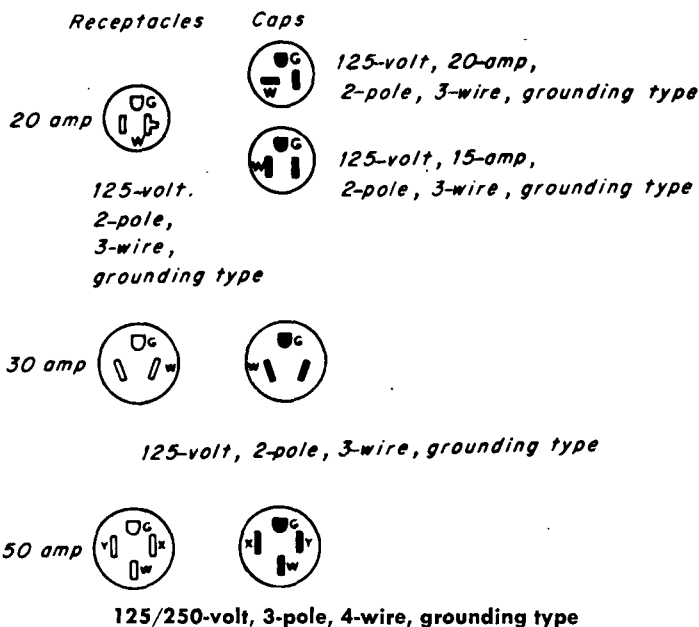
(3) Recreational vehicles wired in accordance with Sections 551-8(b) or 551-8(c) shall have an attachment plug which shall be 2-pole, 3-wire, grounding-type, rated 30 amperes, 125 volts, conforming to the configuration shown in Figure 551-13(c) intended for use with units rated at 30 amperes, 125 volts.

Complete details of this configuration can be found in American National Standard Dimensions of Caps, Plugs and Receptacles, ANSI C73.13-1972.

(4) Recreational vehicles having a power-supply assembly rated 40 amperes or 50 amperes as permitted by Section 551-8(c) shall have a 3-pole, 4-wire, grounding-type attachment plug rated 50 amperes, 125/250 volts, conforming to the configuration shown in Figure 551-17(c).

Complete details of this configuration can be found in American National Standard Dimensions of Caps, Plugs and Receptacles, ANSI C73.13-1972.

Figure 551-13(c). Configurations for grounding-type receptacles and attachment plug caps used for recreational vehicle supply cords and recreational vehicle lots.



(d) **Labeling at Electrical Entrance.** Each recreational vehicle shall have permanently affixed to the exterior skin at or near the point of

entrance of the power-supply cord(s) a tag 3 inches by 1¾ inches minimum size, made of etched, metal-stamped or embossed brass, stainless steel, anodized or alclad aluminum not less than 0.020 inch thick, or other approved material (e.g., 0.005-inch plastic laminates), which reads, as appropriate, either:

"This connection is for 110-125-volt AC, 60-Hz (Cycles) service. Do not connect to higher voltage"; or

"This connection is for 3-wire 120/240-volt AC, 60-Hz (Cycles) _____ ampere service." The correct ampere rating shall be marked in the blank space.

(e) **Location.** The point of entrance of a power-supply assembly shall be located within 25 feet of the rear, on the left (road) side or at the rear, left of the longitudinal center of the vehicle, within 18 inches of the outside wall.

Exception: A trailer having a gross vehicle weight rating of 1,500 pounds or less, a motor home, or a truck camper shall be permitted to have the electrical point of entrance located on either side provided the main drain outlet is located on the same side.

551-14. Wiring Methods.

(a) Electrical metallic tubing, flexible metal conduit, metal-clad cable, and nonmetallic-sheathed cable with a grounding conductor, shall terminate by means of fittings, clamps or connectors approved for the purpose. Flexible metal conduit shall be permitted as a grounding means where both the conduit and the fittings are approved for the purpose.

(b) Rigid metal conduit shall be provided with a locknut inside and outside the box, and a conduit bushing shall be used on the inside. Inside ends of the conduit shall be reamed.

(c) Nonmetallic outlet boxes shall be acceptable only with nonmetallic-sheathed cable.

(d) 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.

(e) Wall and ceiling outlets shall be mounted in accordance with Article 240.

Exception: Snap-in type boxes or boxes provided with special wall or ceiling brackets that securely fasten boxes in walls or ceilings shall be permitted.

(f) The sheath of nonmetallic cable or the armor of metal-clad cable shall be continuous between outlet boxes and other enclosures.

(g) Metal-clad and nonmetallic cables shall be permitted to pass through the centers of the wide side of 2-inch by 4-inch studs. However, they shall be protected where they pass through 2-inch by 2-inch studs or at other studs or frames where the cable would be less than 1½ inches from the inside or outside surface. Steel plates on each side of the cable, or a steel tube, with not less than No. 16 MSG wall thickness, shall be installed to protect the cable. These plates or tubes shall be securely held in place.

(h) No bend shall have a radius of less than 5 times the cable diameter.

(i) When connected with cable connectors or clamps, cables shall be supported within 12 inches of outlet boxes, distribution panelboards, and splice boxes on appliances. Supports shall be provided every 4½ feet at other places.

(i) Nonmetallic-sheathed cables shall be supported within 8 inches of a nonmetallic outlet box without cable clamps.

Exception: Where approved devices of insulating material are employed with a loop of extra cable to permit future replacement of the device, the cable loop shall be considered as an integral portion of the device.

(k) Where subject to physical damage, exposed nonmetallic cable shall be protected by covering boards, guard strips, or conduit.

(l) Metallic faceplates shall be of ferrous metal not less than 0.030 inch in thickness or of nonferrous metal not less than 0.040 inch in thickness. Nonmetallic faceplates shall be of an approved type.

(m) Where metallic faceplates are used, they shall be effectively grounded.

(n) Where outdoor or underchassis wiring is 115 volts (nominal) or over and is exposed to moisture or physical damage, the wiring shall be protected by rigid metal conduit, or by electrical metallic tubing that is closely routed against frames and equipment enclosures.

551-15. Conductors and Outlet Boxes.

(a) The maximum number of conductors permitted in outlet and junction boxes, shall be in accordance with Section 370-6.

Exception: Outlet boxes of dimensions less than those required in Table 370-6(a) of this Code shall be permitted provided the box has been tested and approved for the purpose.

(b) At least 4 inches of free conductor shall be left at each outlet box except where conductors are intended to loop without joints.

551-16. Grounded Conductors. The identification of grounded conductors shall be in accordance with Section 200-6.

551-17. Connection of Terminals and Splices. Conductor splices and connections at terminals shall be in accordance with Section 110-14. If splices of the grounding wire in nonmetallic-sheathed cable are made in outlet boxes, the splices shall be insulated.

551-18. Switches. Switches shall be rated as follows:

(a) For lighting circuits, switches shall be rated not less than 10 amperes, 120-125 volts and in no case less than the connected load.

(b) For motors or other loads, switches shall have ampere or horsepower ratings, or both, adequate for loads controlled. (An AC general-use snap switch shall be permitted to control a motor 2 horsepower or less with full-load current not over 80 percent of the switch ampere rating.)

551-19. Receptacles. All receptacle outlets shall be: (1) of the grounding type; and (2) installed in accordance with Sections 210-21 and 210-25.

551-20. Lighting Fixtures.

(a) **General.** Any combustible wall or ceiling finish exposed between the edge of a fixture canopy, or pan and the outlet box, shall be covered with noncombustible material of either metal equal to the thickness of the fixture or asbestos of 1/16 inch.

(b) **Shower Fixtures.** If a lighting fixture is provided over a bathtub or in a shower stall, it shall be of the enclosed and gasketed type and approved for the type of installation.

The switch for shower lighting fixtures and exhaust fans, located over a tub or in a shower stall, shall be located outside the tub or shower space.

(c) **Outdoor Outlets, Fixtures, Air-Cooling Equipment, Etc.** Outdoor fixtures and other equipment shall be approved for outdoor use.

551-21. Grounding. (See also Section 551-23 on bonding of non-current-carrying metal parts.)

(a) **Power-Supply Grounding.** The grounding conductor in the supply cord or feeder shall be connected to the grounding bus or other approved grounding means in the distribution panelboard.

(b) **Distribution Panelboard.** The distribution panelboard shall have a grounding bus with sufficient terminals for all grounding conductors or other approved grounding means.

(c) **Insulated Neutral.**

(1) The grounded circuit conductor (neutral) shall be insulated from the equipment grounding conductors and from equipment enclosures and other grounded parts. The grounded (neutral) circuit terminals in the distribution panelboard and in ranges, clothes dryers, counter-mounted cooking units, and wall-mounted ovens shall be insulated from the equipment enclosure. Bonding screws, straps or buses in the distribution panelboard or in appliances shall be removed and discarded.

(2) Connection of electric ranges and electric clothes dryers utilizing a grounded (neutral) conductor, if cord-connected, shall be made with 4-conductor cord and 3-pole, 4-wire grounding-type plug caps and receptacles.

551-22. Interior Equipment Grounding.

(a) In the electrical system, all exposed metal parts, enclosures, frames, lighting fixture canopies, etc., shall be effectively bonded to the grounding terminals or enclosure of the distribution panelboard.

(b) Bare wires, green-colored wires, or green wires with yellow stripe(s) shall be used for equipment grounding conductors only.

(c) Where grounding of electrical equipment is specified, it shall be permitted as follows:

(1) Connection by metallic raceway (conduit or electrical metallic tubing) or the sheath of metal-clad cable to metallic outlet boxes.

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

(3) The grounding wire in nonmetallic-sheathed cable shall be per-

mitted to be secured under a screw threaded into the fixture canopy other than a mounting screw or cover screw; or attached to an approved grounding means (plate) in a nonmetallic outlet box for fixture mounting (grounding means shall also be permitted for fixture attachment screws).

(d) A connection between the one or more grounding conductors brought into a nonmetallic outlet box shall be so arranged that a connection can be made to any fitting or device in that box that requires grounding.

(e) Where more than one equipment grounding conductor of a branch circuit enters a box, all such conductors shall be in good electrical contact with each other, and the arrangement shall be such that the disconnection or removal of a receptacle, fixture, or other device fed from the box will not interfere with or interrupt the grounding continuity.

(f) Cord-connected appliances, such as washing machines, clothes dryers, refrigerators, and the electrical system of gas ranges, etc., shall be grounded by means of an approved cord with grounding conductor and grounding-type attachment plug.

551-23. Bonding of Noncurrent-Carrying Metal Parts.

(a) All exposed noncurrent-carrying metal parts that may become energized shall be effectively bonded to the grounding terminal or enclosure of the distribution panelboard.

(b) A bonding conductor shall be connected between any distribution panelboard and an accessible terminal on the chassis.

Exception: Any recreational vehicle which employs a unitized metal chassis-frame construction to which the distribution panelboard is securely fastened with a bolt(s) and nut(s) or by welding or riveting shall be considered to be bonded.

(c) Grounding terminals shall be of the solderless type and approved as pressure terminal connectors recognized for the wire size used. The bonding conductor shall be solid or stranded, insulated or bare, and shall be No. 8 copper minimum, or equal.

(d) The metallic roof and exterior covering shall be considered bonded if:

(1) The metal panels overlap one another and are securely attached to the wood or metal frame parts by metallic fasteners, and

(2) The lower panel of the metallic exterior covering is secured by metallic fasteners at each cross member of the chassis, or the lower panel is bonded to the chassis by a metal strap.

(e) The gas, water and waste pipes shall be considered grounded if they are bonded to the chassis.

See Section 551-23(b) for chassis bonding.

(f) Furnace and metallic circulating air ducts shall be bonded.

551-24. Appliance Accessibility. Every appliance shall be accessible for inspection, service, repair and replacement without removal of permanent construction.

551-25. Factory Tests (Electrical).

Electrical Factory Test. Each recreational vehicle shall be subjected to the following tests:

(a) **Circuits of 115 Volts or 115/230 Volts.** Each recreational vehicle designed with a 115-volt or a 115/230-volt electrical system shall withstand the applied potential without electrical breakdown of a one-minute, 900-volt dielectric strength test, or a one-second, 1080-volt dielectric strength test, with all switches closed, between current-carrying conductors, including neutral, and the recreational vehicle ground. During the test, all switches and other controls shall be in the "on" position. Fixtures and permanently installed appliances shall not be required to withstand this test.

Each recreational vehicle shall be subjected to:

(1) a continuity test to assure that all metallic parts are properly bonded,

(2) operational tests to demonstrate that all equipment is properly connected and in working order, and

(3) polarity checks to determine that connections have been properly made.

(b) **Low-Voltage Circuits.** Low-voltage circuit conductors in each recreational vehicle shall withstand the applied potential without electrical breakdown of a one-minute, 500-volt or a one second, 600-volt dielectric strength test. The potential shall be applied between live and grounded conductors.

The test shall be permitted on running light circuits before the lights are installed provided the vehicle's outer covering and interior cabinetry has been secured. The braking circuit shall be permitted to be tested before being connected to the brakes, provided the wiring has been completely secured.

B. Recreational Vehicle Parks

551-40. Application and Scope. Part B covers electrical systems on recreational vehicle parks. It does not apply to the electrical systems of recreational vehicles or the conductors that connect them to the park electrical supply facilities. Wherever the requirements of other Articles of this Code and Article 551 differ, the requirements of Article 551 shall apply.

551-41. Definitions.

Lot: The area in a recreational park intended for the connection of one recreational vehicle.

Power-Supply Assembly: The conductors, including the grounding conductors, insulated from one another, the connectors, attachment plug caps, and all other fittings, grommets, or devices installed for the purpose of delivering energy from the source of electrical supply to the distribution panelboard within the recreational vehicle.

Recreational Vehicle Lot Electric Supply Equipment: The necessary equipment, usually a power outlet, consisting of a circuit breaker or switch and fuse and their accessories, located near the point of entrance of supply conductors to a recreational vehicle lot and intended

to constitute the disconnecting means for the supply to that lot.

Recreational Vehicle Park: Recreational vehicle park is the contiguous parcel of land which is used for the accommodation of occupied recreational vehicles.

551-42. Receptacles Required. A minimum of 75 percent of all lots with electrical supply shall each be equipped with a 20-ampere and 30-ampere 125-volt receptacle conforming to Figure 551-13(c). The remainder of all lots with electrical supply shall each be equipped with a 20-ampere 125-volt receptacle conforming to Figure 551-13(c).

Exception: Where the type of lot justifies, special permission may be given to alter the percentage of lots to be equipped with both 20-ampere and 30-ampere receptacles, as specified herein.

Complete details of these receptacle configurations can be found in American National Standard Dimensions of Caps, Plugs and Receptacles, ANSI C73.12-1972 (20 ampere) and ANSI C73.13-1972 (30 ampere).

551-43. Distribution System. The recreational vehicle park secondary electrical distribution system to recreational vehicle lots shall be derived from a single-phase 120/240-volt, 3-wire system.

551-44. Calculated Load.

(a) Electrical service and feeders shall be calculated on the basis of not less than 3,600 watts per lot equipped with both 20-ampere and 30-ampere supply facilities and 2,400 watts per lot equipped with only 20-ampere supply facilities. The demand factors set forth in Table 551-44 shall be the minimum allowable demand factors that shall be permitted in calculating load for service and feeders.

Table 551-44
Demand Factors for Feeders and Service-Entrance Conductors for
Park Lots

Number of Recreational Vehicle Lots	Demand Factor (percent)	Number of Recreational Vehicle Lots	Demand Factor (percent)
1	100	10-12	29
2	100	13-15	28
3	70	16-18	27
4	55	19-21	26
5	44	22-40	25
6	39	41-100	24
7-9	33	101 and over	23

(b) For the purpose of this Code, where the park service exceeds 240 volts, transformers and secondary distribution panelboards shall be treated as services.

(c) The demand factor for a given number of lots shall apply to all lots indicated. For example: 20 lots calculated at 26 percent of 3,600 watts result in a permissible demand of 936 watts per lot or a total of 18,720 watts for 20 lots.

(d) Recreational vehicle lot feeder circuit conductors shall have adequate ampacity for the loads supplied, and shall be rated at not less than 30 amperes.

551-45. Overcurrent Protection. Overcurrent protection shall be provided in accordance with Article 240.

551-46. Grounding. All electrical equipment and installations in recreational vehicle parks shall be grounded as required by Article 250.

551-47. Recreational Vehicle Lot Electric Supply Equipment.

(a) **Disconnecting Means.** A disconnecting switch or circuit breaker shall be provided in the lot supply equipment for disconnecting the power supply to the recreational vehicle.

(b) **Access.** All lot supply equipment shall be accessible by an unobstructed entrance or passageway not less than two feet wide and 6½ feet high.

(c) **Mounting Height.** Lot supply equipment shall be located not less than 2 feet nor more than 6½ feet above the ground.

(d) **Working Space.** Sufficient space shall be provided and maintained about all electrical equipment to permit ready and safe operation, in accordance with Section 110-16.

551-48. Grounding, Recreational Vehicle Lot Supply Equipment.

(a) Exposed noncurrent-carrying metal parts of fixed equipment, metal boxes, cabinets and fittings, which are not electrically connected to grounded equipment shall be grounded by a continuous grounding conductor run with the circuit conductors from the service equipments or from the transformer of a secondary distribution system.

(b) Each secondary distribution system shall be grounded at the transformer.

(c) The neutral conductor shall not be used as an equipment ground for recreational vehicles or equipment within the recreational vehicle park.

(d) No connection to a grounding electrode shall be made to the neutral conductor on the load side of the service disconnecting means or transformer distribution panelboard.

551-49. Protection of Outdoor Equipment.

(a) **Wet Locations.** All switches, circuit breakers, receptacles, control equipment and metering devices located in wet places or outside of a building shall be rainproof equipment.

(b) **Meters.** If secondary meters are installed, meter sockets without meters installed shall be blanked off with an approved blanking plate.

551-50. Overhead Conductors.

(a) **Vertical Clearance.** Open conductors of not over 600 volts shall have a vertical clearance of not less than 18 feet in all areas subject to recreational vehicle movement. In all other areas, vertical clearances shall conform to Section 225-18.

For clearance of conductors of over 600 volts, see National Electrical Safety Code (ANSI C2-1973).

(b) **Horizontal Clearance.** The horizontal clearance from structures

and recreational vehicles for overhead conductors shall be not less than 3 feet for 600 volts or less.

551-51. Underground Service, Feeder, Branch-Circuit and Recreational Vehicle Lot Feeder Circuit Conductors.

(a) **General.** All direct-burial conductors, including the equipment grounding conductor if of aluminum, shall be insulated and specifically approved for the purpose. All conductors shall be continuous from fitting to fitting. All splices shall be made in approved junction boxes.

(b) **Mechanical Protection.** Where underground conductors enter or leave a building or trench, they shall have mechanical protection in the form of rigid metal conduit, electrical metallic tubing or other approved mechanical means, extending a minimum of 18 inches into the trench from the finished grade.

See Section 310-6 and Article 339 for conductors or Type UF cable used underground or in direct burial in earth.

551-52. Receptacles. A receptacle to supply electric power to a recreational vehicle shall be one of the configurations shown in Figure 551-13(c) in the following ratings:

(a) 125/250 volts, 50-ampere, 3-pole, 4-wire, grounding type for 115/230-volt systems.

(b) 125-volt, 30-ampere, 2-pole, 3-wire grounding type for 115-volt systems.

(c) 125-volt, 20-ampere, 2-pole, 3-wire, grounding type for 115-volt systems.

Complete details of these configurations can be found in American National Standard Dimensions of Caps, Plugs and Receptacles, ANSI C73.17-1972; ANSI C73.13-1972; and C73.12-1972.

ARTICLE 555 — MARINAS AND BOATYARDS

555-1. Scope. This Article covers the installation of wiring and equipment in the areas comprising fixed or floating piers, wharfs, and docks, and other areas in marinas, boatyards, boat basins, and similar establishments that are used, or intended for use for the purpose of repair, berthing, launching, storage, or fueling of small craft.

555-2. Application of Other Articles. Wiring and equipment for marinas and boatyards shall comply with this Article and also with the applicable provisions of other Articles of this Code.

See notes following Sections 210-19(a) and 215-2(c) for voltage drop on branch circuits and feeders respectively.

555-3. Receptacles. Receptacles that provide shore power for boats shall be rated not less than 20 amperes and shall be single and of the locking and grounding types.

For various configurations and ratings of locking- and grounding-type receptacles and caps, see Dimensions of Caps, Plugs, and Receptacles (ANSI C73-1972).

555-4. Branch Circuits. Each single receptacle that supplies shore power to boats shall be supplied from a power outlet or panelboard by an individual branch circuit of the voltage class and rating corresponding to the rating of the receptacle.

555-5. Feeders and Services. The load for each ungrounded feeder and service conductor supplying receptacles that supply shore power for boats shall be calculated as follows:

For 1 to 4 receptacles—100 percent of the sum of the rating of the receptacles.

For 5 to 8 receptacles—90 percent of the sum of the rating of the receptacles.

For 9 to 13 receptacles—80 percent of the sum of the rating of the receptacles.

For 14 or more receptacles—70 percent of the sum of the rating of the receptacles.

555-6. Wiring Methods. Where exposed to the weather or water, the wiring method shall be one or more of the following:

- (1) Rigid nonmetallic conduit approved for the purpose.
- (2) Mineral-insulated metal-sheathed cable.
- (3) Nonmetallic cable approved for the purpose.
- (4) Corrosion-resistant rigid metal conduit approved for the purpose.
- (5) Underground wiring that complies with the requirements of this Code.

Exception No. 1: Where flexibility is required, other types approved for the purpose.

Exception No. 2: Open wiring shall be permitted by special permission.

In granting special permission, major factors include possible contact of open wires with masts, cranes, or similar structures or equipment.

See Fire Protection Standard for Marinas and Boatyards (NFPA No. 303-1969) for further information on wiring methods for various locations.

555-7. Grounding.

(a) Equipment to Be Grounded. The following items shall be connected to an equipment grounding conductor run with the circuit conductors in a raceway or cable:

- (1) Boxes, cabinets, and all other metal enclosures.
- (2) Metal frames of utilization equipment.
- (3) Grounding terminals of grounding-type receptacles.

(b) Type of Equipment Grounding Conductor. The equipment grounding conductor shall be an insulated copper conductor with a continuous outer finish that is either green or green with one or more yellow stripes.

(c) Size of Equipment Grounding Conductor. The insulated copper equipment grounding conductor shall be sized in accordance with Section 250-95 but not smaller than No. 12.

(d) Branch-Circuit Equipment Grounding Conductor. The insulated

equipment grounding conductor for branch circuits shall terminate at a grounding terminal in a remote panelboard or the grounding terminal in the main service equipment.

(e) Feeder Equipment Grounding Conductors. Where a feeder supplies a remote panelboard, an insulated equipment grounding conductor shall extend from a grounding terminal in the service equipment to a grounding terminal in the remote panelboard.

555-8. Wiring Over and Under Navigable Water. Wiring over and under navigable water shall be subject to approval by the authority having jurisdiction.

555-9. Gasoline Dispensing Stations — Hazardous (Classified) Locations.

(a) The following spaces shall be considered a Class I, Division 1 location:

(1) The space within the dispenser from its base to a level measured 4 feet vertically from its base.

(2) The space outside the dispenser for a distance measured 4 feet horizontally from all points of the dispenser and measured vertically upwards for a distance of 18 inches from the base of the dispenser.

(3) The entire space between the base of the dispenser and the lowest water surface for a distance of 4 feet measured horizontally from any point on the outside of the dispenser.

(b) In an outside location, the following space shall be considered a Class I, Division 2 location (spaces which are Class I, Division 1 as defined above are excluded. Buildings within the following space which are not suitably cut off shall be included). This space shall include the entire volume enveloped within the following limits:

(1) A horizontal limit of 20 feet from all points on the exterior enclosure of a dispenser.

(2) An upper limit of 18 inches measured vertically from the base of the dispenser.

(3) A lower limit which shall be the lowest water surface.

555-11. Sealing.

(a) At Dispenser. An approved seal shall be provided in each conduit run entering or leaving a dispenser or any cavities or enclosures in direct communication therewith.

(b) At Boundary. Additional seals shall be provided in accordance with Section 501-5. Sections 501-5(a)(4) and 501-5(b)(2) shall apply to horizontal as well as to vertical boundaries of the defined hazardous (classified) locations.

Chapter 6. Special Equipment

ARTICLE 600 — ELECTRIC SIGNS AND OUTLINE LIGHTING

A. General

600-1. Scope. This Article covers the installation of conductors and equipment for electric signs and outline lighting as defined in Article 100.

600-2. Disconnect Required. Each outline lighting installation, and each sign of other than the portable type, shall be controlled by an externally operable switch or breaker which will open all ungrounded conductors.

(a) In Sight of Sign. The disconnecting means shall be within sight of the sign or outline lighting which it controls.

Exception: Signs operated by electronic or electromechanical controllers located external to the sign shall have a disconnecting means located within sight from the controller location. The disconnecting means shall disconnect the sign and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently. The disconnecting means shall be permitted to be in the same enclosure with the controller. The disconnecting means shall be capable of being locked in the open position.

(b) Control Switch Rating. Switches, flashers and similar devices controlling transformers shall be either a type approved for the purpose or have an ampere rating not less than twice the ampere rating of the transformer.

Exception: For other than motors, AC general use snap switches shall be permitted to be used on alternating-current circuits to control inductive loads not exceeding the ampere rating of the switch.

See Section 380-14 for rating of Snap Switches.

600-3. Enclosures As Pull Boxes. The wiring method used to supply signs and outline lighting shall terminate in the sign or transformer enclosures.

Exception: Such signs and transformer boxes shall be permitted to be used as pull or junction boxes for conductors supplying other adjacent signs, outline lighting systems and floodlights that are part of signs provided the conductors extending from the equipment are protected by an overcurrent device rated 20 amperes or less.

600-4. Listing Required. Every electric sign of any type, fixed or portable, shall be listed and installed in conformance with that listing.

600-5. Grounding. Signs, troughs, tube terminal boxes, and other metal frames shall be grounded in the manner specified in Article 250.

Exception No. 1: Insulated and Inaccessible. Where they are insulated from ground and from other conducting surfaces and are inaccessible to unauthorized persons, they need not be grounded.

Exception No. 2: Isolated Parts. Isolated noncurrent-carrying metal parts of outline lighting may be bonded by No. 14 conductors and grounded in accordance with Article 250.

Exception No. 3: Portable Signs. Signs of the portable incandescent or fluorescent lamp type in which the open-circuit voltage does not exceed 150 volts to ground are not required to be grounded.

600-6. Branch Circuits.

(a) **Rating.** Circuits which supply lamps, ballasts, and transformers, or combinations shall be rated not to exceed 20 amperes. Circuits containing electric-discharge lighting transformers exclusively shall not be rated in excess of 30 amperes.

(b) **Required Branch Circuit.** Each commercial building and each commercial occupancy with ground floor footage shall be provided at an accessible location outside the occupancy, with at least one outlet for sign or outline lighting use. This outlet shall be supplied by an individual 20-ampere branch circuit.

600-7. Marking.

(a) **Signs.** Signs shall be marked with the maker's name; and, for incandescent lamp signs, with the number of lampholders; and, for electric-discharge-lamp signs, with input amperes at full load and input voltage. The marking of the sign shall be visible after installation.

(b) **Transformers.** Transformers shall be marked with the maker's name; and transformers for electric-discharge-lamp signs shall be marked with the input rating in amperes or volt-amperes, the input voltage, and the open-circuit output voltage.

600-8. Enclosures.

(a) **Conductors and Terminals.** Conductors and terminals in sign boxes, cabinets, and outline troughs shall be enclosed in metal or other noncombustible material.

Exception: The supply leads shall not be required to be enclosed.

(b) **Cutouts, Flashers, etc.** Cutouts, flashers, and similar devices shall be enclosed in metal boxes, the doors of which shall be arranged so they can be opened without removing obstructions or finished parts of the enclosure.

(c) **Strength.** Enclosures shall have ample strength and rigidity.

(d) **Material.** Signs and outline lighting shall be constructed of metal or other noncombustible material. Wood shall be permitted for external decoration if placed not less than 2 inches from the nearest lampholder or current-carrying part.

Exception: Portable signs of the indoor type shall not be required to meet this requirement.

(e) **Minimum Thickness — Enclosure Metal.** Sheet copper shall be at least 20 ounce (0.028 inch). Sheet steel shall be of No. 28 MSG.

Exception: For outline lighting and for electric-discharge signs, sheet steel shall be of No. 24 MSG if not ribbed, corrugated, or embossed over its entire surface and of No. 26 MSG if it is so ribbed, corrugated, or embossed.

(f) Protection of Metal. All steel parts of enclosures shall be galvanized or otherwise protected from corrosion.

(g) Enclosures Exposed to Weather. Enclosures for outdoor use shall be weatherproof and shall have an ample number of drain holes, each not larger than $\frac{1}{2}$ inch or smaller than $\frac{1}{4}$ inch. Wiring connections shall not be made through the bottoms of nonraintight enclosures exposed to the weather.

600-9. Portable Letters. Portable letters, fixtures, symbols and similar displays used in conjunction with fixed outdoor signs shall only be used when in compliance with all applicable provisions of this Code and, in addition, shall meet all of the following requirements:

(a) A weatherproof receptacle and attachment plug having one pole for grounding shall be provided for each individual letter, fixture, or sign.

(b) All cords shall be Type SJ, SO, ST, or SU, 3-conductor, with one conductor grounded as provided in the foregoing.

(c) No cord shall be less than 10 feet from the ground level directly underneath.

600-10. Clearances.

(a) Vertical and Horizontal. Signs and outline system enclosures shall have not less than the vertical and horizontal clearances from open conductors specified in Article 225.

(b) Elevation. The bottom of sign and outline lighting enclosures shall not be less than 16 feet above areas accessible to vehicles.

Exception: The bottom of such enclosures may be less than 16 feet above areas accessible to vehicles where such enclosures are protected from physical damage.

B. 600 Volts, Nominal or Less

600-21. Installation of Conductors.

(a) Wiring Method. Conductors shall be installed in rigid metal conduit, intermediate metal conduit, flexible metal conduit, liquidtight flexible metal conduit, electrical metallic tubing, metal-clad cable, metal troughing, aluminum-sheathed cable, copper-sheathed cable, and mineral-insulated metal-sheathed cable.

(b) Insulation and Size. Conductors shall be of a type approved for general use and shall not be smaller than No. 14.

Exception: Conductors not smaller than No. 18 of a type approved for the purpose shall be permitted:

a. In portable signs.

b. As short leads permanently attached to lampholders or electric-discharge ballasts.

c. As leads not more than 8 feet long permanently attached to electric-discharge lampholders or electric-discharge ballasts if the leads are enclosed in wiring channels.

d. For signs with multiple incandescent lamps requiring one conductor from a control to one or more lamps whose total load does not exceed 250 watts, if in an approved cable assembly of two or more conductors.

(c) Exposed to Weather. Conductors in raceways, metal-clad cable, or enclosures exposed to the weather shall be of the lead-covered type or other type specially approved for the conditions.

Exception: This shall not apply when rigid conduit, electrical metallic tubing, or enclosures are made raintight and arranged to drain.

(d) Number of Conductors in Raceway. The number of conductors in a raceway for sign fixtures shall be in accordance with Table 1 of Chapter 9.

(e) Conductors Soldered to Terminals. Where the conductors are fastened to lampholders other than of the pin type, they shall be soldered to the terminals or made with wire connectors approved for the purpose; and the exposed parts of conductors and terminals shall be treated to prevent corrosion. Where the conductors are fastened to pin-type lampholders that protect the terminals from the entrance of water, and that have been found acceptable for sign use, the conductors shall be of the stranded type but shall not be required to be soldered to the terminals.

600-22. Lampholders. Lampholders shall be of the unswitched type having bodies of suitable insulating material and shall be so constructed and installed as to prevent turning. Miniature lampholders shall not be employed for outdoor signs and outline lighting. The screw-shell contact of all sign lampholders in grounded circuits shall be connected to the grounded conductor of the circuit.

600-23. Conductors Within Signs and Troughs. Wires within the sign and outline lighting troughs shall be installed as to be mechanically secure.

600-24. Protection of Leads. Bushings shall be employed to protect wires feeding through enclosures.

C. Over 600 Volts, Nominal

600-31. Installation of Conductors.

(a) Wiring Method. Conductors shall be installed as concealed conductors on insulators, in rigid metal conduit, in flexible metal conduit, in liquidtight flexible metal conduit, or in electrical metallic tubing.

(b) Insulation and Size. Conductors shall be of a type approved for the purpose and for the voltage of the circuit and shall not be smaller than No. 14.

Exception: Conductors not smaller than No. 18 of a type approved for the purpose shall be permitted:

a. As leads not more than 8 feet long permanently attached to electric-discharge lampholders or electric-discharge ballasts if the leads are enclosed in wiring channels.

b. In show window displays or small portable signs, as leads not more than 8 feet long that run from the line ends of the tubing to the

secondary windings of transformers if the leads are permanently attached within the transformer enclosure.

(c) Bends in Conductors. Sharp bends in the conductors shall be avoided.

(d) 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 and not less than one inch for voltages of 10,000 or less. They shall be installed in channels lined with noncombustible material and used for no other purpose, except that the primary circuit conductors shall be permitted to be in the same channel. The insulators shall be of noncombustible, non-absorbent material. Concealed conductors on insulators shall not be allowed outside the sign enclosure.

(e) Conductors in Raceways. Where the conductors are covered with lead or other metal sheathing, the covering shall extend beyond the end of the raceway, and the surface of the cable shall not be injured where the covering terminates.

(1) In damp or wet locations, the insulation on all conductors shall extend beyond the metal covering or raceway not less than 4 inches for voltages over 10,000, 3 inches for voltages over 5000 but not exceeding 10,000, and 2 inches for voltages of 5000 or less.

(2) 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 5000 but not exceeding 10,000, and 1½ inches for voltages of 5000 or less.

(3) For conductors at grounded midpoint terminals, no spacing shall be required.

(4) A metal raceway containing a single conductor from one secondary terminal of a transformer shall not exceed 20 feet in length.

(f) Show Windows and Similar Locations. Conductors that hang freely in the air, away from combustible material, and where not subject to physical damage, as in some show window displays, shall not be required to be otherwise protected.

(g) Between Tubing and Grounded Midpoint. Conductors shall be permitted to be run from the ends of tubing to the grounded midpoint of transformers specifically designed for the purpose and provided with terminals at the midpoint. Where such connections are made to the transformer grounded midpoint, the connections between the high-voltage terminals of the transformer and the line ends of the tubing shall be as short as possible.

600-32. Transformers.

(a) Voltage. The transformer secondary open-circuit voltage shall not exceed 15,000 volts with an allowance on test of 1,000 volts additional. For end-grounded transformers, the secondary open-circuit voltage shall not exceed 7500 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 5000 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 more than 30 milliamperes.

Exception: Where the transformers and all wiring connected to them are installed in accordance with Article 410 for electric-discharge lighting of the same voltage.

(c) **Exposed to Weather.** Transformers used outdoors shall be of the weatherproof type or shall be protected from the weather by enclosure in the sign body or in a separate metal box.

(d) **Transformer Secondary Connections.** The high-voltage windings of transformers shall not be connected in parallel or in series.

Exception No. 1: Two transformers each having one end of its high-voltage winding connected to the metal enclosure shall be permitted to 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.

Exception No. 2: Transformers for small portable signs, show windows, and similar locations that are equipped with leads permanently attached to the secondary winding within the transformer enclosure and that do not extend more than 8 feet beyond the enclosure for attaching to the line ends of the tubing, but shall not be smaller than No. 18 and shall be of a type approved for the purpose.

(e) **Accessibility.** Transformers shall be located where accessible and shall be securely fastened in place.

(f) **Working Space.** A work space at least three feet high and measuring at least three feet by three horizontally shall be provided about each transformer or its enclosure where not installed in a sign.

(g) **Attic Locations.** Transformers may be located in attics provided there is a passageway at least 3 feet in height and at least 2 feet in width, provided with a suitable permanent fixed walkway or catwalk at least 12 inches in width extending from the point of entry into the attic to each transformer.

600-33. Electric-Discharge Tubing.

(a) **Design.** The tubing shall be of such length and design as not to cause a continuous overvoltage on the transformer.

(b) **Support.** Tubing shall be adequately supported on noncombustible, nonabsorbent supports. Tubing supports shall, where practicable, be adjustable.

(c) **Contact with Flammable Material and Other Surfaces.** The tubing shall be free from contact with flammable material and shall be located where not normally exposed to physical damage. Where operating at over 7500 volts, the tubing shall be supported on noncombustible, nonabsorbent insulating supports that maintain a spacing of not less than $\frac{1}{4}$ inch between the tubing and the nearest surface.

600-34. Terminals and Electrode Receptacles for Electric-Discharge Tubing.

(a) **Terminals.** Terminals of the tubing shall be inaccessible to unqualified persons and isolated from combustible material and grounded metal or shall be enclosed. Where enclosed, they shall be separated from grounded metal and combustible material by noncombustible, nonabsorbent insulating material approved for the purpose or by not less than 1½ inches of air. Terminals shall be relieved from stress by the independent support of the tubing.

(b) **Tube Connections Other Than with Receptacles.** Where tubes do not terminate in receptacles designed for the purpose, all live parts of tube terminals and conductors shall be supported so as to maintain a separation of not less than 1½ inches between conductors or between conductors and any grounded metal.

(c) **Receptacles.** Electrode receptacles for the tubing shall be of noncombustible, nonabsorbent 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 7500 volts, bushings shall be used unless receptacles are provided. Electrode terminal assemblies shall be supported not more than 6 inches from the electrode terminals.

(e) **Show Windows.** In the exposed type of show-window signs, terminals shall be enclosed by receptacles.

(f) **Receptacles and Bushing Seals.** A flexible, nonconducting seal shall be permitted to close the opening between the tubing and the receptacle or bushing against the entrance of dust or moisture. This seal shall not be in contact with grounded conductive material and shall not be depended upon for the insulation of the tubing.

(g) **Enclosures of Metal.** Enclosures of metal for electrodes shall not be less than No. 24 MSG sheet metal.

(h) **Enclosures of Insulating Material.** Enclosures of insulating material shall be noncombustible, nonabsorbent, and approved for the voltage of the circuit.

(i) **Live Parts.** Live parts shall be enclosed or suitably guarded to prevent contact.

600-35. Switches on Doors. Doors or covers giving access to uninsulated parts of indoor signs or outline lighting exceeding 600 volts and accessible to the general public shall either be provided with interlock switches that 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.

600-36. Fixed Outline Lighting and Skeleton-Type Signs for Interior Use.

(a) **Tube Support.** Gas tubing shall be supported independently of the conductors by means of insulators of noncombustible, nonabsorptive materials such as glass or porcelain or by suspension from suitable wires or chains.

(b) **Transformers.** Transformers shall be installed in metal enclosures and as near as practicable to the gas tubing system.

(c) **Supply Conductors.** The supply conductors for the transformers shall be enclosed in grounded metallic raceway.

(d) High-Tension Conductors. High-tension conductors shall be insulated for the voltage of the circuit and shall be enclosed in grounded metallic raceway.

Exception: Conductors not exceeding 4 feet in length between gas tubing and adjacent metallic enclosures shall be permitted to be enclosed in continuous glass or other insulating sleeves.

600-37. Portable Gas Tube Signs for Show Windows and Interior Use. This Section shall apply to the installation and use of portable gas tube signs.

(a) Location. Portable gas tube signs shall be for indoor use only.

(b) Transformer. The transformer shall be of the window type or shall be within a metal enclosure.

(c) Supply Conductors. Supply conductors shall consist of hard or extra-hard usage type cord containing a grounding conductor. The cord shall not exceed more than 10 feet in length.

(d) High-Voltage Conductors. High-voltage conductors shall not be more than 6 feet long and shall be located where not subject to mechanical injury, and shall be insulated for the voltage of the circuit and be protected by continuous glass or other insulating sleeves or tubing.

(e) Grounding. Transformers and attached noncurrent-carrying metal parts shall be grounded in accordance with Article 250.

(f) Support. Portable indoor signs shall be held in place by not to exceed two open hooks attached to the transformer case.

ARTICLE 610 — CRANES AND HOISTS

A. General

610-1. Scope. This Article covers the installation of electrical equipment and wiring used in connection with cranes, monorail hoists, hoists, and all runways.

For further information, see Safety Code for Cranes, Derricks, Hoists, Jacks, and Slings, ANSI B-30.

610-2. Special Requirements for Particular Locations.

(a) Hazardous Locations. All equipment which operates in a hazardous location shall conform to Article 500.

(1) Equipment used in locations which are hazardous because of the presence of flammable gases or vapors shall conform to Article 501.

(2) Equipment used in locations which are hazardous because of combustible dust shall conform to Article 502.

(3) Equipment used in locations which are hazardous because of the presence of easily ignitable fibers or flyings shall conform to Article 503.

(b) Combustible Materials. Where a crane, hoist, or monorail hoist operates over readily combustible material, the resistors shall be placed in a well-ventilated cabinet composed of noncombustible material so constructed that it will not emit flames or molten metal.

Exception: Resistors shall be permitted to be located in a cage or cab constructed of noncombustible material which encloses the sides of the cage or cab from the floor to a point at least 6 inches above the top of the resistors.

B. Wiring

610-11. Wiring Method. Conductors shall be enclosed in raceway or be Type ALS cable, Type CS cable, or Type MI cable.

Exception No. 1: Contact conductors.

Exception No. 2: Short lengths of open conductors at resistors, collectors, and other equipment.

Exception No. 3: Where flexible connections are necessary to motors and similar equipment, flexible stranded conductors shall be installed in flexible metal conduit, liquidtight flexible metal conduit, metal-clad cable, multiconductor cable, or an approved nonmetallic enclosure.

Exception No. 4: Where multiconductor cable is used with a suspended pushbutton station, the station shall be supported in some satisfactory manner that protects the electric conductors against strain.

610-12. Raceway Terminal Fittings. Conductors leaving raceways shall comply with one of the following:

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

(b) A bushing shall be permitted to be used in lieu of a box at the end of a conduit or electrical metallic tubing where the raceway terminates at D.C. split frame motors, unenclosed control, or similar equipment including contact conductors, collectors, resistors, D.C. series wound brakes, and power circuit limit switches.

610-13. Types of Conductors. Conductors shall be of the rubber-covered or the thermoplastic-insulated type or Type MI cable.

Exception No. 1: Conductors exposed to external heat or connected to resistors shall have an insulation suitable for the temperature and location. Where conductors not having flame-resistant outer covering are grouped together, the group shall be covered with a flame-resistant tape.

Exception No. 2: Contact conductors along runways, crane bridges, and monorails shall be permitted to be bare, but shall be guarded in an approved manner where accidental contact can occur, and shall be copper, aluminum, steel, or other alloys or combinations thereof in the form of hard drawn wire, tees, angles, tee rails, or other stiff shapes.

Exception No. 3: Flexible conductors shall be permitted to be used to convey current and, where practicable, cable reels or take-up devices shall be employed.

Exception No. 4: Varnished-cambric insulated conductors (Type V) or asbestos varnished-cambric insulated conductors (Type AVA and AVB) shall be permitted in dry locations.

610-14. Rating and Size of Conductors.

(a) **Ampacity.** The allowable ampacities of conductors shall be as shown in Table 610-14(a).

For the ampacities of conductors between controllers and resistors, see Section 430-23.

(b) **Secondary Resistor Conductors.** Where the secondary resistor is separate from the controller, the minimum size of the conductors between controller and resistor shall be calculated by multiplying the motor secondary current by the appropriate factor from Table 610-14(b) and selecting a wire from Table 610-14(a).

(c) **Minimum Size.** Conductors external to motors and controls shall not be smaller than No. 16.

Exception No. 1: No. 18 wire in multiple conductor cord shall be permitted for control circuits at not over 7 amperes.

Exception No. 2: Wires not smaller than No. 20 shall be permitted for electronic circuits.

(d) **Contact Conductors.** Contact wires shall have an ampacity not less than that required by Table 610-14(a) for 75°C wire, and in no case shall they be smaller than the following:

Distance Between End Strain Insulators or Clamp-Type Intermediate Supports	Size of Wire
0-30 feet	No. 6
30-60 feet	No. 4
Over 60 feet	No. 2

(e) Calculation of Motor Load.

(1) For one motor, use 100 percent of motor nameplate full-load ampere rating.

(2) For multiple motors on a single crane or hoist, the minimum circuit ampacity of the power supply conductors on a crane or hoist shall be the nameplate full-load ampere rating of the largest motor or group of motors for any single crane motion, plus 50 percent of the nameplate full-load ampere rating of the next largest motor or group of motors, using that column of Table 610-14(a) which applies to the longest time rated motor.

(3) For multiple cranes and/or hoists supplied by a common conductor system, compute the motor minimum ampacity for each crane as defined in Section 610-14(e), add them together, and multiply the sum

by the appropriate demand factor from Table 610-14(e).

Table 610-14(a)
Ampacities of Insulated Conductors up to Four Conductors in Raceway or Cable**
Used with Short-Time Rated Crane and Hoist Motors

Max. Oper- ating Temp.	75°C		90°C		110°C	
Size AWG MCM	Type MTW, RH, RHW, THW, THWN, XHHW		Type AVB, FEP, FEPB, RHH, SA, TA, THHN, XHHW*		Type AVA	
	60 min	30 min	60 min	30 min	60 min	30 min
16	10	12				
14	25	26	31	32	38	40
12	30	33	36	40	45	50
10	40	43	49	52	60	65
8	55	60	63	69	73	80
6	76	86	83	94	93	105
5	85	95	95	106	109	121
4	100	117	111	130	126	147
3	120	141	131	153	145	168
2	137	160	148	173	163	190
1	143	175	158	192	177	215
0	190	233	211	259	239	294
00	222	267	245	294	275	331
000	280	341	305	372	339	413
0000	300	369	319	399	352	440
250	364	420	400	461	447	516
300	455	582	497	636	554	707
350	486	646	542	716	616	809
400	538	688	593	760	666	856
450	600	765	660	836	740	930
500	660	847	726	914	815	1004

Other insulations shown in Table 310-13 and approved for the temperatures and location shall be permitted to be substituted for those shown in Table 610-14(a).

The allowable ampacities of conductors used with 15-minute motors shall be the 30-minute ratings increased by 12 percent.

* For dry locations only. See Table 310-13.

** For 5 or more power conductors in raceway or cable, the ampacity of each power conductor shall be reduced to a value of 80 percent of that shown in the table.

Table 610-14(b). Secondary Conductor Rating Factors

Time in Seconds		Ampacity of Wire in Percent of Full-Load Secondary Current
On	Off	
5	75	35
10	70	45
15	75	55
15	45	65
15	30	75
15	15	85
Continuous Duty		110

(f) Other Loads. Additional loads, such as heating, lighting, and air conditioning, shall be provided for by application of the appropriate Sections of this Code.

(g) Nameplate. Each crane, monorail, or hoist shall be provided with a visible nameplate marked with the maker's name, the rating in volts, frequency, number of phases, and circuit ampacity as calculated in Section 610-14(e) and (f).

Table 610-14(e). Demand Factors

Number of Cranes or Hoists	Demand Factor
2	0.95
3	0.91
4	0.87
5	0.84
6	0.81
7	0.78

610-15. Common Return. Where a crane or hoist is operated by more than one motor, a common-return conductor of proper ampacity shall be permitted.

C. Contact Conductors

610-21. Installation of Contact Conductors. Contact conductors shall comply with (a) through (h) below:

(a) Locating or Guarding Contact Conductors. Runway contact conductors shall be guarded and bridge contact conductors shall be located or guarded in a manner that persons cannot inadvertently touch energized current-carrying parts.

(b) **Contact Wires.** Wires that are used as contact conductors shall be secured at the ends by means of approved strain insulators and shall be so mounted on approved insulators that the extreme limit of displacement of the wire will not bring the latter within less than 1½ inches from the surface wired over.

(c) **Support Along Runways.** Main contact conductors carried along runways shall be supported on insulating supports placed at intervals not exceeding 20 feet.

Exception: Supports for grounded rail conductors as provided in (f) below shall not be required to be of the insulating type.

Such conductors shall be separated not less than 6 inches other than for monorail hoists where a spacing of not less than 3 inches shall be permitted. Where necessary, intervals between insulating supports shall be permitted to be increased up to 40 feet, the separation between conductors being increased proportionately.

(d) **Support on Bridges.** Bridge wire contact conductors shall be kept at least 2½ inches apart, and where the span exceeds 80 feet, insulating saddles shall be placed at intervals not exceeding 50 feet.

(e) **Supports for Rigid Conductors.** Conductors along runways and crane bridges, which are of the rigid type specified in Section 610-13, Exception No. 2, and not contained within an approved enclosed assembly, 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 conductors of not less than one inch.

(f) **Track As Circuit Conductor.** Monorail, tramrail, or crane-runway tracks shall be permitted as a conductor of current for one phase of a 3-phase alternating-current system furnishing power to the carrier, crane, or trolley, provided all of the following conditions are met:

(1) The conductors supplying the other two phases of the power supply are insulated.

(2) The power for all phases is obtained from an insulating transformer.

(3) The voltage does not exceed 300 volts.

(4) The rail serving as a conductor is effectively grounded at the transformer and also shall be permitted to be grounded by the fittings used for the suspension or attachment of the rail to a building or structure.

(g) **Electrical Continuity of Contact Conductors.** All sections of contact conductors shall be mechanically joined to provide a continuous electrical connection.

(h) **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.

610-22. Collectors. Collectors shall be so designed as to reduce to a minimum sparking between them and the contact conductor; and where

operated in rooms used for the storage of easily ignitable combustible fibers and materials, they shall comply with Section 503-13.

D. Disconnecting Means

610-31. Runway Conductor Disconnecting Means. A disconnecting means having a continuous ampere rating not less than that computed in Section 610-14(e) and (f) 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. 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 view of the crane or hoist and the runway contact conductors.

610-32. Disconnecting Means for Cranes and Monorail Hoists. A motor circuit switch or circuit breaker arranged to be locked in the open position shall be provided in the leads from the runway contact conductors or other power supply on all cranes and monorail hoists.

Exception: Where the crane or monorail hoist installation meets all of the following, the disconnect shall be permitted to be omitted:

- (a) *The unit is floor controlled.*
- (b) *Only one unit is supplied by the runway conductor system or other power supply.*
- (c) *The unit is within view of the power supply disconnecting means.*
- (d) *No fixed work platform has been provided for servicing the unit.*

Where the disconnecting means is not readily accessible from the crane operating station, means shall be provided at the crane operating station to open the power circuit to the crane motors.

610-33. Rating of Disconnecting Means. The continuous ampere rating of the switch or circuit breaker required by Section 610-32 shall not be less than 50 percent of the combined short-time ampere rating of the motors, nor less than 75 percent of the sum of the short-time ampere rating of the motors required for any single motion.

E. Overcurrent Protection

610-41. Feeders, Runway Conductors. The runway supply conductors and main contact conductors of a crane or monorail shall be protected by an overcurrent device(s) which shall not be greater than the largest rating or setting of any branch-circuit protective device, plus the sum of the nameplate ratings of all the other loads with application of the demand factors from Table 610-14(e).

610-42. Branch-Circuit Protection. Branch circuits shall be protected as follows:

(a) **Fuse or Circuit Breaker Rating.** Crane, hoist, and monorail hoist motor branch circuits shall be protected by fuses or time-limit circuit breakers having a rating in accordance with Table 430-152. Taps to control circuits shall be permitted to be taken from the load side of a

branch-circuit protective device, provided each tap and piece of equipment is properly protected.

Exception No. 1: When two or more motors operate a single motion, the sum of their nameplate current ratings shall be considered as a single motor current in the above calculations.

Exception No. 2: Two or more motors shall be permitted to be connected to the same branch circuit if no tap to an individual motor has an ampacity less than one-third that of the branch circuit and if each motor is protected for running overcurrent according to Section 610-43.

(b) Tap Conductors. Taps to brake coils do not require separate overcurrent protection.

610-43. Motor Running Overcurrent Protection. Each motor shall be protected from running overcurrent by one of the following means:

(1) A single motor shall be considered as protected when the branch-circuit overcurrent device meets the rating requirements of Section 610-42.

(2) Overload relay elements in each ungrounded circuit conductor, with all relay heaters protected from short circuit by the branch-circuit protection.

(3) Thermal sensing device(s), sensitive to motor temperature or to temperature and current which are thermally in contact with the motor winding(s). A hoist or trolley is considered to be protected if the sensing device is connected in the hoist's upper limit switch circuit so as to prevent further hoisting during an overcurrent condition of either motor.

Exception No. 1: If the motor is manually controlled, with spring return controls, the running overcurrent protective device need not protect the motor against stalled rotor conditions.

Exception No. 2: Where two or more motors drive a single trolley, truck, or bridge and are controlled as a unit by a single set of running overcurrent devices with a rating equal to the sum of their rated full-load currents. A hoist or trolley is considered to be protected if the sensing device is connected in the hoist's upper limit switch circuit so as to prevent further hoisting during an overtemperature condition of either motor.

Exception No. 3: Hoists and monorail hoists and their trolleys which are not used as part of an overhead traveling crane do not require individual motor running overcurrent protection provided the largest motor does not exceed 7½ horsepower and all motors are under manual control of the operator.

F. Control

610-51. Separate Controllers. Each motor shall be provided with an individual controller.

Exception No. 1: Where two or more motors drive a single hoist, carriage, truck, or bridge, they shall be permitted to be controlled by a single controller.

Exception No. 2: One controller shall be permitted to be switched between motors provided,